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Second Report to Congress on Great Lakes Water Quality

U.S. Environmental Protection Agency

March 1991

This report was prepared pursuant to Sections 118(c)(6) and 118(f) of the Clean Water Act, which state:

118(c)(6) Comprehensive Report. — Within 90 days after the end of each fiscal year, the Administrator shall submit to Congress a comprehensive report which —

(A) describes the achievements in the preceding fiscal year in implementing the Great Lakes Water Quality Agreement of 1978 and shows by categories (including judicial enforcement, research, State cooperative efforts, and general administration) the amounts expended on Great Lakes water quality initiatives in such preceding fiscal year;

(B) describes the progress made in such preceding fiscal year in implementing the system of surveillance of the water quality in the Great Lakes System, including the monitoring of groundwater and sediment, with particular reference to toxic pollutants;

(C) describes the long-term prospects for improving the condition of the Great Lakes; and

(D) provides a comprehensive assessment of the planned efforts to be pursued in the succeeding fiscal year for implementing the Great Lakes Water Quality Agreement of 1978, which assessment shall —

(i) show by categories (including judicial enforcement, research, State cooperative efforts, and general administration) the amount anticipated to be expended on Great Lakes water quality initiatives in the fiscal year to which the assessment relates; and

(ii) include a report of current programs administered by other Federal agencies which make available resources to the Great Lakes water quality management efforts.

118(f) Interagency Cooperation. — The head of each department, agency, or other instrumentality of the Federal Government which is engaged in, is concerned with, or has authority over programs relating to research, monitoring, and planning to maintain, enhance, preserve, or rehabilitate the environmental quality and natural resources of the Great Lakes, including the Chief of Engineers of the Army, the Chief of the Soil Conservation Service, the Commandant of the Coast Guard, the Director of the Fish and Wildlife Service, and the Administrator of the National Oceanic and Atmospheric Administration, shall submit an annual report to the Administrator with respect to the activities of that agency or office affecting compliance with the Great Lakes Water Quality Agreement of 1978.

Foreword

Over the past two decades, the United States and Canada have taken giant steps toward restoring the Great Lakes. The two nations have achieved a world-class success in abating nutrient-related algae problems in Lake Erie. They have likewise dramatically helped native fish species by controlling sea lampreys, a parasitic eel-like invader that by the 1950s had devastated lake trout. Levels of many targeted contaminants have declined drastically in fish and wildlife, resulting in clear improvements in the health of many species. This success has been obtained by use restrictions on targeted contaminants and by huge public and private investments in pollution treatment and abatement. The U.S. alone has invested over $8 billion since 1971 in municipal wastewater treatment facilities in the Great Lakes watershed. The eight Great Lakes Governors have signed a historic charter to protect their vital ecosystem and have begun to endow a trust fund to help finance the elimination of toxic substances from the lakes. EPA and State hazardous waste programs are pursuing major cleanups around the Great Lakes.

We should not allow this heartening progress to make us complacent. The health of the Great Lakes ecosystem remains a matter of concern. Unacceptable levels of persistent toxic substances continue to show up in the tissues of fish and wildlife. These substances are associated with a number of health problems in fish and wildlife, including tumors and impaired reproduction. Humans who ingest these substances through fish consumption face increased risk of cancer. Moreover, there is some disturbing evidence that children of mothers who have eaten Great Lakes fish may suffer developmental decrements.

Two additional concerns are loss of fish and wildlife habitat and introduction of exotic (non-native) species. Wetlands provide vital ecological functions, giving food and shelter to fish and wildlife, yet it has been estimated that since 1800 about two-thirds of Great Lakes wetlands have been lost. There are development pressures on the remainder. Another critical habitat is nearshore bottom sediment that in many locations has been poisoned by past or continuing loadings of toxicants. One recent exotic intruder to the Great Lakes, likely via the ballast water of a transoceanic vessel, is the zebra mussel. A prolific breeder, this mollusc may cause catastrophic ecological effects. It devours microscopic plants at the foundation of the food web and may create a food shortage, ultimately threatening top predators like walleye, salmon, and lake trout. In time, the zebra mussel is likely to spread across North America as it has across Europe; it has already been spotted in the Hudson River.

To go beyond past successes and solve current problems, we need to conceive of new ways to protect an ecosystem. States, EPA, and other Federal agencies are now joined in creating such a holistic approach to environmental protection for the Great Lakes. Our broad agenda is to prevent, abate, and remediate toxic pollution; and to inventory, protect, and restore damaged habitat and native species. To accomplish this agenda efficiently, we will set priorities based on comparative assessment of risks to the ecosystem. Pollution prevention will be a preferred means to reduce risks; we want to work with industries to cut their toxic emissions voluntarily, sharply, rapidly. At the same time, we will better integrate our enforcement of environmental laws to address the overall pollution problem at a facility. We will aggressively inform the public about environmental issues, out of the related convictions that it is their right to know and that an informed public is the ultimate guardian of the health of the Great Lakes. Local stakeholders are integral to successful solutions; we will invite both citizens and industries to participate in planning the restoration of Great Lakes toxic hotspots. We will select appropriate measures from our suite of air, water, and waste programs to fit the needs of these areas. We will judge

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our progress in tangible, ecological terms, as in the health of sensitive fish and wildlife species. In all this, we will take the utmost advantage of opportunities for cooperative actions with Canada.

The two nations will know that they have succeeded when their citizens can safely eat Great Lakes fish and wildlife in unlimited quantities and when a vulnerable species like the bald eagle, the proud national symbol of the United States, can thrive in its traditional domain along the shores of the Great Lakes.

In environmental affairs, as in our championing of democracy, human rights, and a market economy, the United States is an example for much of the world. The world is at an historic crossroads with respect to the environment, as environmental concerns sweep the globe. Many nations will look to the successes of our shared stewardship of the Great Lakes for encouragement in restoring their own natural resources. As I look ahead into the 1990s, I feel confident that the United States and Canada will continue to reverse many decades of environmental abuse to the Great Lakes. It is our responsibility, both to our own and to future generations.

William K. Reilly

Preface

This is the second report by the EPA on United States progress in implementing the Great Lakes Water Quality Agreement with Canada and, more broadly, on Great Lakes environmental trends and programs. This report addresses Fiscal Year (FY) 1989 and 1990 accomplishments and FY 1991 plans, estimated expenditures relating to these years, and long-term prospects for improving the condition of the Great Lakes system. Except where noted otherwise, it is written as of the start of Federal FY 1991 (October 1, 1990).

In order to provide a broad view of Federal programs pertaining to Great Lakes water quality, this report draws on information provided by five other Federal agencies: the U.S. Army Corps of Engineers, the Soil Conservation Service of the U.S. Department of Agriculture, the U.S. Coast Guard, the U.S. Fish and Wildlife Service, and the National Oceanic and Atmospheric Administration.

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Chapter 1

Introduction

To help place Great Lakes environmental issues in context, this chapter discusses some aspects of the physical features of the Great Lakes, of economic development within the region over the past three centuries, and of ecological outcomes associated with this development.

The Great Lakes

By many measures, the five Great Lakes are freshwater seas. Formed by the melting and retreat of mile-thick glaciers 10 to 12 thousand years ago, the Great Lakes water system represents about 18 percent of the world's surface freshwater and 95 percent of the surface freshwater of the United States. If poured over the continental United States, the 6 quadrillion gallons of the Great Lakes would immerse the "lower 48" States to a depth of almost 10 feet. The breadth of the lakes, between eastern and western extremes, is 800 miles. The Great Lakes and their connecting channels have 7,437 miles of shoreline within eight States and the Canadian Province of Ontario. Their surface area is 96,394 square miles, an area about that of the State of Oregon. Their 201,000 square mile watershed holds nearly 80,000 small lakes—one-third within the United States—that would collectively cover an area larger than Lake Erie.

By virtue of their size, the Great Lakes have pronounced effects upon the climate of their region. Heat stored in the surface waters of the lakes during the summer warms adjacent land in the fall and winter. As a result, areas of Michigan, southern Ontario, and western New York have warmer winters than some other parts of North America at similar latitudes.

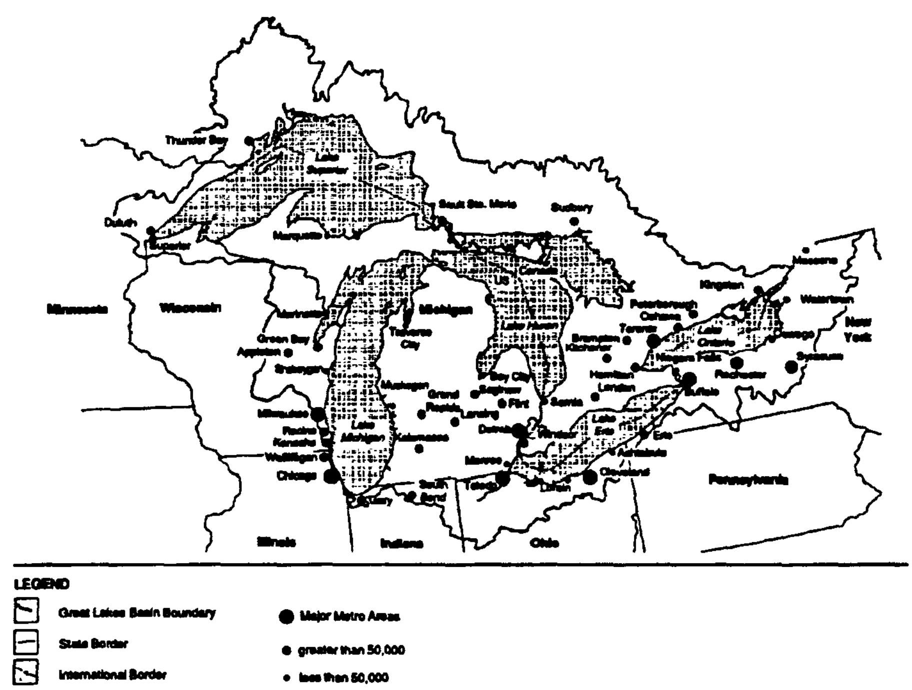
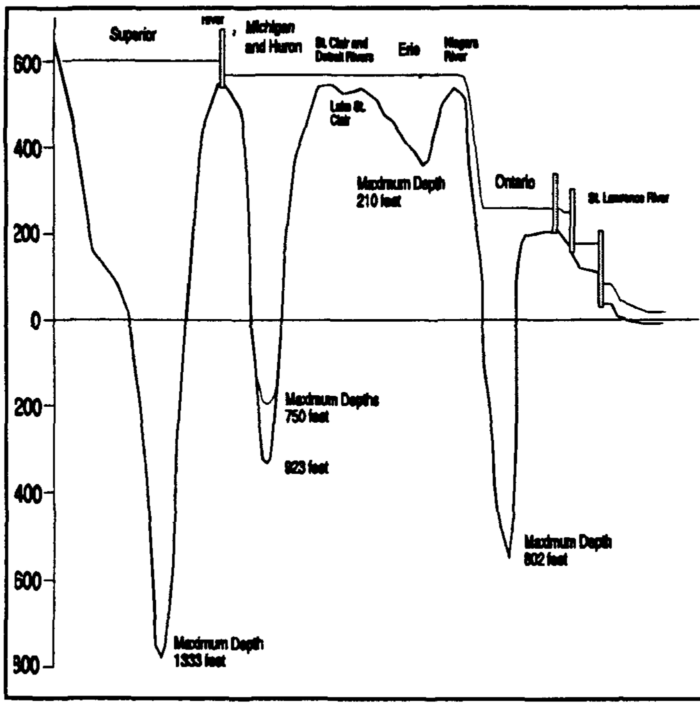


Figure 1-1. The Great Lakes Basin.

However, these same areas receive heavy snowfalls as prevailing winds from the west pick up moisture over the lakes. In the spring and summer, the lakes are slow to warm, cooling nearshore land.



Lake/ Feature	Superior	Michigan	Huron	Erie	Ontario
Average Depth (feet)	483	279	195	62	283
Volume (cubic miles)	2,900	1,180	850	116	393
Area:Water (sq. mi.)	31,700	22,300	23,000	9,910	7,340
Land Drainage Area (sq. mi.)	49,300	45,600	51,700	30,140	24,720
Total Area (sq. mi.)	81,000	67,900	74,700	40,050	32,080
Shoreline Length (miles)	2,726	1,638	3,827	871	712

Figure 1-2. Depth Profile of the Great Lakes and Summary of their Physical Features.

As would be expected across such a large geographical area, the physical characteristics of the Great Lakes watershed are varied. In the north, the land is heavily forested, particularly by conifers. The soil is generally thin and acidic, covering a hard, ancient bedrock called the Laurentian Shield. The climate is cold. Principal industries are timber, mining, and hydroelectric power. In the south, soils are deeper and fertile, rocks sedimentary and nutrient rich, temperatures warmer, the density of human population greater. Vast wetlands and deciduous forests have generally been replaced by agricultural, industrial, and residential uses.

By surface area, Lake Superior is the largest freshwater lake in the world. It is the second largest in terms of water volume, trailing only the immensely deep Lake Baikal in the Soviet Union. Superior holds just over one-half of the water in the Great Lakes system. It is the coldest and deepest of the lakes. About 90 percent of the Superior watershed is forested; only 3 percent is used for agriculture. Due to its huge volume, Lake Superior has the longest water retention time of any of the Great Lakes—191 years. Superior's outlet is the St. Marys River that flows southeasterly into Lake Huron.

Lake Michigan is the only Great Lake that lies wholly within the United States. It is the second largest in terms of water volume, holding about 21 percent of the water in the Great Lakes system. With the exception of Wisconsin's Fox River Valley, the northern part of Lake Michigan's watershed is sparsely populated. The southern end of the lake is ringed by lakefront cities, including Milwaukee, Chicago, and Gary. Lake Michigan's watershed holds the largest surrounding human population of all of the Great Lakes—about 14 million. Lake Michigan's water retention time is 99 years, the second longest of the lakes. Water from Lake Michigan primarily flows out through the Straits of Mackinac into Lake Huron. A much smaller outflow is artificially diverted into the Mississippi River system via the Chicago Sanitary and Ship Canal.

Like Lake Superior, Lake Michigan does not have a major inflow of water from another lake via a connecting river. Its watershed has many small tributaries. Over 100 rivers flow into Lake Michigan. Just nine of these have an average flow of over 1,000 cubic feet per second (cfs). The four largest—the Fox, St. Joseph, Grand (Michigan), and Menominee—have flows of around 4,000 cfs. To put these flows into some perspective, the natural flow over Niagara Falls averages about 200,000 cfs.

Lake Huron is the second largest of the Great Lakes in terms of surface area, slightly larger than Lake Michigan in this regard. Lake Huron receives both the outflow of Lake Superior and a net outflow from Lake Michigan through the Straits of Mackinac. Lake Huron holds about 16 percent of the water of the Great Lakes. About two-thirds of Huron's watershed is forested; another quarter is devoted to agriculture, particularly around Saginaw Bay. Lake Huron's water retention time is 22 years. The lake's outlet is the St. Clair River that flows into Lake St. Clair, a shallow lake (average depth 11 feet) northeast of Detroit.

Lake Erie is the smallest of the Great Lakes in water volume, with an average depth of just 62 feet. Lake Erie has three distinct basins that are defined by water depth and separated by underwater ridges. The western basin is shallow, with an average depth of 24 feet; its waters are well mixed. The central basin is deeper; its waters stratify by temperature, and its narrow bottom layer is vulnerable to oxygen depletion. The eastern basin is the deepest of the three. Its bottom layer is thicker than that of the central basin, making it much less vulnerable to oxygen depletion. Lake Erie has the shortest water retention time, just 2.6 years, making it the lake most responsive to both environmental abuse and cleanup.

Lake Erie is the southernmost of the Great Lakes. Its waters are the warmest in summer and the most productive in a biological sense, supporting healthy fisheries. Because of its shallowness, Erie is the lake most affected by air temperature. As a result, Lake Erie regularly has 95 percent ice cover in the winter in contrast to the deeper Lake Ontario that has an average cover of only 15 percent. Lake Erie's watershed is the most agricultural, the most urban, and the least forested of the lake basins; about two-thirds of it is used for farming. Erie has the highest rate of sedimentation of the five lakes, receiving soil particles from the rich farmlands of its watershed. Of the lakes, Erie also has the highest surrounding human population density. Erie's western basin receives water from the upper lakes via the Detroit River and from the Maumee River that joins the lake near Toledo. The Niagara River that flows north into Lake Ontario is Erie's primary outlet.

Lake Ontario is the smallest of the lakes in surface area, but contains more than three times the water volume of Lake Erie. About one-quarter of the Lake Ontario watershed is used for agriculture; dairy and cattle farms are the most prevalent types. The Canadian population within Lake Ontario's watershed is about twice that of the United States and it has significantly increased through the 1970s and 1980s, whereas the United States population has been stable. Canada's largest industrial region lies along the western and northwestern shores of Lake Ontario, including Toronto, a city of three million. In the southern portion of the Lake Ontario watershed, New York State cities include Buffalo, Niagara Falls, Rochester, and Syracuse.

The dominant source of water into Lake Ontario is the Niagara River flowing from Lake Erie. The Niagara provides about three-quarters of the estimated net inflow to the lake. Water from the Niagara River circulates rapidly; any contaminant borne by the Niagara is well distributed around the lake in one or two years. A much smaller inflow is artificially diverted into Lake Ontario via Canada's Welland Canal that provides a navigable connection to Erie. Stretches of the Niagara River are industrialized, principally on the U.S. side. Lake Ontario is about 325 feet lower in elevation than Lake Erie, causing the Niagara River to cascade spectacularly at the famous Niagara Falls. Lake Ontario's water retention time is six years. Its outlet is the St. Lawrence River that has an annual outflow to the Gulf of St. Lawrence that is less than one percent of the water volume of the Great Lakes.

This relatively small outflow is an important characteristic of the Great Lakes. The lakes are a nearly closed system. Persistent pollutants introduced into the lakes, especially into Superior and Michigan with their long water retention times, are primarily removed by evaporation, burial, or induction into the aquatic food chain. The system does not flush contaminants quickly. This attribute makes the Great Lakes ecosystem sensitive to environmental stresses.

Another important characteristic of the Great Lakes is their clarity. Before intense European settlement of the region began around 1800, the Great Lakes contained little phosphorus, were rich in oxygen, and, with the exception of western Lake Erie and shallow bays, were very clear (oligotrophic or poorly nourished). One reason for these phenomena was that the lakes' shorelines were for the most part rimmed by forests and wetlands, providing little nutrient runoff to stimulate the production of microscopic plants (i.e., phytoplankton, such as algae). While phytoplankton are a necessary, primary building block of the Great Lakes food web, over-enrichment and excessive algal growth cloud water and, by their decay, deplete oxygen. Today, most of Superior and Huron remain oligotrophic, as do parts of the northern basin of Lake Michigan.

The most biologically productive waters are those of shallow embayments, such as Green Bay, Saginaw Bay, and western Lake Erie that are fed, respectively, by the Fox, Saginaw, and Maumee Rivers and that have warmer waters than the open lakes. Green Bay was so named by early settlers because of the hue imparted by its phytoplankton.

Before 1800, there were also about 150 native fish species in the Great Lakes. Nearshore species included smallmouth and largemouth bass, muskellunge, northern pike, and channel catfish. Lake herring, blue pike, lake whitefish, grayling, walleye, sauger, freshwater drum, lake trout, white bass, and sturgeon inhabited deeper waters. Sturgeon lived to 150 years, reaching 9 feet in length and 400 pounds, whereas lake trout lived to 75 years.

The species mix varied between lakes. A large population of Atlantic salmon was confined to Lake Ontario. The deep eastern basin of Lake Erie supported lake trout, whereas the shallower and warmer western basin did not. Lake Erie sustained the most inshore species, whereas cold Superior was the least productive. Superior, however, provided the best habitat for the whitefish that were so plentiful a fisherman could dip a net and catch hundreds in a day. Atlantic salmon, whitefish, and lake trout were top predators among fish. These delicious-tasting species were a staple of the diet of local Native Americans.

The composition of fish populations in the Great Lakes is very different today. Fish are generally smaller than two centuries ago, and many non-native fish have been introduced, so that there are now about 190 species. Among the reasons for changes in fish populations are alterations to the aquatic food web; deliberate introduction of sport-fish, notably Pacific salmon; inadvertent introduction of non-native species, such as alewife, carp, smelt, and sea lamprey; habitat loss or disruption; over-fishing; and the effects of pollutants on fish reproduction.

Grayling are now extinct in the Great Lakes. By 1900, Atlantic salmon were gone from Lake Ontario. Blue pike disappeared from Lake Erie, and thus from the world, in the 1950s. Lake trout, sturgeon, and lake herring survive in decreased numbers. Even in relatively pristine Superior, hatchery-reared lake trout must be stocked to bolster the population. Populations of some native species, such as walleye and white bass, are more robust, and the whitefish populations in Superior and parts of Michigan and Huron are sufficient to support commercial fishing. Stocked, non-native Pacific salmon—coho and chinook—are the most abundant top predators in the open lakes, except in western Lake Erie, where the top predator is walleye.

The Great Lakes region also sustains a rich diversity of birds and other wildlife. Following the Atlantic and Mississippi flyways, an estimated three million waterfowl migrate through the Great Lakes each year, using the lakes for food and shelter. During their spring and fall migrations, up to 25,000 raptors (birds of prey) can be observed each day from Whitefish Point in eastern Lake Superior. The lakes are home to multitudes of terns, herons, gulls, egrets, and cormorants. Native animals include moose, deer, fox, wolves, and the fur-bearing mammals—mink, muskrats, and beaver—that fueled the early development of the region by European settlers.

Economy in Historical Perspective

During the past 300 years, various industries have boomed in the Great Lakes region. Fur trapping, especially of beavers, thrived from the last half of the 17th century until the early 19th century. As trapping depleted Great Lakes beaver populations, the fur trade expanded over much of the continent, to California, Oregon, and the Arctic Ocean. Even after trapping had moved far westward, the Great Lakes remained vital to the industry as a transportation system. The Great Lakes and St. Lawrence River provided a 2,200 mile waterway to the Atlantic coast whence furs were shipped to customers in Europe. Many early settlements on the Great Lakes were fur-trading posts, among them Detroit, Chicago, Green Bay, and Duluth.

About the time the beaver industry ended because of the scarcity of beavers and the whims of fashion, early settlers to the Great Lakes region began a massive harvest of trees. There were three principal types of forests surrounding the lakes. In the north, on the Laurentian Shield above Superior and reaching down to the eastern shore of Huron, were spruce and fir. The second forest of birch, hemlock, and pines ranged from south of Lake Superior, to northern Michigan, to the north shore of Lake Erie, and encircled Lake Ontario. South of this region were hardwoods: ash, oak, maple, and dogwood. The first deforestation was by local settlers clearing land for agriculture and building homes and barns. Commercial logging began in the 1830s, after the opening of the Erie Canal provided access to eastern markets. The logging began in Michigan and soon extended to Minnesota and Wisconsin. Loggers cut the softwoods first, chiefly white pine, often hundreds of years old and more than 100 feet high. Softwood timber framed homes and ships. Hardwoods made barrels and furniture.

The heyday of Great Lakes lumbering was 1850 to 1900. During the 1890s, there were 100 sawmills adjacent to the Saginaw River; by tonnage shipped, Saginaw was the largest port on the Great Lakes. Tugboats pulled enormous floating trains of trees from Canada to the Saginaw mills. Around Muskegon Lake, near Lake Michigan, there were 50 sawmills in 1900.

The Great Lakes lumber industry ran out of trees early in the 20th century. The soils of the North Woods and the Laurentian Shield are generally not conducive to farming. With the passage of time, forests have now returned to much of their former domain in the northern half of the Great Lakes region, though the trees are much younger and smaller than their predecessors. Today, these woods are harvested for paper. The paper-making industry, begun in the 1860s, remains important in both the United States and Canada. In 1982, the forest industry of Michigan, Minnesota, and Wisconsin employed about 50,000 people with sales of $15 billion. An additional 80,000 persons were employed in forest recreation.

The mining industry grew concurrently with the lumber industry and remains important. In 1845, rich iron ore was found in the Marquette Range of Michigan's upper peninsula. Further iron ranges were later discovered near Lake Superior—the Cuyuna, Mesabi, and Vermillion Ranges in Minnesota, the Menominee Range in Michigan's upper peninsula, and the Gogebic Range on the Wisconsin and Michigan border. In 1855, completion of the Sault Canal opened Superior to shipping and permitted mining of these ranges.

Iron ore from the mineral-rich Lake Superior watershed subsequently helped to make the Great Lakes a center of iron-making, steel-making, and heavy manufacturing. The Great Lakes provided an efficient waterway for ore to be shipped to lakeside cities, like Buffalo, Detroit, Cleveland, Gary, Sault-Sainte Marie, and Hamilton. Another key ingredient for steelmaking, limestone, was quarried near the northeast shore of Michigan's lower peninsula. Coal from Illinois, Ohio, and Pennsylvania fired industrial hearths.

Oil became another significant industry. The world's first oil well was tapped in the northwestern Pennsylvania town of Titusville in 1859. Oil was later found north-east of Lake St. Clair around Petrolia and London, Ontario. Cleveland, Ohio, already an industrial hub in part owing to being the terminus of a canal that linked the Great Lakes to the Ohio River, became the nation's oil refining center. In 1863, a 23-year old bookkeeper, John D. Rockefeller, invested $4000 in a Cleveland oil refinery. By 1880, his Standard Oil Company refined 95 percent of the nation's oil. Ten years later, Cleveland had a population of 260,000.

Owing to the easy confluence of iron ore, limestone, coal, oil, and water transportation, the Great Lakes region became an industrial heartland of both the United States and Canada. Detroit's population soared by almost 400 percent between 1890 to 1920 as Ford Motor Company began mass production of automobiles. The Ford, Chrysler, and General Motors corporations were producing eight million cars and trucks a year by 1950. Much of their U. S. production was near the Great Lakes in cities such as Kenosha and Milwaukee (Wisconsin); Chicago (Illinois); Indianapolis, South Bend, and

Fort Wayne (Indiana); Columbus, Dayton, Akron, and Cleveland (Ohio); Kalamazoo, Lansing, Flint, Pontiac, and Dearborn (Michigan); and Buffalo (New York). Their Canadian production was also adjacent to the Great Lakes in Oshawa, Kitchener, Oakville, and Windsor.

Industries associated with the automobile business, such as tool and die, machining, aluminum, and rubber, were drawn to the area. By the 1920s, Akron, where Benjamin Goodrich had opened a rubber factory in 1871, was processing almost half the world's rubber. Proximity to the steel industry helped to attract agricultural equipment and appliance manufacturers. Proximity to industrial and agricultural customers helped to attract chemical manufacturers.

During the 1970s and early 1980s, foreign competition and rising energy costs caused red-ink and job losses in Great Lakes heavy industry, especially in the United States. By that time, foreign economies devastated by the Second World War had developed into strong competitors to Detroit's automobile manufacturers. The demand for fuel efficient cars made lighter materials, like plastics and aluminum, desirable alternatives to steel. During the 1970s, Detroit lost 20 percent of its residents. About one million manufacturing jobs were eliminated in the early 1980s in just five Great Lakes States. Yet heavy industries, such as mining, steel, and auto-making, have adjusted, reducing production to meet demand and investing in new facilities. Today, manufacturing remains the largest single sector in the economy of most Great Lakes States, although the steel industry in particular will face increasing competition from higher strength, lighter weight composite materials.

Mining and manufacturing are likewise major elements in the economy of the Province of Ontario. The Sudbury area produces the largest quantity of nickel in the world. Ontario is a major producer of gold, silver, platinum, uranium, zinc, iron, copper, salt, and gypsum. The Province produces nearly 50 percent of Canada's manufactured goods. Manufacturing is the largest component of Ontario's economy.

Agriculture is another productive element of the Great Lakes economy. During the 19th century, cheap land with ample top soil, flat terrain amenable to mechanization, horse-drawn harvesting machines, and railroads that brought crops to distant markets combined to achieve extraordinary agricultural productivity in the American Midwest. After 1914, combustion engines supplanted horses in powering farm machinery. Since 1950, farm yields have soared further, owing to advances in biology, chemistry, and engineering. Breeding of plants has provided varieties with higher yields. Fertilizers, especially nitrogen, have raised soil productivity, and pesticides have abated crop losses to weeds, fungi, and insects. Farm machines have become vastly more effective.

As a result of these improvements, agricultural output within the U. S. Great Lakes watershed has increased over the last 40 years, though farm acreage has actually shrunk by one-third. Cropland accounts for 18 percent of the lands in the U. S. counties of the Great Lakes watershed, predominantly in the south. Major cropland areas include east-central Wisconsin, the Saginaw Bay watershed, and northwest Ohio. The largest crop is corn (42 percent of farm acreage), followed by soybeans (24 percent), and small grains, especially wheat (17 percent). Dairy products, fruits, vegetables, and tobacco are other important crops. Wisconsin ranks first among States in milk output; Michigan leads the nation in production of blueberries, tart cherries, and navy beans.

Convenient waterways have abetted the economic successes of the region. The Erie Canal was completed in 1825, connecting Buffalo to the Hudson River at Albany. (Rebuilt, it still operates today as the New York State Barge Canal.) About the same time, Canada constructed the Lachine Canal to bypass rapids on the St. Lawrence and the first Welland Canal between Ontario and Erie to bypass Niagara Falls. The 27-mile long Welland has been enlarged a number of times. Its locks are now 30 feet deep and 859 feet long.

These dimensions set size limits on transoceanic vessels that enter the Great Lakes. There are about 300 "lakers" that ply the Great Lakes. Long and narrow, they tend to be 650 to 730 feet long with a maximum width of 75 feet and a cargo capacity of 20,000 tons. The most recent lock at Sault-Sainte Marie, completed in 1969, permits larger ships on the upper lakes. About 25 vessels, up to 1,100 feet in length, with a capacity of 60,000 tons, traverse the lakes west of Buffalo.

The five parallel locks at Sault-Sainte Marie, connecting Superior and Huron, are among the busiest in the world. In 1990, 5,000 vessels carrying 90 million tons of cargo (including 50 million tons of iron ore) passed through these locks. Many of these vessels are headed to or from the port of Duluth/Superior, which ranked 14th in the United States by tonnage shipped in 1987. Among its products, Duluth ships low-sulfur coal from the American west. Thunder Bay, Ontario is the port of embarkation for about one-half of Canada's total grain production.

The St. Lawrence Seaway connects Lake Ontario to Montreal and provides the final link in a 2,200 mile commercial waterway between Duluth and Montreal. Completed in 1959, the Seaway is 27 feet deep, as are the shipping channels that cut through the St. Marys, St. Clair, and Detroit Rivers, and through shallow Lake St. Clair. This inland waterway is navigable by about three-quarters of the world's saltwater fleet. In 1986, 40 million tons of cargo passed through the St. Lawrence Seaway.

The waters of the Great Lakes confer other economic benefits, as well. They provide abundant drinking water to millions. Industries use water as an ingredient (as in the beer for which Milwaukee is famous) and as a coolant for manufacturing processes. Some rivers are harnessed to generate electricity; up to one-half of the natural flow of the Niagara River is diverted for electrical generation. Another connecting channel, the St. Marys River, is also harnessed for electricity.

Another large element of the Great Lakes economy is recreation, including sight-seeing, fishing, boating, camping, hiking, and lodging. In 1987, Michigan had more registered boat owners than any other State. The Great Lakes sustain both sport and commercial fisheries, although recreational fishing is the more important of the two today. As the value of recreational fishing has increased in comparison with commercial fisheries, some jurisdictions have established policies that favor sport fishing. The Great Lakes Fisheries Commission has estimated that five million sport fisherman on the Great Lakes spent $2 billion in 1985; during the same year, the value of the commercial fish catch was just $41 million. The years of the largest recorded commercial fish harvests were 1889 and 1899. By weight, the commercial yield in recent years has been about two-thirds of these peak years, yet the value is small, since the size and species harvested are less desirable. The economic potential of Great Lakes fisheries is much higher than their recent value.

At the onset of the 20th century, the human population of the Great Lakes watershed was just over ten million. According to 1986 census data, the region has 35 million residents—27.5 million U. S. citizens, 7.5 million Canadians. The Lake Superior and Lake Huron basins are sparsely inhabited. The south and southwestern shorelines of Lake Michigan, the Canadian shore of Lake Ontario, and the U.S. side of Lake Erie are far more heavily populated. Among the inhabitants of the Great Lakes region are Indian Tribes. Five Indian reservations within the United States touch upon the shores of the Great Lakes; fourteen do so on the Canadian side.

Some Ecological Impacts of Development

Intense development of the Great Lakes region has wrought vast changes to the ecosystem, many permanent. Humans have altered habitat, introduced exotic (non-native) species, and cast a wide range of contaminants into the lakes. Some effects have been dramatic. Through discharge of raw sewage into the lakes, cities infected their water supplies and citizens with typhoid and cholera during the 19th and early 20th centuries. By the mid-1950s, non-native sea lampreys (small, parasitic eel-like fish) decimated lake trout to the extent that commercial catches in Lakes Huron and Michigan fell to one percent of the yield twenty years before. By the 1960s, the over-enrichment of Lake Erie was infamous; mats of algae fouled beaches and water intakes. In 1967, millions of another exotic fish, alewife, a four to six-inch long member of the herring family, washed up on the Lake Michigan shore, victims of cold weather and starvation. Overpopulation related to the decline of alewife predators like lake trout helped cause the massive die-off. In 1969, a stretch of the Cuyahoga River in Cleveland was so laden with oil products, chemicals, and debris that it caught fire. During the 1970s, researchers began to note tragic birth defects, probably caused by persistent toxic chemicals, in birds like double-crested cormorants, born with grotesquely crossed beaks.

Yet the Great Lakes ecosystem has been pervasively changed in other, less dramatic fashions. The decline of beavers meant fewer beaver dams. These had impeded tributaries and helped to create wetlands. In their absence, river flows increased, faster rivers captured and carried more silt, burying the spawning grounds of fish.

The reaping of forests had profound ecological consequences. Forests were cleared, exposing soil to drying by direct sunlight and to erosion by wind and water, increasing the silting of rivers. Loggers floated trees down tributaries, gouging soil from river banks to cover gravel bottoms where fish spawned and fed. Debris from sawmills heaped upon spawning grounds and, through decay, depleted oxygen from the water. Forests had provided shade along tributaries. In their absence, the temperature of streams increased, further modifying the habitat of fish.

Agriculture also increased soil erosion. Erosion of soil from tilled fields is imperceptible, yet inexorable. It has been estimated that by 1910 between a quarter to a half of the deep original topsoil of the great Missouri and Mississippi river drainage basins had been washed away, largely because of profligate agricultural husbandry. Since 1950, eroding soil particles and rainfall runoff have carried agricultural chemicals—pesticides and fertilizers. The over-enrichment of Lake Erie in the 1960s was partly the result of increased nutrient use by farmers.

The growth of human population around the Great Lakes has imposed further ecological change. Roads and sidewalks, roofs and parking lots distort natural infiltration of rainwater into the ground. Rain that would otherwise seep into the soil is caught by drainage systems and discharged to streams. As a result, tributaries become much more variable in their flow and less hospitable to fish.

The Great Lakes have been vastly altered for shipping and flood control. River mouths, critical habitat for fish and wildlife, have especially attracted development. Hundreds of them have been dredged and surrounded by breakwaters. Dredging and the wash from ship propellers injure organisms in bottom sediments upon which fish feed. Canals and ships have introduced non-native species. Unchecked by natural predators, some of these have wreaked profound damage to native species. One canal has notably diverted pollution from the Great Lakes. The Chicago Sanitary and Ship Canal, completed in 1900, reversed the flow of the Chicago River, flushing Chicago's wastewater into the Illinois River and protecting Lake Michigan at a price of tapping its water volume.

Wetlands and sand dunes are other habitats that humans have profoundly modified. Wetlands have vital ecological functions—acting as buffers against floods and erosion, and serving as nursery, resting, and breeding habitat for fish and wildlife. It is thought that wetlands once constituted 60% of southwest Ontario and 30% of Michigan. Perhaps two thirds of Great Lakes region wetlands have been drained or filled since 1800, including the huge Black Swamp of northwest Ohio, almost entirely converted to rich farmland. Before parks were established to preserve the remainder, a vast array of sand dunes at the base of Lake Michigan, home to a rich diversity of wildlife, were mined for glass production and to fill railway beds. Cheap lakefront land and a large nearby labor force in Chicago also made the dunes attractive to heavy industry. Standard Oil Company (now Amoco) established a refinery in Whiting, Indiana in 1889; Inland Steel Company opened in East Chicago in 1901; and Gary took its name from the chairman of United States Steel when

America's first billion dollar corporation opened a huge works there in 1906. Bethlehem, National, and LTV steel companies followed. Today, northwestern Indiana is an American Ruhr valley of metal, oil, and petrochemical facilities. In places, large amounts of oil float on the groundwater table; during rainfall, the rising table lifts oil into municipal drainage systems. Through this region meanders the Grand Calumet River that takes most of its waters from industrial and municipal dischargers. Its river bed holds contaminants of extraordinary toxicity.

Manufacturing firms have loaded a broad range of contaminants to the lakes. One of the most potent is the family of organic chemical compounds called polychlorinated biphenyls (PCBs). PCBs were widely used from 1929 until banned by EPA in 1977. They are highly stable, which made them useful as hydraulic fluids and lubricants in high temperature or pressure processes. They were also used in paint, ink, plastics, caulking compounds, and metals. Accidental ingestion of PCBs in Japan in 1968 established that they are highly toxic to humans. Subsequent tests have shown that PCBs may cause reproductive disorders, birth defects, and cancers in laboratory animals. The stability that made PCBs desirable in commercial applications has undesirable environmental consequences; they magnify up the Great Lakes food web and do not degrade. PCB contamination is the most frequent grounds for health advisories regarding consumption of Great Lakes fish. The site of the greatest PCB contamination on the lakes is Waukegan Harbor, Illinois, from where it is estimated that hundreds of thousands of pounds of PCBs have entered Lake Michigan. Other areas notably suffering PCB-contamination include Ashtabula River, Ohio; Fox River/Green Bay, Wisconsin; Grand Calumet River/Indiana Harbor, Indiana; Kalamazoo River, Michigan; Manistique River, Michigan and Wisconsin; Saginaw River, Michigan; St. Lawrence River around Massena, New York; and Sheboygan River, Wisconsin.

Though the practice ceased in the U.S. during the 1970s, some pulp and paper mills released mercury, a persistent toxic substance that has magnified in concentration within the Great Lakes food web. In the 1980s, the EPA recognized that pulp and paper mills, particularly those using the bleached kraft process, discharge very low concentrations of chlorinated dibenzodioxins and dibenzofurans. These are byproducts of bleaching pulp and paper with chlorine. Dioxins and furans represent a family of 210 structurally related chemical compounds. The most infamous of the dioxin compounds—2,3,7,8-TCDD—produces a variety of toxic effects in laboratory animals at very low doses. The pulp and paper industry also continues to be a significant source of conventional pollutants to the Great Lakes, particularly to Lake Superior. According to a 1989 report by the International Joint Commission, pulp and paper mills in the Province of Ontario generally do not use secondary (biological) processes to treat their wastewater. Secondary treatments, usually practiced by U. S. mills, decrease conventional pollutants and can reduce 25 to 60 percent of the toxic organic byproducts of papermaking.

Metals-based industries, including mining and steel-making, have been a significant source of pollutants to the Great Lakes. Torch Lake, a tributary to Lake Superior near the base of the Keweenaw Peninsula, received copper tailings for more than 100 years, before mining ceased in 1969. Two hundred million tons of tailings fill more than 20 percent of the lake's original volume. Steel-making generates such byproducts as ammonia, cyanide, coal tar, zinc, lead, and a range of air pollutants, including fly ash, sulfur compounds, and the gases benzene, toluene, and xylene. Steel mills are one of many sources of benzo(a)pyrene, the most toxic member of the family of polyaromatic hydrocarbons (PAHs). Like other PAHs, benzo(a)pyrene is a product of incomplete combustion of fossil fuels, and is suspected of causing dermal tumors in bottom-dwelling fish. PAHs are common in nearshore bottom sediments.

Chapter 2

Great Lakes Environmental Problems

Introduction

This chapter discusses four broad problems facing the Great Lakes ecosystem: unacceptable levels of persistent toxic substances in fish and fish-eating birds; impaired and lost habitat, including bottom sediments and wetlands; damage to native fish populations from exotic (non-native) species; and excess nutrients.

Persistent Toxic Substances

Except in a few nearshore areas, and then usually on an intermittent basis, persistent toxic substances do not pose a drinking water problem for humans. Concentrations of contaminants in the water column are extremely low, in part due to their dilution in the vastness of the lakes. Also, many troublesome pollutants do not remain permanently in the water column, but are adsorbed into the food web or bottom sediments. Open lake concentrations of contaminants are measured in parts per million or even parts per trillion. A part per trillion is represented by a teaspoon in 1.3 billion gallons of water. A human would have to drink two or three million gallons of water to be exposed to a quantity of contaminants equivalent to that ingested by eating a single, good-sized lake trout (1).

Low levels of contaminants in water concentrate in the tissues of predators through the phenomena of bioaccumulation and biomagnification through the food web. The base or start of the food web involves the utilization of sunlight and mineral nutrients by microscopic plants—called phytoplankton—for nourishment. Microscopic animals, known as zooplankton, feed on such vegetation and are in turn eaten by fish. Another source of food for some small fish are tiny sediment-dwelling insects and crustaceans. Higher predators, fish and birds, consume smaller fish. A simplified view of the Great Lakes food web is shown by Figure 2-1. One simplification in this view is that it does not show the many different species of phytoplankton, zooplankton, and benthic animals.

Phytoplankton and zooplankton, continually bathed in contaminants, and benthic organisms living in contaminated sediments, adsorb and bioaccumulate small quantities of persistent toxic substances. As higher organisms in the food web graze on large quantities of plants and other organisms, they accumulate higher quantities of contaminants. The increasing concentration of contaminants in higher levels of the food web is known as biomagnification.

Fish and birds living in or around Lake Michigan and Lake Ontario tend to have the highest contaminant levels in the Great Lakes area, markedly above those of the other three lakes. The relatively low levels in Lake Erie biota are a bit surprising, since that lake has a high surrounding population and is known to receive high loadings of toxic substances from the Detroit River. Scientists offer two possible explanations; Erie's relatively high sedimentation may adsorb and remove toxic substances from the water column, making them less available to the food web, and/or; Erie's

The Problems

- Unacceptable levels of persistent toxic substances in Great Lakes fish and wildlife
- Degraded and lost habitat, including poisoned bottom sediments and lost and threatened wetlands
- Damage to native fish populations from exotic species
- Excess nutrients

Contamination of Fish and Wildlife

The Great Lakes food web is contaminated by persistent toxic substances, leading to unacceptably high levels of these in the tissues of certain fish and wildlife. Levels of some contaminants in organisms are much lower than in the early 1970s due to use restrictions and major investments in pollution treatment and abatement, but continue to justify the issuance of public health advisories regarding fish consumption. Consumption of some fish present risks to human health, though the degree of risk is contingent on the species and location of fish, the amount consumed, the method of cleaning and cooking, and the gender and age of the consumer, among other factors. Fish contamination detracts from the potential value of sport and commercial fisheries. Contaminants have been associated with reproductive and other health problems in Great Lakes fish and wildlife, though with the sharp decline of targeted pollutants many species seem to be recovering. Problems persist for fish and wildlife in certain locations, particularly in harbors and rivers with highly contaminated sediments and for predators high in the food web like lake trout, mink, herring gulls, and bald eagles.

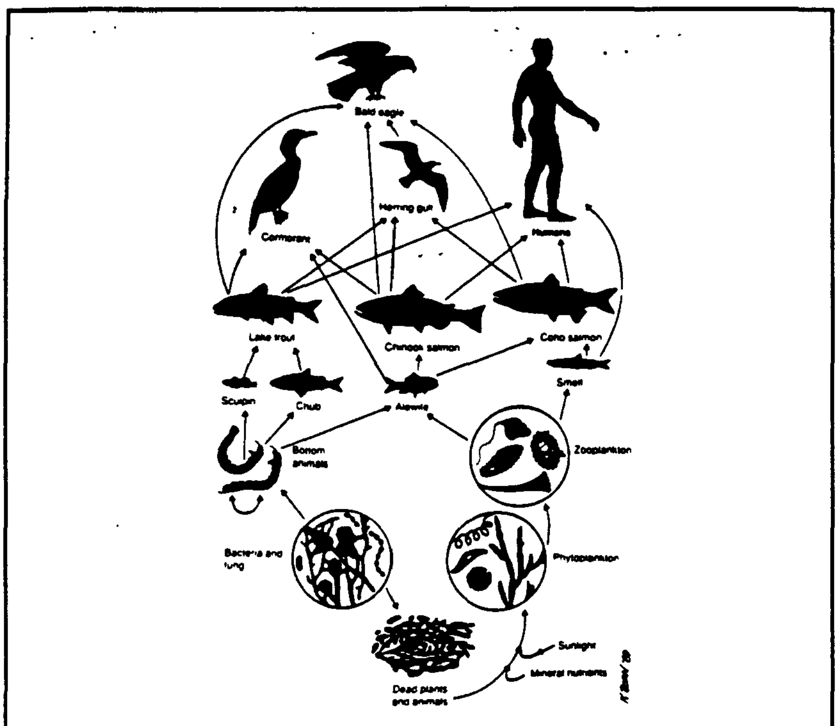


Figure 2-1. The Food Web.
Source: Colborn et al., 1990.

abundance of phytoplankton may result in a lower contaminant concentration at the bottom of the food web than in Lakes Michigan and Ontario, resulting in lower concentrations higher up the web.

There have been striking declines in levels of some targeted substances over the last two decades. Figures 2-2 and 2-3 show declines in two substances, PCBs and the pesticide DDT, in Lake Michigan herring gulls and bloater chubs.

Despite these marked declines, levels of contaminants remain high. The U.S. Fish and Wildlife Service monitors contaminants in freshwater fish across the United States. As shown in Figure 2-4, the Service reports contaminant levels in Great Lakes fish as among the highest in the nation. State public health authorities issue fish consumption advisories for some species in each lake and in various rivers and bays. These tend to be based on risks from PCBs, mercury, and the pesticide chlordane. A summary of advisories issued for 1990 is presented in Table 2-1.

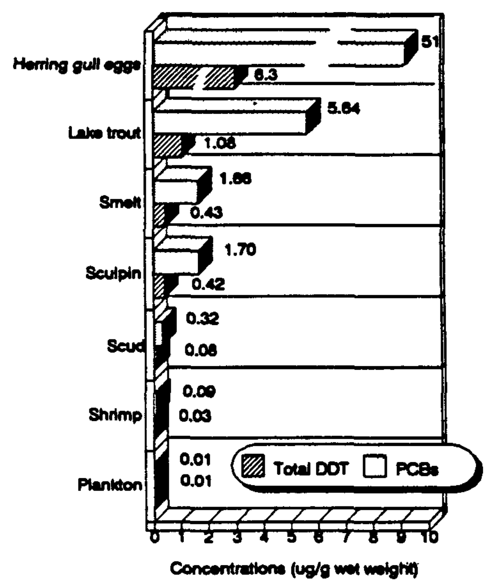
EPA has no formal role in setting sport fish consumption advisories. However, the Agency shares responsibilities with States, under the Clean Water Act, to protect the quality of surface waters through establishment of State Water Quality Standards and the regulation of water dischargers under the National Pollutant Discharge Elimination System (NPDES). State standards are sometimes governed by the risks posed by human consumption of fish that bear bioaccumulative pollutants. In September 1989, EPA's Office of Water Regulations and Standards released a guidance manual on "Assessing Human Health Risks from Chemically Contaminated Fish and Shellfish." This document provides the Agency's recommended procedures for assessing risks related to the consumption of fish.

Effects on Wildlife

Over the last few decades, researchers have observed population declines and health problems among many Great Lakes fish and wildlife species that have seemed to be associated with exposure to various persistent toxic substances. Effects have usually been most pronounced at the top of the food web and across generations, as expressed in birth defects. With the reduction of many targeted pollutants in the food web, the populations of species generally seem to be improving. The bald eagle, a top predator, began to decline in population across the nation during the 1940s. Since EPA banned and restricted the persistent pesticides DDT and dieldrin in the 1970s, improved bald eagle reproductive success has led to a recovery in the national population. However, bald eagles have not recovered so vigorously along the shores of the Great Lakes (9). Researchers have noted that eagles do not reproduce as successful-

Lake Ontario Food Web Biomagnification

Persistent toxic substances concentrate up the food web. Top predators, like herring gulls and lake trout, can accumulate PCB levels that are, respectively, 51,000 and 5,600 times greater than those found in plankton. Within Lake Ontario, the average concentration of total PCBs is almost three million times greater than the average open-lake water concentration.



Source: Environment Canada, 1990 (2).

ly along the lakes as they do further inland. Great Lakes fish appear to provide too toxic a diet for bald eagles to raise viable young.

During the 1970s, herring gulls around the Great Lakes were also found to have reproductive problems (13). Changes in behavior were a contributing factor—herring gulls neglected their nests, leading to low hatching success. Populations have increased coincident with the decline of food web contamination with PCBs and pesticides.

Also during the 1970s, scientists observed deformities in various bird species, such as double crested cormorants, common terns, caspian terns, ring-billed terns, and herring gulls (14). Birds were found with crossed bills, jaw defects, malformed feet and joints. Although the incidence of these deformities have declined in conjunction with contaminant levels, such problems remain in relatively contaminated areas. Mink have proved extremely sensitive to a diet of Great Lakes fish. In the mid 1960s, mink breeders found that their animals were experiencing high mortality rates and almost complete reproductive failure. The ranch animals were being fed coho salmon from Lake Michigan tributaries. Laboratory toxicology experiments found that mink are highly susceptible to such contaminants as PCBs and dioxins. As with bald eagles, it is thought that wild mink populations are higher inland than along the shores of the Great Lakes.

Great Lakes contaminants may also have contributed to a sharp decline in the population of beluga whales in the St. Lawrence estuary. The whales are burdened by many contaminants, including mirex, a persistent toxic substance known to be present in Lake Ontario. Though beluga do not enter the Great Lakes, they eat Atlantic eels that migrate from Lake Ontario and that are suspected to contain mirex.

Another suspected impact of persistent toxic substances on fish has been noted in bottom-dwelling or -feeding fish such as bullheads and suckers. These fish have been found to suffer a high incidence of dermal and liver tumors at a number of Great Lakes locations (16). The causes of these tumors are difficult to determine be-

Why monitor gull eggs?

Fish-eating birds like the herring gull are near the top of the food web. Only top predators such as the bald eagle, which eats gulls and other foods, builds up higher concentrations of contaminants. Fish are about 3/4 of the diet of herring gulls but they also ingest mammals, insects, birds and bird eggs, amphibians, earthworms and crayfish as well as garbage. Herring gulls remain on the Great Lakes year around rather than migrating far away. Thus, they are good indicators of localized levels of contamination. Herring gulls nest in established colonies, making it easy to collect egg samples regularly from the same colony. By collecting eggs, the birds do not have to be killed to be sampled. The gulls usually lay more eggs to replace ones lost early in the nesting season, so this kind of sampling doesn't threaten their populations (Environment Canada, 1990).

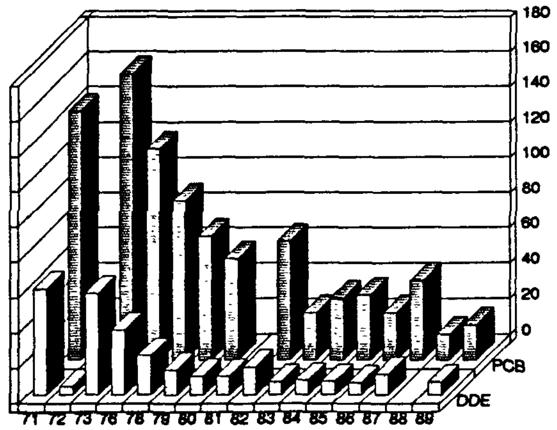


Figure 2-2. Contaminants in Herring Gull Eggs on Sister Island (Green Bay) Wisconsin. (Concentrations are in ppb.)
Source: Environment Canada, 1990 (5)

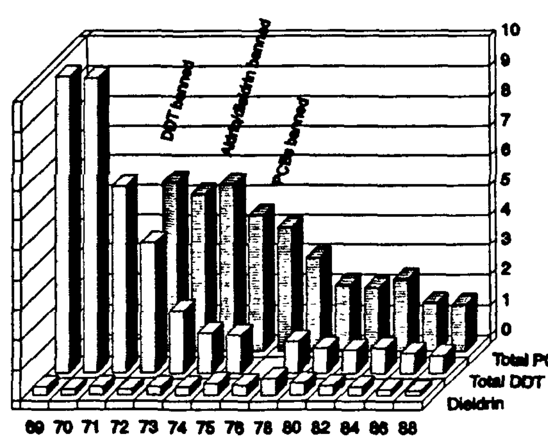


Figure 2-3. Annual Trends in Pesticides and PCBs in Lake Michigan Bloater Chubs. (Analyses of whole fish – concentrations are in μg/g wet weight)
Source: U.S. Fish and Wildlife Service, National Fisheries Research Center-Great Lakes (6).

Human Health Effects

A person who eats Great Lakes fish ingests potentially carcinogenic substances. As to whether eating these fish is "safe" is a matter of personal judgment for an informed individual.

Fish of different species, locations, and size carry different burdens of potential carcinogens; those that bear the largest burdens tend to be large, bottom-dwelling, high in the food web, and high in fat content. Modern risk assessment methods generally assume the probability of cancer is proportional to dose, so that there is zero probability at zero dosage. Because risk is based on cumulative exposure, high consumption of "low risk" fish can actually pose greater risk than less consumption of "high risk" fish.

There is value in informing the public about which fish species tend to carry the highest burdens of contaminants. This is the approach usually followed by State health authorities in issuing fish advisories. Another valuable way to communicate risk is to compare the risks of sport fish consumption to other risks. One study, using fish from 1981, concluded that breathing urban air and drinking polluted urban groundwater pose cancer risks as high as those for consuming Lake Michigan sport fish (3). Another study has contrasted consumption of four species of Lake Michigan fish, based on samples collected in 1984 and analyzed for four potential carcinogens, with cancer risks from ingestion of some other foods and exposure to natural radiation and urban air pollution, and with the chance of death by various accidents and occupations (4). These comparisons are provided at Table 2-2.

Some clarifications should be made about estimates of risk. First, risk assessments have substantial uncertainty in that they are usually based on estimates of carcinogenic potency obtained by tests on animals; actual human effects are likely to be different. Second, assessments produce a range of risk; the practice of health authorities is to use the high end of the range. Third, some methods of cleaning and cooking fish can lower the dose of potential carcinogens. Fourth, not all potential carcinogens may have been detected, which would cause an assessment to underestimate actual risk. And fifth, risk assessments tend to be based on estimates of cancer incidence and do not consider other harmful health effects.

This last point is important, since some research over the last decade indicates non-cancer, transgenerational effects associated with contaminants found in Great Lakes fish tissues. A series of studies of human health effects from eating Lake Michigan fish containing PCBs began in 1980 (7). The studies have focused on children whose mothers had regularly eaten Lake Michigan fish, examining them at birth, seven months, and four years of age. The studies concluded that infants whose mothers consumed Lake Michigan fish showed lower birth weights, smaller head circumference, and slower responsiveness than infants whose mothers had not consumed such fish. Young children whose mothers ate Lake Michigan fish had poorer short-term memory. The deficits noted were small in magnitude, and were not evident outside the testing situation. There was no indication that the long-term memory of young children was affected. Since short-term memory is important in the acquisition of reading and arithmetic skills, however, the deficits may augur later impacts on academic performance. One implication of these studies is that a woman's lifetime exposure to PCBs may adversely affect her children. Eliminating exposure during pregnancy or lactation may not prevent adverse affects.

Because of the Lake Michigan study and other research, public health authorities consider children and women who anticipate bearing children to be the most vulnerable consumers of Great Lakes fish. Fish advisories recommend that these populations avoid eating the fish species cited in Table 2-1.

cause of the broad suite of substances to which these fish are exposed. However, the incidence of tumors is strongly correlated with polluted conditions, especially with the presence of polyaromatic hydrocarbons (PAH) contamination in bottom sediments (17). Several PAH compounds are known or suspected carcinogens. Although little is known about the significance of tumors on either the health of fish or on the health of humans who might eat these fish, visible abnormalities reduce the commercial and recreational value of fish.

While scientists have noted associations between contaminants and impaired fish and wildlife health, they have thus far only established one cause-and-effect relationship. This is between DDE (a decay product of DDT) and eggshell thinning in some bird species. DDE accumulated in female birds is responsible for inhibiting enzymes that are responsible for incorporating calcium carbonate into eggshells. DDE has made shells of double-crested cormorants and black-crowned night heron too fragile for incubation.

Substances

EPA has established water quality criteria for about 130 substances that are known or suspected to be harmful to humans, fish, or wildlife. Criteria numerically define maximum allowable concentrations of a contaminant in water and serve as a basis for the development of enforceable State Water Quality Standards.

EPA and States have identified a set of pollutants deemed especially injurious to the Great Lakes ecosystem and present at unacceptable levels. A summary of priority pollutants, reviewing their effects, sources, and methods of prevention, is provided in Table 2-3. All are thought to biomagnify up the food web. Several are the most toxic members of groups of related chemicals.

Table 2-1. Great Lakes Fish Consumption Advisories.

Location (States)	Pollutant of Concern (State)	Restrictions Recommended*	DO NOT EAT
Lake Superior Michigan Minnesota Wisconsin	PCBs (MI)	Lake Trout 20"-30"	Lake Trout over 30"
Lake Michigan Illinois Indiana Michigan Wisconsin	PCBs (MI, IL, WI) chlordane (IL)	Lake Trout 20"-23" Coho Salmon over 26" Chinook Salmon 21"-32" Brown Trout over 23"	Lake Trout over 23 " Chinook Salmon over 32" Brown Trout over 22" Carp (any size) Catfish (any size)
Lake Huron Michigan	PCBs (MI)	Brown Trout up to 21" Lake Trout Rainbow Trout	Brown Trout over 21"
Lake Erie Michigan New York Ohio Pennsylvania	PCBs (MI,NY,OH, and PA) chlordane (PA)		Carp (any size) Catfish (any size)
Lake Ontario New York	PCBs, mirex, and dioxins (NY)	Carp, White Perch, smaller Coho Salmon, Rainbow Trout, and Brown Trout	American eel, Catfish, Lake Trout, Chinook Salmon, Coho Salmon over 21", Rainbow Trout over 25", Brown Trout over 20"
Lake St. Clair Michigan	PCBs, and mercury (MI)	Walleye over 18", White Bass over 13", Smallmouth Bass over 18", White Perch over 16", Carp over 22", Rock Bass over 8", Largemouth Bass over 14", Bluegill over 8", Freshwater Drum over 14", Carpsucker over 18", Brown Bullhead over 14", Norther Pike over 22"	Muskie (any size) Sturgeon (any size) Catfish (any size)
Saginaw Bay Michigan	PCBs (MI)	Rainbow Trout Brown Trout	Carp (any size) Catfish (any size)
Detroit River Michigan	PCBs and dioxin (MI)	Freshwater Drum over 14"	Carp (any size)
St. Mary's River Michigan	mercury (MI)	Walleye over 19"	
Green Bay Michigan Wisconsin	PCBs (MI)	Splake up to 16 "	Rainbow Trout over 22", Chinook over 25", Brown Trout over 12", Splake over 16", Northern Pike over 28", Walleye over 20", White Bass, Carp
Niagara River New York			It is recommended that no fish taken between Hyde Park Lake Dam and the river mouth be consumed

* Nursing mother, pregnant women, women who anticipate bearing children, female children of any age, and male children age 15 or under should not eat these fish. All other persons should limit their consumption to one meal per week and follow preparation and cooking recommendations.

Preparation and cooking recommendations: Sport fish can be prepared and cooked in ways which will reduce contaminants in the edible portion. These techniques include removal of the skin and fatty tissue associated with the belly lateral line and dorsal area of large fish and cooking baking, broiling on a rack, or barbecuing so that fatty oil can drip away from the finished meal.

Sources

Persistent toxic substances reach the Great Lakes from a broad range of human activities. Some sources are readily visible such as discharges from sewage systems and industry, and spills from ships and shore. Other sources are much less obvious: transport and deposition of contaminants through the atmosphere, movement of contaminants through groundwater, and urban and agricultural runoff. Even substances that are

Table 2-2. Health Risks of Fish Consumption vs. Other Risks
Source: Clark, et al., 1987 (11).

Avoidable Risks	**Cancer Risk**
1/4 lb. mixed Lake Michigan Fish, per year	1.1×10^{-4} (11 in 100,000)
1/4 lb. mixed Lake Michigan fish, per week	5.8×10^{-3} (58 in 10,000)
2 oz. peanut butter, per week	8.0×10^{-5} (80 in 1,000,000)
1/4 lb. charcoal broiled steak, per week	1.1×10^{-5} (11 in 1,000,000)
1/2 gal. whole milk, per week	1.0×10^{-4} (10 in 100,000)
Unavoidable Risks	**Cancer Risk**
Natural background radiation	1.4×10^{-3} (14 in 10,000)
Air pollution (PAHs, average U.S. cities)	1.0×10^{-3} (10 in 10,000)
Lifetime Chance of death from various causes	**Mortality Risk**
Motor Vehicle Accidents	1.7×10^{-2} (17 in 1,000)
All Home Accidents	8.8×10^{-3} (88 in 10,000)
Falls	4.3×10^{-3} (43 in 10,000)
Fire	2.0×10^{-3} (20 in 10,000)
Electrocution	3.7×10^{-4} (37 in 100,000)

The increased lifetime cancer risk to a person who consumes just four ounces of Great Lakes sport fish per year over their lifetime is about the same increase as eating four ounces of charcoal broiled steak every week. This means that the increased cancer risk from consuming Great Lakes fish is 100 to 500 times that of consuming the same quantity of charcoal broiled steak.

Great Lakes Fish Contamination in National Perspective

In its National Contaminant Biomonitoring Program, the U.S. Fish and Wildlife Service regularly samples native freshwater fish at 112 sites in the U.S., including Alaska and Hawaii. Twelve of the sites are in the Great Lakes. The graph below, using the latest available data (1984), shows that Great Lakes fish are often among the most contaminated in the nation for various parameters. As the graph indicates, for instance, one half of the sites where fish are most contaminated for PCBs lie within the Great Lakes.

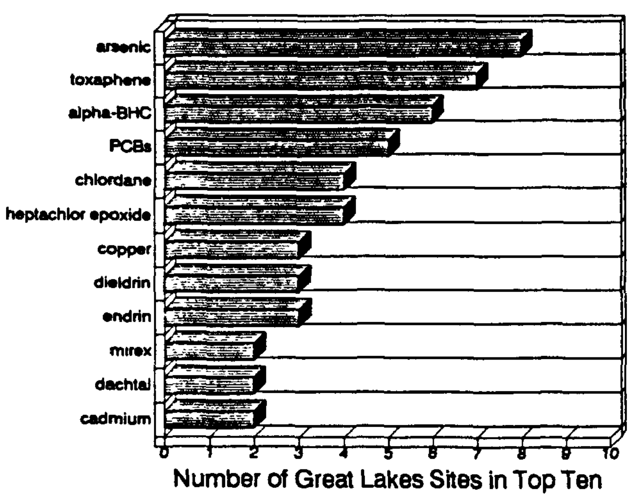


Figure 2-4. Great Lakes Sites with High Contaminant Levels
Source: Schmitt et al., 1990, Schmitt and Brumbaugh, 1990 (12).

no longer produced continue to reach the Great Lakes, albeit in smaller quantities, by incineration, runoff, or volatilization of terrestrial contamination.

Many older urban areas have combined sewer and stormwater systems that deliver rain runoff as well as industrial and household effluents to municipal wastewater treatment facilities. During rainstorms, water flow often exceeds the capacity of the drainage system, leading to releases of untreated wastewater to the Great Lakes system. Figure 2-5 shows the locations of 75 Canadian and U.S. overflow points that discharge directly to the Detroit River. Another 170 outfalls annually release an estimated 7.8 billion gallons of untreated water to the Rouge River, which in turn empties into the Detroit River. Overflows from Detroit and Windsor sewer systems represent a major continuing source of pollution to the Great Lakes.

Accidental spills can be a significant, temporary source of toxic substances. The U.S. Coast Guard recorded 5,003 spills of oil or toxic substances into the U.S. waters of the Great Lakes over a near ten year period (January 1980 through September 1989). About 80 percent of these

Table 2-3. Characteristics of Key Great Lakes Pollutants.

Pollutant	Effects	Sources	Prevention
Nutrients			
Phosphorous	eutrophication, oxygen depletion, algal blooms	Agricultural application, Combined Sewer Overflows, Publicly-owned treatment works	Reduction in Fertilizer Application Rates,Materials Substitution in detergents where bans have not yet already been implemented
Toxic Pollutants			
Polychlorinated Biphenyls (PCBs)	bioaccumulative in fish, wildlife and humans. Suspected carcinogens.	Historical use /accumulations in soil and sediment, Accidental releases from transformers and capacitors, Volatilization from landfills	Banned except by special permit since 1979 Research and development needed to identify substitutes
DDT and metabolites	Bioaccumulative in fish, wildlife, and humans. Reproductive impairments in wildlife. Suspected human carcinogen.	Historical use/accumulations in soil and sediment,Continued use in upwind areas	Current use is banned in the U.S., Product substitution in areas outside U.S. where DDT is still used
Dieldrin	Same as DDT	Historical use/accumulations in soil and sediment	Current use is restricted
Toxaphene	Bioaccumulative	Historical use/accumulations in soil and sediment	Current use is restricted
2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD)	Bioaccumulative in fish, wildlife, and humans. Suspected human carcinogen	Landfill leachate, Manufacturing byproduct of chlorophenols,Bleached kraft paper mill process, By-product of daethal production, Municipal waste incinerators, Historical use/accumulations in soil and sediment	Process changes to eliminate dioxin production (e.g., substitute H_2O_2 for Cl_2, control O_2 to Cl_2 ratios in bleaching to reduce PCDDs and PCDFs)
2,3,7,8-tetrachlorodibenzofuran (2,3,7,8-TCDF)		By-product of PCB formation, Municipal waste incinerators, Emissions from certain manufacturing processes (e.g., pulp and paper	Research and development needed to identify substitutes
Mirex	Bioaccumulative in fish, wildlife, and humans. Suspected human carcinogen.	Historical manufacture and use/accumulations in soil and sediment	Current use is restricted
Mercury	Bioaccumulative in fish and wildlife. Can cause and brain damage and birth defects.	Historical use of chlor-alkali, Accumulations in sediment near old industrial discharges, Coal combustion emissions	Process modification to use non-mercury catalysts and raw materials
Alkylated lead	Bioaccumulative in fish, wildlife, and humans. can cause anemia, fatigue, and irreversible brain damage in humans; especially in children.	Leaded gasoline	Product substitution (unleaded gasoline)
Benzo(a)pyrene (BAP)	bioaccumulative	Many types of combustion sources, Coke/iron/steel production	Improved BAP recovery during coking operations
Hexachlorobenzene	Bioaccumulative in fish, wildlife, and humans. May produce skin rash, nausea, and headache. Suspected carcinogen.	Historical use/accumulations in sediment, By-product of chlor-alkali and chlorinated aliphatics manufacture,By-product of pesticides in current use (e.g., pentachloronitrobenzene)	Product substitution

spills came from land facilities such as oil storage tanks and pipelines; the balance came from ships. Most were oil spills, and small in volume. However, there have been oil spills up to a million gallons and toxic substance spills up to two hundred thousand gallons.

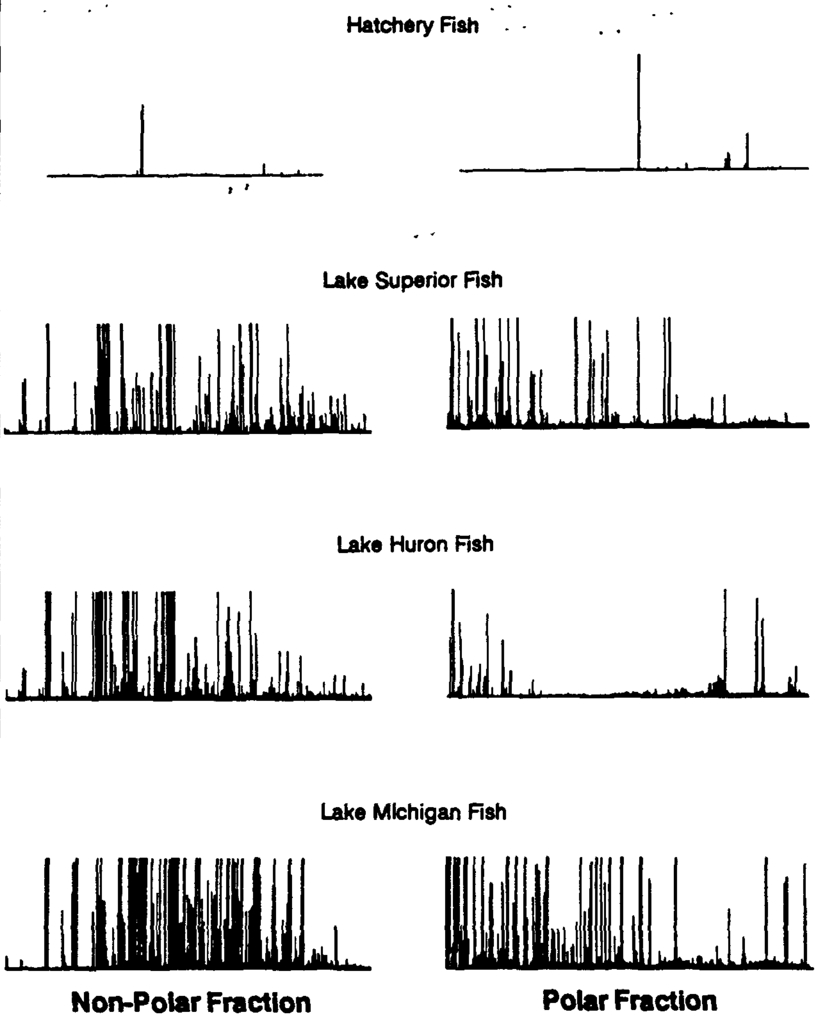
Transport of contaminants by groundwater is known to be a problem in some places, notably along the Niagara River, owing to the coincidence of certain geological features and leaking adjacent landfills. Rain runoff from farms and urban areas brings with it pesticides and surface contamination.

Since the late 1970s, scientists have been aware of the potential of the atmosphere as a pollution pathway. Studies on Isle Royale, a relatively isolated island in Lake Superior, revealed levels of PCBs, DDT, and toxaphene in the waters of its lakes. Researchers theorized that such pollution could only have been the result of deposition from the air. Since toxaphene was principally used to control insects on cotton crops in the south, and not generally used near the Great Lakes, there was an implication that some of the contaminants had been transported a great distance through the atmosphere. Other recent research has concluded that air transport and deposition is the primary pathway for mercury, given off by coal-burning power plants and garbage incinerators, to reach remote lakes in northern Minnesota.

Degraded Habitat

Wetlands

Wetlands are a vital component of the Great Lakes ecosystem. Wetlands constitute the link between the aquatic and terrestrial ecosystems. As a result, they are biologically rich, serving as habitat for a diversity of aquatic and terrestrial species, as well as some species that are unique to wetlands. Coastal wetlands serve important functions including filtering wastes;



GC/MS Scans of Hatchery vs. Great Lakes Lake Trout

Great Lakes fish and wildlife are exposed to a wide variety of substances. This is clearly illustrated in this figure which contrasts GC/MS (gas chromatography/mass spectroscopy) readings of chemical compounds detected in the tissues of hatchery fish with fish from several of the lakes. Fish raised in the protected environment of a hatchery registered only eight compounds in their tissues. A total of 476 different compounds were found in the tissues of fish taken from the lakes. More than half of these compounds are believed to be man-made. Another interesting finding from these analyses is that many compounds are unique to the fish of one lake, suggesting that many contaminants are local problems and are not spread through the entire system either through the atmosphere or by water currents.

Source: U.S. Fish and Wildlife Service, 1991.

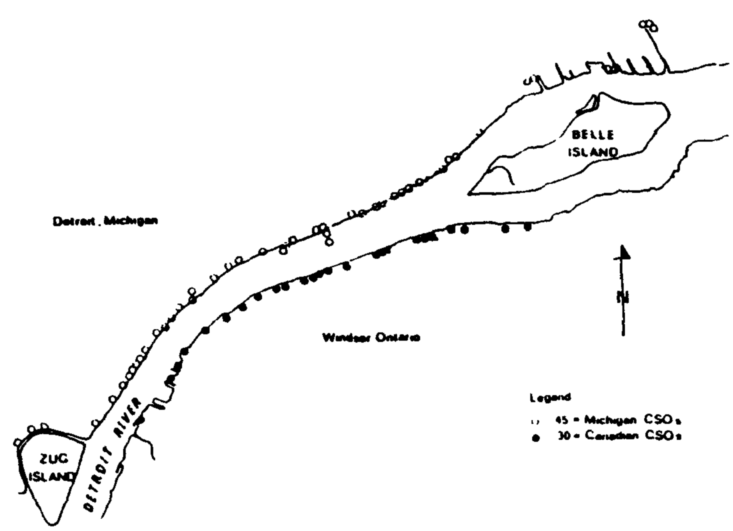


Figure 2-5. Combined Sewer Overflows along the Detroit River.
Source: UGLCC, 1988

The Toxics Releases Inventory (TRI)

Some evidence of the magnitude of contaminants used, released, and transferred by industry is reported to the public by large U.S. manufacturing firms. Since 1987, these firms have reported annual releases or transfers of over 300 toxic substances under the Emergency Planning and Community Right-to-Know Act. EPA compiles this information into a database called the Toxics Release Inventory (TRI). As shown in Figure 2-6, during 1988, firms in the counties of the Great Lakes watershed reported that they released or transferred over 1 million pounds of toxic substances. Relatively little of this was directly released to surface water, though more indirectly reaches the Great Lakes by, for instance, atmospheric deposition. Many of these substances do not bio magnify in the food web. The distribution of releases and transfers is shown in Figure 2-7. Figure 2-8 shows releases and transfers by industrial groups.

The TRI does not directly indicate the amounts of toxicants to which humans or the environment are exposed, nor does it directly measure the risks that these substances pose to either. TRI data does not necessarily indicate regulatory violations, in part because manufacturers report transfers off site to authorized disposal facilities. Not all toxic substances are included under TRI, nor are all sources of their release to the environment; the TRI does not, for example, include releases from small manufacturing firms and from non-manufacturing firms.

serving as nursery, resting, feeding and breeding locations for birds, fish and mammals; and acting as buffers against floods and erosion. Natural fluctuations in Great Lakes water levels help to maintain and rejuvenate coastal marshes by keeping plant life at an early successional stage and by releasing nutrients from sediments and decaying vegetation (20).

Wetlands are essential to a number of fish species. They provide protection from waves and predators and offer water temperatures warmer than that in nearshore lake waters. Their high biological productivity provides an abundant food supply (21).

Wetlands are used as habitat by waterfowl for nesting, roosts and shelter. Submerged plants support a diverse ecology including bacteria, phytoplankton, zooplankton. Larval and juvenile fish may be eaten by waterfowl. Geese graze on the upper parts of wetlands, while both emergent and submergent plants are consumed by ducks (23).

What is a wetland?

A wetland is a marsh, swamp, bog or fen, an area where the water table is above the land surface for at least a part of the year, although most vegetation rises above the surface of the water.

Due primarily to human activities, much of the wetlands of the Great Lakes watershed have been lost. Between 1800 and 1982, more than 60 percent of the wetlands in southern Ontario were lost. In southwestern Ontario, more than 90 percent have been converted to other uses (24). Similar losses occurred in the U.S. portion of the basin. According to an inventory compiled by the U.S. Fish and Wildlife Service in the mid-1970s (25), Minnesota had the most remaining Great Lakes wetlands (15 to 25 percent of its land area). Michigan and Wisconsin had between 5 and 15 percent wetlands. The other Great Lakes States had less than 5 percent wetlands. The vast (1,500 square mile) Black Swamp of northwest Ohio (shown in Figure 2-9) was almost entirely converted to farmland by the 1920s (26).

Contaminated Bottom Sediments

The threat posed by contaminated sediments first came to light when it was discovered that the concentrations of chlorinated organics (like DDT and PCB) in fish throughout the Great Lakes did not decrease as rapidly as expected when these chemicals were banned. Scientists soon discovered that contaminated bottom sediments were the likely culprit. More recently, bottom-dwelling fish from the Buffalo River in New York and the Black River in Ohio have been found with grotesque tumors, providing graphic evidence of environmental insult. Again, contaminated bottom sediments were implicated. This kind of evidence showed that contaminated sediments could, on their own, present a serious threat to the environment even when point sources were already under control and water quality criteria were not being exceeded. It is now widely accepted that contamination of sediments by a variety of pollutants poses a substantial environmental threat.

When the IJC compiled information on the 42 Great Lakes Areas of Concern, it found that 41 of the 42 (98 percent) had contaminated sediment problems. All 26 of the Areas of Concern that are wholly or partly within the United States have contaminated sediment problems.

Sediment contamination differs from water contamination in two important ways.

- Contaminated sediments often respond much more slowly to cleanup efforts than does overlying water. Contaminants lodged in bottom sediments can persist for decades.
- Much more so than for contaminants in water, differences in the physical and chemical properties of sediments have pronounced effects on the degree of hazard posed by a contaminated sediment. This makes it much more difficult to

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Figure 2-6. Releases of Toxic Substances in Great Lakes Counties.
Source: TRI, 1988

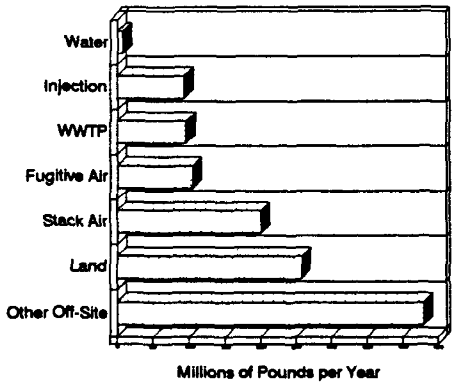


Figure 2-7. Routes of Releases of Toxic Substances in the Great Lakes.
Source: TRI, 1988

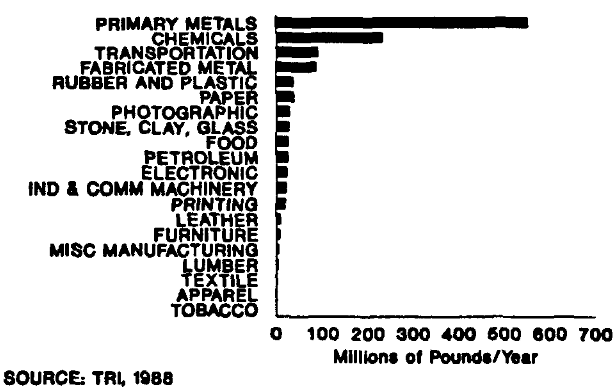


Figure 2-8. Industrial Releases of Toxic Substances in the Great Lakes.
Source: TRI, 1988

- determine whether a sediment is "contaminated,"
- derive sediment criteria, and
- predict the effects of remedial actions.

Contaminated sediments pose a variety of problems for the Great Lakes ecosystem, including physical, chemical, biological, human health, and economic impacts.

Even uncontaminated sediments can have adverse impacts on benthic organisms, either by smothering them or simply being of the wrong particle size to suit their habitat needs. Particle size of sediments also affects the suitability of the bottom for spawning by fish. Resuspended bottom sediments can cause a number of impacts to water column organisms. Because impacts on organisms at any trophic level affect those further up the food web, these impacts are felt throughout the ecosystem.

Chemical contamination of the sediments can be toxic to benthic organisms, either killing them or impairing their normal functioning. The chemicals causing these impacts are often pesticides, organic compounds, or heavy metals. However, more mundane problems such as ammonia toxicity and dissolved oxygen depletion can be just as lethal.

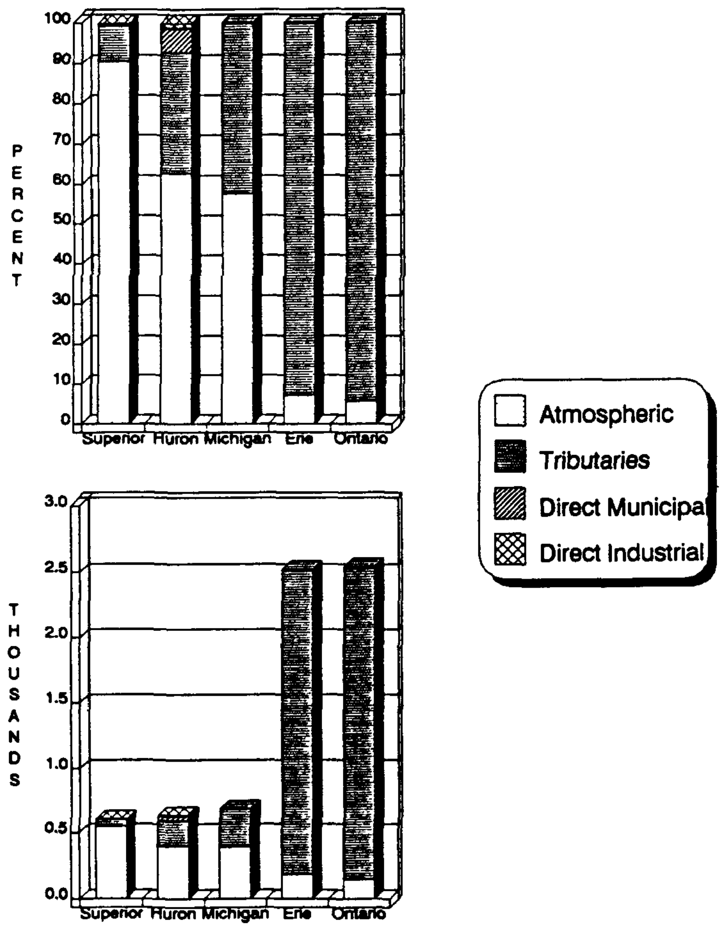
Even if organisms are not killed outright, their ability to function in a healthy way can be impaired. Sublethal effects include mutagenic effects such as the tumors found in bottom fish in the Black River, Ohio and the Buffalo River, New York. Other possible impacts include reproductive impairments, reductions in growth rate, increased susceptibility to disease or predation, and impairment of feeding ability. Genetic alterations may lead to cellular level alterations that are passed on to offspring (mutagenicity) or create developmental abnormalities (teratogenicity).

Effects which are attributable to sediment contaminants (27) have been found in benthic invertebrates, phytoplankton, zooplankton, benthic community structure, fish, and mammals.

Contaminated sediments increase the costs of navigational dredging, because they require special precautions

Atmospheric Deposition of Contaminants

The upper bar chart shows the estimated relative importance (as a percentage) of atmospheric deposition, tributary inflow, and direct municipal and industrial discharges. The lower graph shows the estimated total annual loadings of PCBs to each of the lakes (in kg of PCBs) from each of these sources. Note that estimates of direct municipal and industrial loadings were only available for Lakes Superior and Huron. Atmospheric deposition is most significant in Lake Superior (90%) and decreases steadily in importance as one proceeds downstream in the system. This is due, in part, to differences in the relative surface areas of the lakes, which is reflected in decreases in the absolute loadings (lower graph). The other cause is that the tributary inputs, which include the inflows from the upstream lakes, increase steadily downstream.



Estimated Loadings of PCBs to the Great Lakes.
Source: Strachan and Eisenreich, 1988 (19).

in dredging and disposal. In a number of instances (Indiana Harbor, Indiana; Ashtabula River, Ohio; Sheboygan Harbor, Wisconsin; Menominee River, Michigan), navigational dredging has been delayed for many years because of concerns over disposal of dredged sediments. Reduced dredging increases transportation costs because industries must find alternative transportation methods or reduce the loading of ships and barges to raise their drafts.

Exotic Species

Since 1800, human activity has been responsible for the introduction of numerous non-native species to the Great Lakes. Some introductions have been intentional, such as the Pacific salmon, but unintentional introductions, such as the sea lamprey, alewife, zebra mussel, carp, and smelt, have had profoundly adverse effects on native species populations.

Exotic species affect native populations in various ways: through direct competition for food resources; through displacement of species from physical environments; through direct attack on native populations; and through alteration of the chemical or physical environment.

Figure 2-10 indicates that the introduction of exotic species has been accelerating phenomenon (29). Of all species introduced to the Great Lakes system since 1810, fully 45 percent of these have appeared in just the last 30 years. This can most likely be attributed to increases in international shipping traffic in Great Lakes waters.

Humans have often provided the means for non-native organisms to find their way into the Great Lakes. In the 19th century, canals bypassed natural barriers into the lakes. When the Welland Canal was completed, species that had been barred form the upper lakes by Niagara Falls found their way in for the first time. Humans have also spanned barriers

Lost, Degraded, and Threatened Wetlands

Wetlands provide vital ecological functions, providing shelter and food for fish and wildlife, yet it has been estimated that since 1800 about two-thirds of the wetlands that were in the Great Lakes watershed have been lost. Nutrient-rich wetlands have been converted to productive farmland. Wetlands near the mouths of rivers, particularly valuable for fish and wildlife, have been converted to harbors and urban centers. The present rate of habitat destruction is much less than in prior eras, but development continues to pressure remaining wetlands.

Contaminated Bottom Sediments

Bottom sediments of many harbors and rivers are poisoned by past or continuing loadings of persistent toxic substances. Many contaminants do not remain in the water column, but attach themselves to particles and fall to the bottom. Depending on physical conditions, contaminants lodged in bottom sediments are stirred-up by storms and passing ships or buried by further sedimentation. Contaminated sediments are of ecological concern because: they are associated with dermal and liver tumors in bottom-dwelling or feeding fish; they serve as a reservoir of contaminants that recycle into the food web through resuspension or uptake by benthic organisms; and they injure sensitive bottom-dwelling insects such as mayfly which are a staple of native species such as lake trout. In various locations, sediment contamination has delayed navigational dredging, because of concerns about the means of their removal and disposal.

The Release of Contaminants from Bottom Sediments

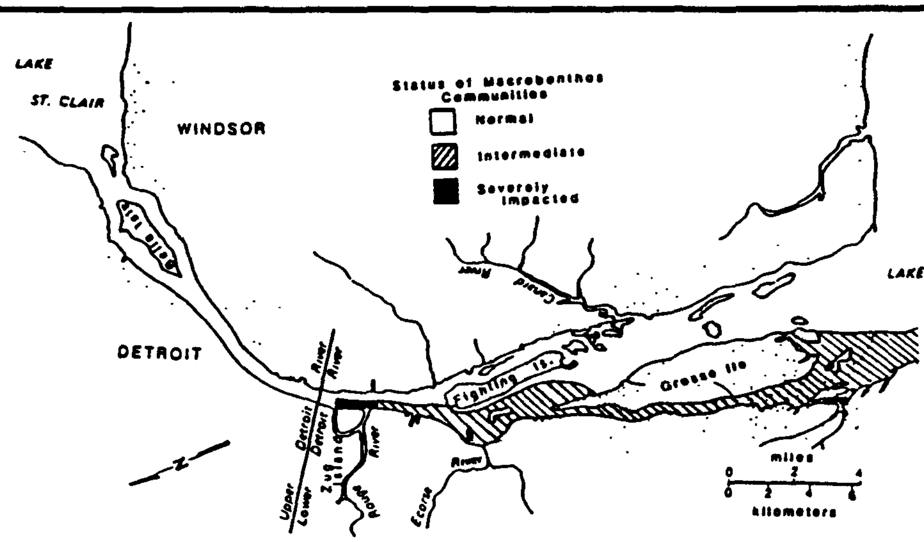
Physical, chemical, and biological factors affect the quantity and rate of transfer of sediment-bound pollutants to the overlying water column.

Physical forces involve mechanical movements of the sediments. Human activities such as dredging, boat traffic, and offshore dumping resuspend bottom sediments. Natural forces like waves and currents caused by storms or floods can have similar effects. Finally, burrowing and feeding activity by inhabitants of the bottom waters also resuspend sediments.

Chemical properties of both contaminants and sediments determine how tightly bound the contaminants are to the sediments. The binding force is strongly affected by sediment particle size. Fine sediments tend to have a greater binding capacity for contaminants. Scientists have found that the presence of some substances, such as organic carbon and sulfides, have a strong affect on the binding of many contaminants.

A typical volume of bottom sediments contains a high percentage of water (20 to 80 percent). This water, called interstitial water, can contain high concentrations of dissolved forms of the contaminants that are bound to the actual sediment particles. Contaminants are slowly diffused from the interstitial water into the overlying water. During a resuspension event, like a storm, the contaminated interstitial water can be released rapidly to the overlying water, affecting both the water column and any organisms present. Concentration of contaminants in interstitial water have been shown to be correlated to effects on benthic organisms rather than contaminant concentrations in the whole sediment. The boundary between sediments and water is indistinct; one cannot look at either water quality or sediment quality without considering the effects on the other.

A highly active benthic **biological** community can disturb sediment through burrowing and feeding activities. In addition, this reworking of the sediments can retard the burial of historical deposits by cycling deeper, more contaminated sediments back up to the surface. Finally, predation of benthic organisms transfers pollutants up the food web through the process of bioaccumulation.



Sediment Contamination in the Detroit River as Reflected by Impacts on Benthic Macroinvertebrate Communities.

Source: UGLCC, 1988.

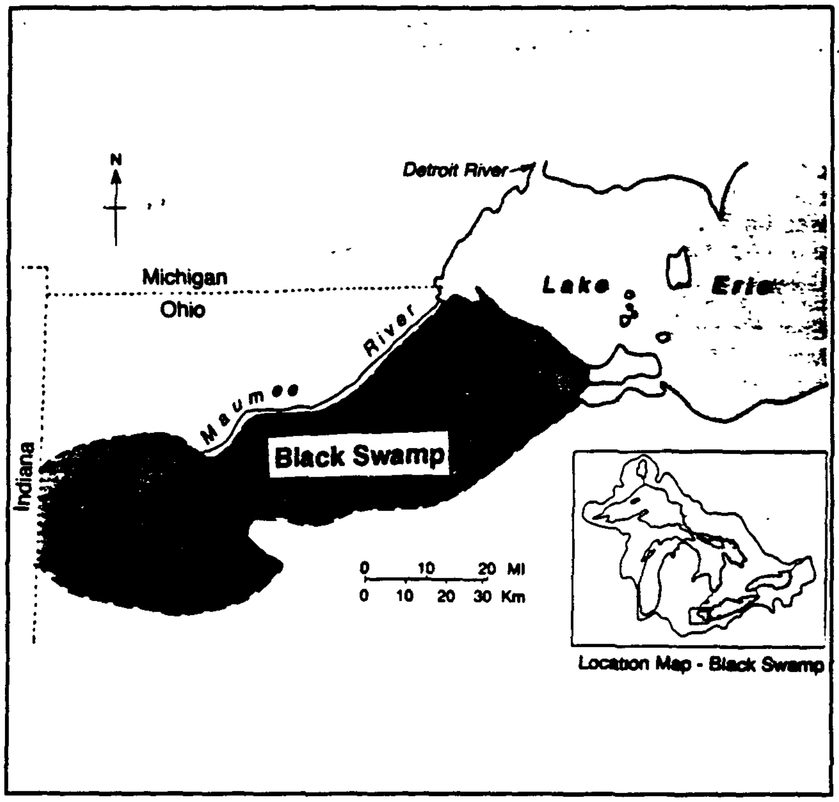


Figure 2-9. Presettlement Extent of the Black Swamp in Northwestern Ohio.
Source: Colborn et al (1990) from Forsyth (1960). (22)

separating the Great Lakes from freshwater bodies on other continents. The ballast water of ocean-going ships is often carried from its origin in a distant port. This ballast water can carry organisms on the long journey.

Some introductions of species have been intentional. Pacific (chinook and coho) salmon have been introduced to the lakes and are regularly stocked to provide an additional top predator to balance the food web, as well as to enhance sport fishing. The salmon provide alternatives to the now greatly diminished lake trout populations.

The relative frequency of the routes by which exotic species enter the Great Lakes are shown in Figure 2-11. Of 121 species believed to have entered the lakes since 1810, more than half were conveyed by ships, mainly through ballast water (30). During the 1987 navigation season, 577 ocean-going ships entered the Great Lakes. In recent years, it is estimated that one to two hundred ocean vessels entered carrying no cargo. Since large vessels are designed to operate best with a full load, the operators of vessels often will often on ballast water to stabilize the ships when they travel with little or no cargo. This ballast water is often taken on in the port of origin before the vessel reaches the open sea. As the water is taken in, organisms in the water are taken in as well. When one of these ships reaches the Great Lakes, it may be necessary to discharge most or all of the ballast water to accommodate the 26 foot maximum draft of the navigation channels. This discharge of water can release exotic species. Organisms that can survive in ballast tanks are frequently very adaptable and aggressive; when they are transferred to an ecosystem in which they have few natural predators, they can proliferate and severely affect the existing balance between native species.

The problem of transfer of exotic species through ballast water can be essentially prevented by requiring ocean vessels to exchange their ballast water at sea before entering the Great Lakes. Open ocean organisms are unlikely to survive in the Great Lakes. Inspection of ships' logs and sampling of ballast water salinity help to ensure that the required exchange has been done.

Since the early 1800s, the estimated number of fish species has increased from about 150 to almost 190. Numerous other non-fish species have also been introduced. Figure 2-12 shows the different types of organisms that are known to have been introduced since 1800 (32).

Sea Lamprey

The sea lamprey was one of the first exotic species in the Great Lakes to have pronounced adverse effects on native populations. Sea lamprey were present in Lake Ontario by the early 1900s, but were kept from the other lakes by Niagara Falls. With the opening of the Welland Canal in the 1930s, they spread rapidly through the other four lakes. Sea lamprey are parasitic, eel-like fish that attach themselves to larger fish and live off of their bodily fluids, often killing the host fish.

The primary targets of the lampreys were large, predator fish, especially lake trout. As a result, trout populations in the upper lakes were reduced such that commercial catches in the 1950s were only one percent of those 20 years earlier.

Sea lamprey populations began to come under control when chemical control of sea lamprey populations began in 1961. Currently, the U.S. Fish and Wildlife Service maintains an extensive program for controlling sea lamprey which entails the application of lampricides to tributary waters where spawn.

Alewife

The alewife is a four- to six-inch long member of the herring family. Alewife populations had been present in the lakes for some time before 1967, when decline of lake trout populations, and the subsequent explosion of alewife populations, led to massive die-offs of the alewife in Lake Michigan.

Alewife were native to northeastern U.S. waters and entered the Great Lakes, presumably through the Erie Canal, in the mid 1800s.

Some Notable Exotic Species in the Great Lakes

Alewife

4" to 6" member of the herring family. Alewife populations exploded with decline of the lake trout. A massive alewife die-off fouled shorelines around Lake Michigan in 1967.

Sea Lamprey

Small, parasitic eel-like fish which bypassed Niagara Falls through the Welland Canal in the 1930s. Attacked large native fish in the upper lakes such as lake trout, decimating populations

Zebra Mussel

Thumbnail sized clam-like mollusc introduced from European fresh waters. Forms dense colonies on hard surfaces including water intakes and ships. May upset ecology through consumption of organisms at base of food chain.

River Ruffe

Small fish from northern Europe. Competes with yellow perch and feeds on whitefish eggs, reducing population of both.

Bythotrephes

Tiny, planktonic predator introduced from Eurasia. May compete with smaller fish for food

Zebra Mussels

Zebra mussels are small (up to 2 inches) clam-like organisms which live attached to hard surfaces in shallow lake waters. In the early stages of their life cycle, the mussel larvae are free-floating, swimming organisms that are carried with lake currents for some time before finding a suitable hard surface to which to attach themselves and mature into the more familiar mussel form. The mobility of the young mussel larvae accounts for the rapid spread of the mussels throughout the lakes. Once attached, the mussel roots itself to the surface by means of root-like byssal fibers, making removal of the organisms a difficult task.

In June 1988, the first discovery of a zebra mussel in the Great Lakes system was made in Lake St. Clair. Since then, zebra mussels have been found in numerous locations, from Duluth and Milwaukee to the entrance of the St. Lawrence River. If the trend continues, it is expected that the species will occupy most of its suitable living environments within the lakes over the next several years.

Potential ecological and economic zebra mussel impacts on the ecosystem are numerous. The mussels compete with other organisms for living space and food, and can alter the physical environment, changing the conditions necessary for feeding and reproduction of other species. The mussels also have economic impacts — entering the intakes of municipal water supplies, power plant cooling systems, and industrial water supplies and attaching themselves, thereby slowing or stopping the flow of water. They also affect shipping and fishing industries by encrusting vessels and increasing drag or by infiltrating and clogging ships' cooling systems.

There is concern over the possible impact of mussels on fish populations. Mussels feed on phytoplankton. Canadian researchers have observed a two-fold increase in water clarity in the western basin of Lake Erie since the introduction of zebra mussels to that area. Phytoplankton are the foundation of the Great Lakes food web; reductions in phytoplankton could create a food shortage for phytoplankton grazers, ultimately threatening top predator fish species. Lake Erie walleye populations could be affected (33).

Zebra mussels also threaten the preferred spawning sites of fish such as lake trout and walleye. Both types of fish prefer shallow, rocky shoal areas for spawning. This type of environment is precisely that favored by zebra mussels for colonization. This

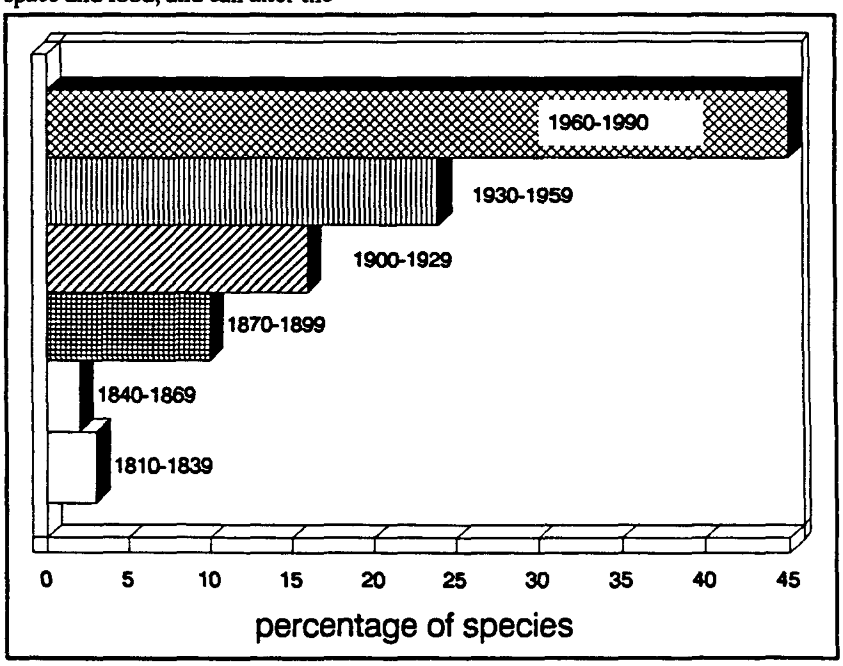


Figure 2-10. Timing of the Introduction of Exotic Species into the Great Lakes.

Source: Mills and Leach, unpublished (31).

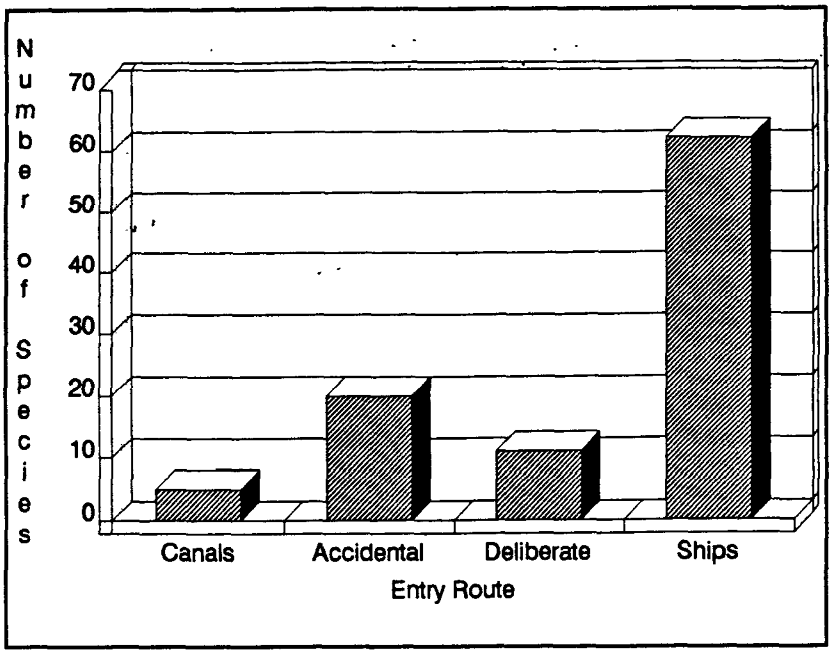


Figure 2-11. Entry Routes of Exotic Species

Source: Mills and Leach, unpublished data. (33)

direct competition for space may threaten lake trout restoration (36).

Recreational beaches can be fouled by the odor of decaying zebra mussels and bathers on some beaches have taken to wearing foot protection to avoid cuts and abrasions from mats of zebra mussels in shallow waters.

River Ruffe

The river ruffe is a small fish introduced from northern European rivers and lakes. Within the Great Lakes, a growing population has been observed in and around Duluth harbor. The ruffe directly competes with fish such as yellow perch for resources and feeds preferentially on the eggs of whitefish. In Russian lakes infested with river ruffe, whitefish production has been observed to decrease by 50 percent (37). This holds clear implications for whitefish populations and the associated fishing industries.

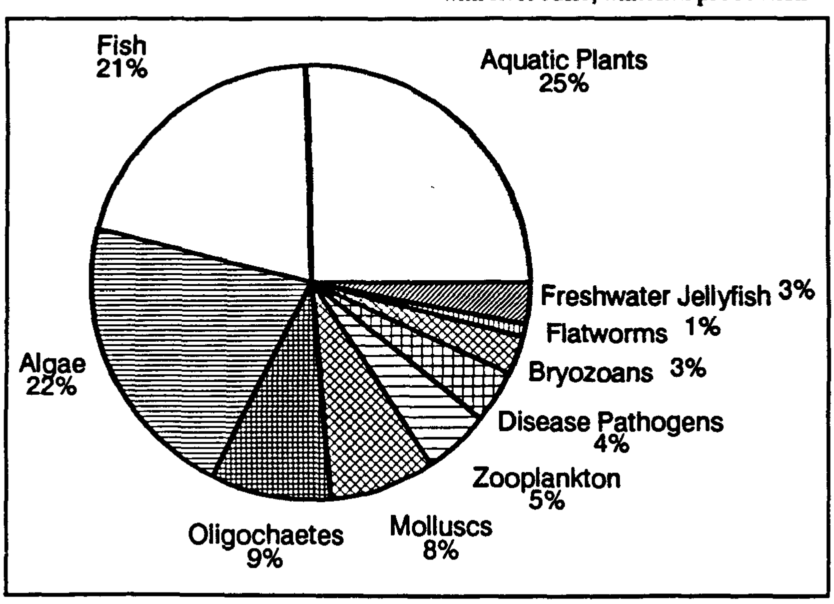


Figure 2-12. Types of Exotic Species Introduced since 1800.

Source: Mills and Leach, Unpublished data. (34)

Bythotrephes (Spiny water fleas)

One of the most recent invaders to the Great Lakes system is the tiny planktonic cladoceran, *Bythotrephes cederstroemii* or the spiny water flea. Bythotrephes is a predator, feeding on organisms at the base of the food chain. It is believed that it arrived in the ballast water of a ship, originating from Eurasian freshwaters (38).

It is not yet understood whether bythotrephes will have definite effects on Great Lakes ecology. The concern over this species arises from its place as a predator in the food chain and its unpalatability to some fish. Bythotrephes feeds on the water flea, which is an important food source to young fish and helps to contribute to water clarity by grazing on smaller plankton. However, some evidence has recently shown that ale wife may consume bythotrephes (39), which would provide a constraint on its population growth.

Nutrients

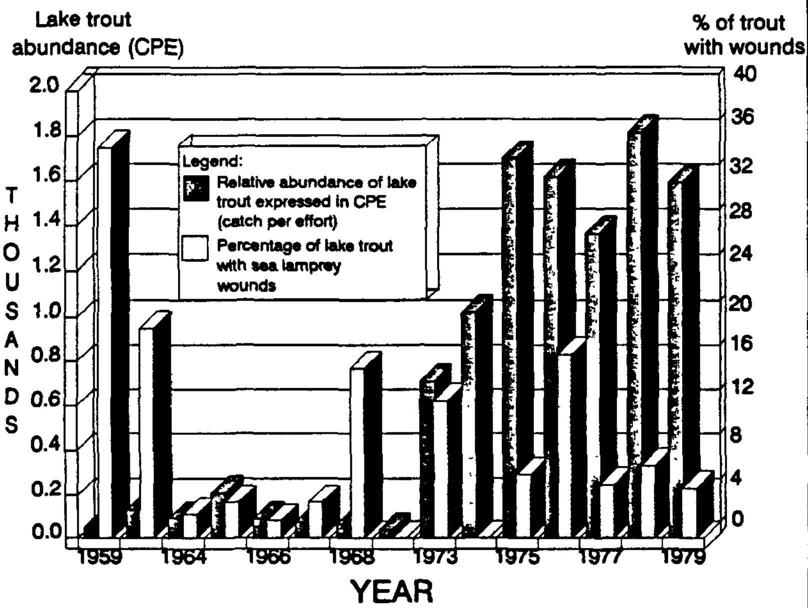
By the late 1960s, various areas of the Great Lakes were exhibiting eutrophic conditions, marked by thick algal blooms, unpleasant odor from and taste to the water,and depletion of dissolved oxygen from the water due to the decay of algae following their seasonal die-off. These conditions were most pronounced in Lake Erie which as the warmest and biologically productive lake was most susceptible to nuisance levels of algae. Lake Erie was also vulnerable because it surpasses other lakes in receipt of effluent form sewage treatment plants and of sediment from the rich farmland in its watershed. Both effluent and sediment brought nutrients, notably phosphorous, that altered the chemistry of the lake and, as a result, its populations of algae. To a lesser degree, eutrophic conditions were also evident in Lake Ontario and in shallow, naturally productive embayments like Saginaw Bay, Green Bay, and the Bay of Quinte.

Lake Trout and the Sea Lamprey

One of the most dramatic illustrations of the effects of exotic species was the decimation of lake trout populations following the passage of sea lamprey into the upper Great Lakes. Sea lamprey are parasitic boneless fish which attach themselves to large fish, drawing on the bodily fluids of the host for nourishment.

The figure below shows the effects on lake trout populations at Stannard Rock in Lake Superior offshore of Marquette, Michigan. Data on numbers of sea lamprey wounds per population of lake trout and the relative populations of lake trout for the years 1959 through 1979 are shown below (Curtis, 1990). Data are for lake trout 63.5 to 73.4 cm in length.

A lampricide program was launched in 1961 and the resulting growth of lake trout populations can be seen clearly in the graph along with the rapid drop in the number of lamprey wounds. Increases in the lake trout population lag behind lamprey controls as the population takes time to rebound. Populations of both lake trout and lamprey seem to be stabilizing in the late 1970s. This stability is artificial. Without continued control of lamprey populations and stocking to bolster numbers of lake trout, the balance could be expected to tilt against the lake trout once again.



Lamprey Effects on Lake Superior Trout.

Source: Curtis, 1990 (40).

Damage to native fish populations from exotic species

The introductions, deliberate and unintended, of exotic (non-native) species have profoundly damaged the populations of desirable native species. The sea lamprey, a parasitic, eel-like fish, entered the upper lakes via the Welland Canal in the 1930s; within twenty years it decimated lake trout populations that to this day are not self-sustaining, though a program of lampricide application has reduced the sea lamprey population. A major recent invader, likely via the ballast water of an ocean vessel, is the zebra mussel. A prolific breeder, this mollusc forms dense colonies on hard surfaces like water intake pipes, imposing immediate economic costs. Ecological effects of the zebra mussel are as yet unknown, but potentially catastrophic. The zebra devours microscopic plants at the foundation of the food web and may create a food shortage for other phytoplankton eaters, ultimately threatening top predators like walleye, salmon, and lake trout.

Over the last two decades, the U.S. and Canada have generally improved water quality across the Great Lakes by reducing phosphorous levels, Lake Erie's improvement, in particular, has been visible and dramatic. Scientists determined that lowering phosphorous concentrations would have the greatest limiting effect on algal productivity. The U.S. and Canada

Excess nutrients

In some shallow waters that receive agricultural runoff of fertilizers and/or in areas having a high surrounding population, like Lake Erie, Lake Ontario, Saginaw Bay, and Green Bay, water is over-enriched with nutrients, particularly phosphorus. The situation is much improved since the late 1960s, when Lake Erie was infamously clogged by foul-smelling mats of algae that depleted dissolved oxygen from bottom waters by its seasonal die-off and decay. Nevertheless, the bottom waters of central Lake Erie continue to suffer periods of oxygen depletion. Phosphorus concentrations in the water column of Lake Erie are approaching those predicted to achieve desired water quality, though this success is partly attributable to several recent years of below average rainfall. Conservation tillage and other farming practices that reduce runoff remain important to achieving desired concentrations of phosphorus. Zebra mussels are expected to reduce algae and, indirectly, phosphorous concentrations, though the full impact of this exotic species on lake productivity is as yet unknown.

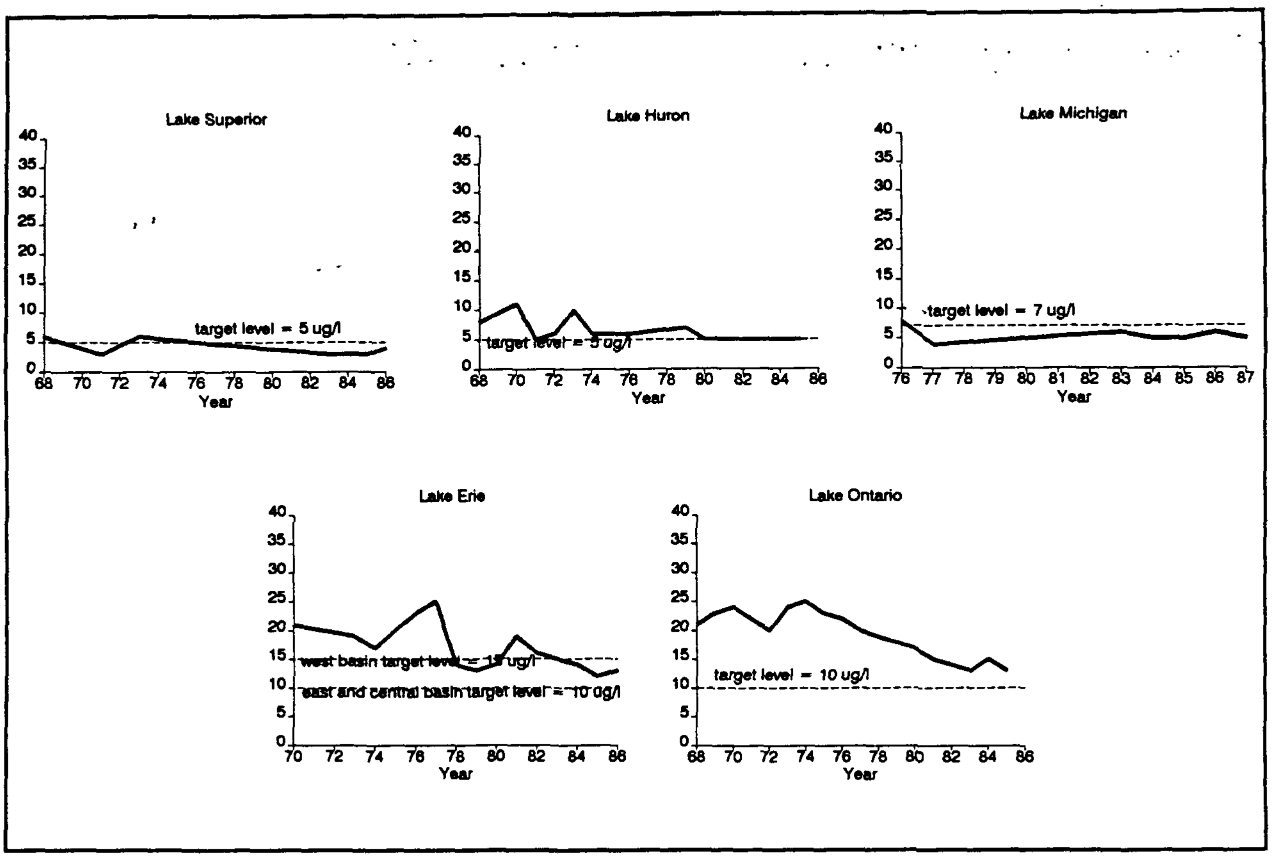


Figure 2-13. Phosphorus Concentrations in the Great Lakes.

Source: (42)

passed laws limiting phosphorous content in household detergents and constructed more effective municipal sewage treatment plants, cutting their phosphorous discharges. As a result, open-lake phosphorous concentrations have declined. As seen in Figure 2-13, phosphorous concentrations in Lakes Michigan, Superior, and Huron continue to be well below levels scientists regard as the highest the allow desirable biological conditions. Phosphorous concentrations in Lakes Ontario and Erie have markedly declined so they are close to their targets.

Chapter 3

The Great Lakes Program

NOTE TO REVIEWER: The next draft to this report will insert a short chapter on the Great Lakes Program, including:

- Model approach to ecosystem protection
- Risk based priorities
- Pollution Prevention as preferred means to reduce risk
- Multi-media focus and enforcement
- Public communication
- Prevent, abate, remediate toxic pollution
- Industrial toxics strategy
- Great Lakes Water Quality Initiative
- New stormwater rule
- National Sediment Strategy, ARCS study
- New Clean Air Act
- Hazardous waste programs
- Natural Resource Damage
- Inventory, protect, restore habitat and native species
- Reduce nutrients
- Measure success in environmental terms
- Green Bay study
- New research vessel
- Atmospheric deposition network for toxicants
- Geographical focus of these remedial approaches under the Agreement

Chapter 4

The Great Lakes Water Quality Agreement

This chapter discusses FY 1989 and 1990 achievements and FY 1991 plans under the Great Lakes Water Quality Agreement. It focuses on the three major approaches under the Agreement for improving Great Lakes water quality: Remedial Action Plans, Lakewide Management Plans, and the Phosphorus Load Reduction Plan.

Background

The United States and Canada have a long history of cooperation on issues pertaining to their joint stewardship of the Great Lakes. In 1905, the two nations created an International Waterways Commission to advise them about Great Lakes water levels and flows. Created under the Boundary Waters Treaty of 1909, the International Joint Commission (IJC) superseded this commission and continues to function today.

The IJC has six members, three appointed by each nation. It has limited authority to approve diversions, obstructions, and uses of Great Lakes waters that affect water flow or levels on the other side of the international boundary. A major activity of the IJC has been to advise the two federal governments about Great Lakes water issues and to conduct studies at the request of the governments. Since 1972, the IJC has had the additional function of reviewing progress of the two nations under their Great Lakes Water Quality Agreement. The IJC has two advisory boards to assist it. The Great Lakes Water Quality Board, comprised of members from federal, state, and provincial environmental agencies, promotes coordination of programs and the sharing of environmental information. The Science Advisory Board consists of government and academic experts who advise the IJC concerning scientific findings and needs. Many of the committees and work groups of these boards convene at the IJC's Great Lakes Regional Office in Windsor, Ontario.

Widespread public concern over the health of the Great Lakes led the United States and Canada to sign the first Great Lakes Water Quality Agreement in 1972. The primary thrust of the first Agreement was to reduce excessive levels of nutrients in the Great Lakes that were causing nuisance levels of aquatic plant life, particularly undesirable algae. By the late 1960s, mats of algae floating on Lake Erie caused changes to the composition of aquatic species, clogged water intakes, created taste and odor problems with municipal water supplies, and degraded boating and fishing. When algae died following their seasonal life cycle, their decay caused the depletion of dissolved oxygen in bottom waters, creating "dead zones" that could not support aquatic organisms. Therefore, the primary intent of the first Agreement was to control the key nutrient phosphorus in order to limit excessive plant life. The Agreement also called for coordinated international environmental research and surveillance of Great Lakes conditions.

In 1978, the two nations signed a new Great Lakes Water Quality Agreement. By that time, there had been clear progress in reducing phosphorus loadings to the Great Lakes. There was also a growing appreciation of a subtler risk to fish, wildlife, and human health—persistent toxic substances. Certain species of fish in many locations through the Great Lakes had been found to contain unsafe levels of persistent toxic substances, such as PCBs, mercury, chlordane, and mirex. The second Agreement added commitments to prohibit the discharge of toxic substances in toxic amounts into the Great Lakes, virtually eliminate all persistent toxic substances, and restore the chemical, physical, and biological integrity of the waters of the Great Lakes basin ecosystem. In 1983, the two nations added provisions under which they pledged to develop phosphorus reduction plans to reduce excessive plant life in areas of the Great Lakes.

In November 1987, the nations revised the Agreement again. Under this revision, they committed to preparing and executing ecosystem cleanup plans for Areas of Concern (in essence toxic "hot spots" in certain harbors or nearshore areas) and for whole-lake problems associated with certain critical pollutants. The two types of cleanup plans were called Remedial Action Plans and Lakewide Management Plans, respectively. The Agreement stated that these plans would be submitted to the IJC for review and comment at various stages. The 1987 revision also added some management commitments. The two nations formally agreed to meet twice a year to coordinate their respective work plans and to evaluate progress. They also agreed to report to the IJC on a biennial basis concerning the progress of certain activities.

The Great Lakes Water Quality Agreement sets forth a joint agenda for international stewardship of the Great Lakes ecosystem. To carry out this agenda, Canada and the United States each control pollution and protect natural resources under their respective national, state, and local laws. Implementation of the Agreement relies on the full range of United States environmental programs. Most United States environmental legislation is administered by the EPA and States in partnership. In addition, five other Federal agencies play important roles in protecting the Great Lakes. These are the U.S. Army Corps of Engineers, the U.S. Coast Guard, the

U.S. Fish and Wildlife Service, the National Oceanic and Atmospheric Administration, and the Soil Conservation Service of the U.S. Department of Agriculture.

EPA is the lead Federal agency for carrying out the terms of the Agreement. EPA's Great Lakes National Program Office coordinates within the Agency and with appropriate Federal, State, Tribal, and international agencies to implement the Agreement. The Program Office also administers a system-wide surveillance network to monitor the water quality of the Great Lakes, with emphasis on the monitoring of toxic pollutants. In addition, it serves as liaison with and provides information to the IJC and to EPA's Canadian counterpart, Environment Canada. The Program Office conducts studies pertaining to the Great Lakes ecosystem, demonstrates cleanup technologies and methods, works with States to develop cleanup plans, and develops this comprehensive report on Federal programs and the long-term prospects for improving the condition of the Great Lakes.

Areas of Concern and Remedial Action Plans

Since 1973, the IJC's Great Lakes Water Quality Board has identified geographic problem areas in the Great Lakes. Over time, the number of areas has increased or decreased as more environmental data have become available, environmental conditions have changed, and definitions of impairments have evolved. In 1976, the Water Quality Board identified 47 "problem areas." In 1981, the Board identified 39 Areas of Concern (toxic hot spots), grouping them into two classifications according to their severity of impairment, with 18 Areas of Concern "significantly degraded" and 21 others "exhibiting degradation." Of the 18 significantly degraded areas, 13 were wholly in the United States; 4 were shared by the two nations; and 1 was in Canada. In 1985, the United States added three more Areas of Concern: the Kalamazoo River in the Lake Michigan basin and Torch Lake and Deer Lake/Carp River in the Lake Superior basin.

Of the 42 current Areas of Concern, 25 are located wholly within the United States, 12 are completely in Canada and 5 are shared. Figure 4-1 shows the locations of all 42 Areas of Concern. Currently, the United States is studying the designation of additional areas, including Presque Isle, Pennsylvania, and Trail Creek, Indiana.

Although the United States has continued to designate Areas of Concern for more than a decade, it should be noted that there have been great environmental improvements in these areas as a result of pollution abatement. Improved water quality in areas such as the Cuyahoga, Black, and Ashtabula Rivers in Ohio and the Buffalo River in New York have allowed fish to return, though contaminants remain in those areas, causing the fish to develop tumors or other abnormalities and to be unsafe for human consumption.

Environmental Problems in Areas of Concern

The United States and Canada designated Areas of Concern on the basis of a variety of impairments, including:

- Populations
  - Degradation of fish and wildlife populations
  - Degradation of benthic (bottom dwelling) macroinvertebrate populations
  - Degradation of phytoplankton or zooplankton
  - Undesirable algae/eutrophication
- Reproduction Problems in Fish and Wildlife
  - Bird or animal deformities or reproductive problems
  - Fish tumors or other deformities
- Human Health
  - Restrictions on fish, wildlife, and drinking water consumption due to contamination
  - Beach closings due to bacterial contamination
- Restrictions on Human Use
  - Tainting of fish and wildlife flavor
  - Taste and odor in drinking water
  - Restrictions on dredging and disposal
  - Added costs for agriculture or industry
  - Degradation of aesthetics (water color, clarity, or odor)
- Loss of Fish and Wildlife Habitat.

Table 4-1 provides a summary of the impairments in each Area of Concern identified by States and by the Province of Ontario.

A problem common to all United States Areas of Concern is the presence of sediments contaminated by toxic substances. EPA is conducting a major study of contaminated sediments in the Great Lakes and of methods for addressing them (see Chapter 5). Even though the problem of contaminated sediments is common, solutions are likely to be varied and site-specific, depending on the nature of the contamination, whether the source of the contaminant loading has been stopped, and the degree of risk posed by the sediments to the ecosystem.

Other common problems within Areas of Concern include fish with readily identifiable tumors or neoplasms and human health advisories for consumption of fish. As of 1987, there were advisories regarding consumption of fish within 26 of the 30 United States Areas of Concern. In addition, 12 United States Areas of Concern were known to contain fish with identified health problems, such as tumors or neoplasms.

Remedial Action Plans

In 1985, the Great Lakes States and the Province of Ontario agreed to develop and implement Remedial Action Plans (RAPs) for Areas of Con-

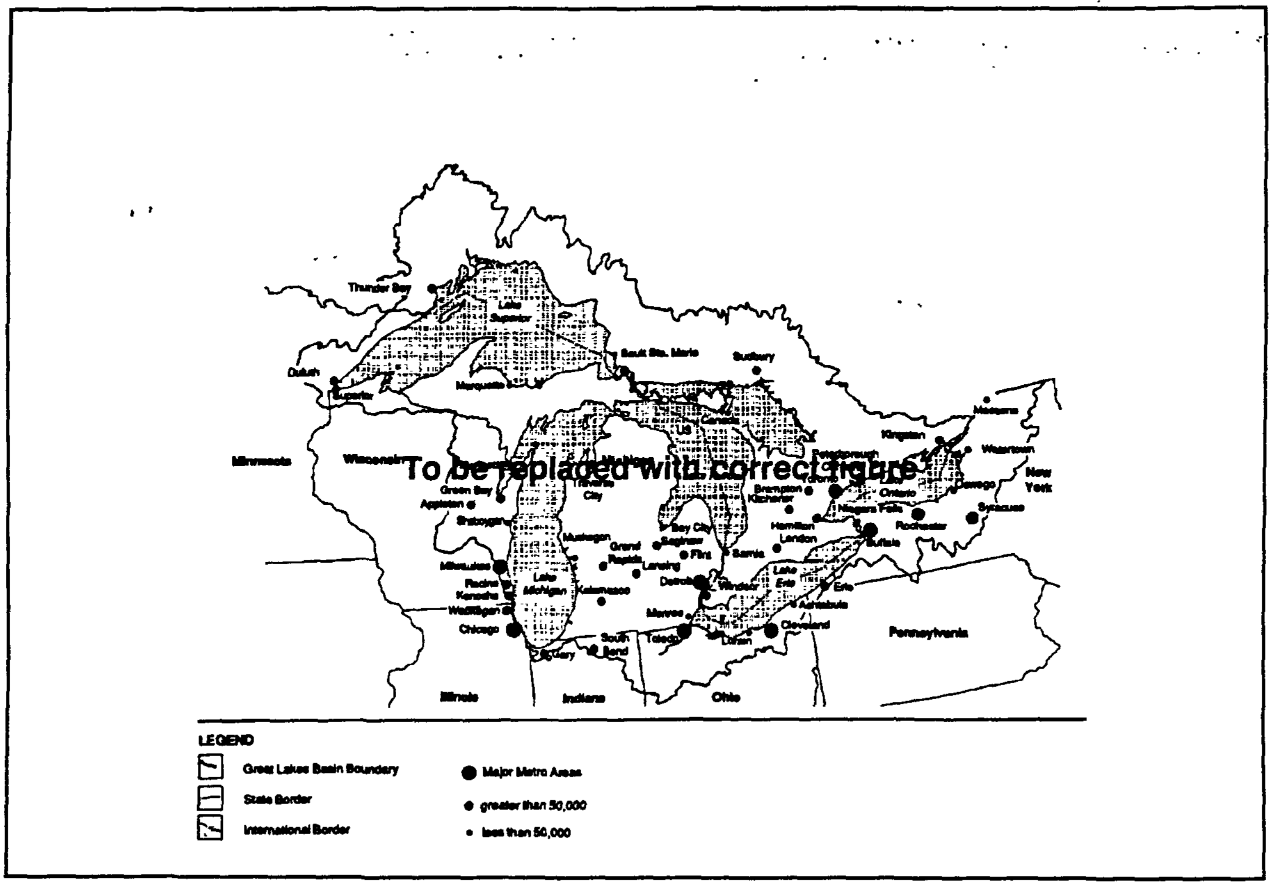


Figure 4-1. Great Lakes Areas of Concern.

cern. The jurisdictions recognize that many lakewide problems originate in certain nearshore areas, so that addressing these through RAPs should reduce lakewide impairments. The United States and Canada formally added provisions concerning RAPs to the Great Lakes Water Quality Agreement in November 1987.

One of the Agreement's general principles regarding RAPs calls for the use of an ecosystem approach to restoring Areas of Concern. Each RAP is to identify the nature and causes of problems, expected completion dates of remedial actions, and responsible organizations. Pursuant to the Agreement, RAPs will be submitted to the IJC for independent review and comment at three stages—after definition of problems, after development of appropriate remedial measures, and after monitoring indicates that beneficial uses have been restored. IJC reviewers include academic and government scientists from both nations.

Another important provision of the Agreement is that the public, particularly from communities adjacent to the Area of Concern, be involved in RAP planning and implementation. The two nations realize that cleanup of many Areas of Concern will be a lengthy, costly process. Abiding public interest is integral to the success of the RAP process.

RAPs are developed and implemented by States consistently with the Federal/State partnership in national environmental legislation. To supplement State funding, EPA provides annual grants to States for administering national water, waste, and air programs. Some of these funds are applied to remedial measures in Areas of Concern. Also augmenting State resources, EPA provides additional grants specifically for RAP development and provides technical assistance. EPA has joined States in funding and participating in a series of major studies on various Great Lakes Areas of Concern, including the Niagara River (completed 1985); the St. Marys, St. Clair, and Detroit Rivers (completed 1988); and Green Bay (in progress). The Agency is also conducting a major study on contaminated sediments in five Areas of Concern: Ashtabula River (Ohio), Buffalo River (New York), Indiana Harbor/Grand Calumet River (Indiana), Saginaw Bay (Michigan) and Sheboygan Harbor (Wisconsin). All these studies have developed information that will be useful in setting cleanup priorities for Areas of Concern. Starting in FY 1990, EPA also assigned a staff person as liaison to each active RAP development group.

Progress of RAPs

Through FY 1991, the Great Lakes States have developed 14 first stage (problem definition) and 10 second stage (proposal of remedial actions) RAPs to the point of submission to the IJC. Seven first stage RAPs were submitted during FY 1988, three during FY 1989, and three during FY 1990. Nine of these fourteen have been submitted by the State of

Table 4-1. Summary of Beneficial Use Impairments Identified by the Jurisdictions in their Areas of Concern.

Source: IJC, 1989, updated by States, 1991.

AREA OF CONCERN	Restriction on fish and wildlife consumption	Tainting of fish and wildlife flavor	Degredation of fish and wildlife populations	Fish tumors and other deformities	Bird or animal deformities or	Degredation of benthos	Restrictions on dredging activities	undesirable algae	Restrictions on drinking water consumption, or	Beach closings	Degredation of aesthetics	Added cost to industry or agriculture	Degredation of phytoplankton and	Loss of fish and wildlife habitat
Peninsula Harbor	●					U	U							
Jackfish Bay	●		●			●					●			●
Nipigon Bay	●		●			●			●		●			●
Thunder Bay	●		●			●	●			U				●
St. Louis Bay/River	●					●	●							
Torch Lake	●			●		●								
Deer Lake-Carp Creek/River	●				●									
Manistique River	●*					●	●							
Menominee River	●*	-				●	●			-	●		-	●
Fox River/Green Bay	●	-	●	●	●	●	●	●	NR	●	●		●	●
Sheboygan	●	-	●	-	-	●	●	●			●		●	
Milwaukee Harbor	●	-	●	●	-	●	●	●		●	●		●	●
Waukegan Harbor	●					●	●							
Grand Calumet River Indiana Harbor Canal	●		●	●		●	●				●		-	●
Kalamazoo River	●													
Muskegon Lake	●													
White lake	●													
Saginaw River/Bay	●				●	●	●	●	●				●	
Collingwood Harbour	●						●	●			●			
Severn Sound	●		U					●			●			U
Spanish River	●	U				●	U	U						
Clinton River			●			●	●							
Rouge River	●		●	●		●	●	●			●			
River Raisin	●					●	●							
Maumee River	●		●			●	●	●		NR	●		●	●
Black River	●		●	●		●	●	●		NR	●		●	●
Cuyahoga River			●	●		●	●	●		NR	●		●	●
Ashtabula River	●		●	●		●	●	●		NR	●		●	●
Wheatley Harbour	●					●	●	●			●			-
Buffalo River	●	L	L	●	L	●	●		NR	NR				●
Eighteen Mile Creek	E	E	E	E	E	E	E	E	E	E	E	E	E	E
Rochester Embayment	E	E	E	E	E	E	E	E	E	E	E	E	E	E
Oswego River	●	E	●	L	L	L		●	NR	NR			-	●
Bay of Quinte	●		●			●	●	●	●	●	●		●	●
Port Hope						●	●							
Toronto Harbour	●					●	●	●		●	●			●
Hamilton Harbour	●	-	U	●	●	●	●	●		●	●	●	●	●
St. Marys River	●					●	U	U			U			
St. Clair River	●					●	U		U	U				
Detroit River	●		U	●	U	●	●	U		●	U		U	●
Niagara River⭑	●		●	●		●	●						●	
St. Lawrence River⭑	●		L	L	L	L							-	●

Symbols used:

Blank	=	data confirm no use impairment	*	=	May be representative of a whole lake problem
●	=	Beneficial use impaired	E	=	Use impairments currently being evaluated through public participation program.
●	=	Under assessment			
⭑	=	Use impairments identified by Ontario; New York is currently evaluating use impairments	L	=	Likely impaired
			NR	=	Not relevant

Michigan; New York has submitted three and Wisconsin has submitted two. Many other RAPs are under development, although several are delayed pending resolution of legal issues related to enforcement actions. Table 4-2 summarizes RAP submission status. Table 4-3 summarizes activities in United States Areas of Concern during FYs 1989 - 1991: (Tables 4-2 and 4-3 can be found at the end of this chapter.)

Some successes of the RAP process to date:

- Public participation "stakeholder" groups are strongly involved in many RAPs. These groups have molded the goals of RAPs and strengthened the sense of local "ownership" of both problems and their solutions.
- Stakeholder participation has helped to increase the awareness of the public at large concerning environmental problems.
- The development of some RAPs has brought together nearby municipalities in addressing common regional problems (e.g., Green Bay, Rouge, and Maumee RAPs).
- The RAPs developed to date represent an impressive assemblage of information on environmental problems and solutions. They serve to inform the public, to guide government actions, and to justify investments in Great Lakes restoration (e.g., the Council of Great Lakes Governors launched a $100 million Great Lakes protection fund in 1988).
- RAPs have called upon a broad range of environmental programs. For instance, they rely on nonpoint source measures (Saginaw, Green Bay, Milwaukee, Maumee), industrial pretreatment programs (Rouge and Grand Calumet), groundwater protection (Niagara), better sewage treatment, and wetlands restoration (Green Bay), among other measures.
- The Water Quality Board has developed a framework for defining impairments to the Great Lakes. This can be useful to RAP developers in defining the nature of the problems they face.

Some of the lessons that have been learned from the Remedial Action Plan process are:

- The development of an effective RAP can be complex and protracted. Once much pertinent environmental data is included, some RAP documents have become lengthy; the Rouge River RAP consisted of seven separate volumes. Sometimes there is extensive existing information about an Area of Concern upon which the RAP may draw (e.g., the Niagara, Detroit, St. Marys, and St. Clair Rivers and Green Bay). In other cases, the development effort must include extensive analysis of water, groundwater, fish tissue, and sediment samples (e.g., Cuyahoga and Maumee Rivers).
- The RAP development process can be greatly facilitated through studies carried out by potentially responsible parties pursuant to enforcement actions (e.g., Ashtabula, Niagara, and St. Lawrence Rivers).
- In some Areas of Concern, ecosystem restoration may take 20 years or more from the onset of cleanup actions. This has implications for maintaining public commitment.
- Some RAP development efforts encounter a host of questions about the extent and causes of ecosystem impairments. Establishing "causality" between known sources of pollution and impaired fish and wildlife may sometimes entail years of study.
- There is often no need to await completion of a RAP before taking effective remedial actions in relation to known pollution sources. Though the Great Lakes Water Quality Agreement envisioned a sequential process of problem definition, solution definition, and solution implementation, in practice, EPA and States often take cleanup steps and develop RAPs simultaneously.
- A difference between the RAP process and the customary practice of environmental programs is the emphasis on defining the full extent and causes of environmental damage in a given area. This approach assures that problems are better understood and provides a historical record against which progress can be measured. Thus, the first stage RAP (problem definition) is very important.
- RAPs were originally intended to be water quality management plans. Partially owing to public participation, they have sometimes become broader in scope to address problems such as habitat loss, loss of native fish or wildlife, and public access to waterfronts. This evolution is consistent with the Agreement's objectives of ecosystem restoration and the restoration of impaired uses of the Great Lakes.
- Governments and stakeholders must set reasonable expectations for the RAP process. Given that Areas of Concern often have multiple impairments from multiple sources, that restoration will sometimes be a lengthy process, and that extensive studies may be needed to document impairment status or to prove causalities between pollutant loads and effects, it will often not be possible to quickly develop a "perfect plan" to restore the ecosystem of an Area of Concern. However, falling short of a perfect plan is not "failure," rather it is partial success. Success in RAP development should be measured in terms of planning reasonable steps toward ecosystem restoration. The ultimate success of the RAP process is not developing plans, but restoring the Great Lakes.

- Through 1989, the Water Quality Board of the IJC had reviewed the first eight United States RAPs. In the Board's view, the first stages (problem definition) were not fully complete in seven of the eight cases. The IJC considered the Green Bay and the Rouge River plans to be the strongest.

- The RAP process will often be iterative and incremental. The first generation of the Rouge River RAP, for instance, is a superb achievement, resulting from exemplary involvement by many communities and public participation. It addresses the most immediate problems of the Area of Concern—overflows from combined sewers and bacteria problems. According to the IJC's Water Quality Board, the Rouge RAP's problem definition concerning toxic substances has not yet been linked to ecosystem health. In the future, the Rouge River RAP will be updated to address the problem of toxic substances.

- Major government investments will be required to restore some Areas of Concern. Large sewage system and treatment facility improvements are underway or will be needed in many Areas of Concern (e.g., Maumee, Rouge, and Detroit Rivers and Milwaukee).

- It is often unclear at present how to address the pervasive problem of contaminated freshwater sediments in rivers and harbors (e.g., Green Bay). EPA is developing a national sediment policy that will provide recommendations on approaches.

- Cleanups of contaminated sediments will vary due to site-specific conditions. A number of different options including in-place containment, removal and disposal, and treatment and incineration are being used in different parts of one site depending upon the degree of contamination (Waukegan Harbor).

- Frequently, progress can be made through reduction of pollutant loadings from regulated facilities. The importance of municipal and industrial dischargers to Great Lakes water bodies was underscored by EPA's major study of the upper Great Lakes connecting channels completed in 1988. The study found that point sources provided the largest loadings of most contaminants to the St. Marys, St. Clair, and Detroit Rivers. Firms and municipalities can reduce their loadings by adoption of new ways of preventing pollution, including industrial process changes and pollution abatement technologies.

- Some communities adjacent to Areas of Concern have citizens with a strong grounding in environmental knowledge that has helped their stakeholder groups to make especially valuable contributions (e.g., Duluth, Green Bay, Rouge and Milwaukee).

Lakewide Management Plans

The second major restoration approach under the Agreement is the development of Lakewide Management Plans (LAMPs) for critical pollutants in order to address whole-lake problems that extend beyond individual Areas of Concern. As with RAPs, LAMPs are intended to follow a comprehensive ecosystem approach, drawing on the full range of Federal, State, and local environmental programs, as needed. One of the statutory foundations of the LAMP concept is the Clean Water Act, which provides for more stringent, water quality-based limits on dischargers when technology-based limits are not sufficient to attain water quality standards. By estimating loadings of pollutants, EPA and States have grounds to set more stringent discharge limits when the assimilative capacity of a lake for a pollutant is exceeded.

EPA and States are giving priority to developing LAMPs for Lakes Ontario and Michigan. Accumulations of persistent toxic substances in the tissues of fish and wildlife are highest in these lakes. Since the Niagara River is the dominant source of water to Lake Ontario, reduction of toxic substance loadings to the Niagara River is an important element of whole lake improvements.

Niagara River Load Reductions

During FY 1989 and 1990, EPA and the New York State Department of Environmental Conservation (NYSDEC), and counterpart agencies in Canada (Environment Canada and Ontario Ministry of the Environment) continued their emphasis on the reduction of toxic chemicals in the Niagara River. This continues a series of activities that followed the first discovery of toxicants in Love Canal in 1978, including the binational Niagara River Study completed in 1985, the 1987 signing of a binational "Declaration of Intent" to cut in half 1987 levels of point and nonpoint loadings of priority toxic chemicals to the Niagara River by 1996 and numerous investigations and cleanups of hazardous waste sites. The sustained effort on the Niagara Frontier represents the most complex environmental cleanup effort undertaken by the United States to improve water quality and environmental conditions within a geographic region.

In cooperation with NYSDEC, EPA completed identification of the hazardous waste sites that are believed to provide the largest loadings of toxic chemicals to the Niagara River from the United States side. EPA and NYSDEC also developed a plan to complete cleanup of the top 20 sites by 1996. Niagara River water quality monitoring data indicate that nonpoint source loadings of target pollutants are much greater than those from water dischargers. Reaching the 1996 target will be partly contingent on negotiation with potentially responsible parties and the outcome of further hazardous waste site investigations. EPA and NYSDEC have committed to report regularly on progress in cleaning up these hazardous waste sites.

EPA, NYSDEC, and the Ontario Ministry of the Environment are also working to reduce point source loadings to the Niagara River. Niagara River monitoring indicates that although point sources contribute smaller loads of priority pollutants than nonpoint sources, they are still a significant source of other toxic chemicals. EPA and NYSDEC estimate that United States point source loadings of toxic substances have already declined by about 80 percent from 1982 through 1987. To achieve the 1996 commitment, U.S. point sources will need to cut their remaining loadings by an additional 50 percent.

Lake Ontario

As part of their Declaration of Intent in 1987, EPA, NYSDEC, and counterpart agencies in Canada agreed to develop a "Lake Ontario Toxics Management Plan." The first generation of this plan was adopted in February 1989. The goal of the plan is a lake that provides drinking water and fish that are safe for unlimited human consumption and allows natural reproduction of the most sensitive native species, such as bald eagles, ospreys, mink, and otters.

Under the plan, the four agencies have compared concentrations of toxic substances in fish and in the Lake Ontario water column with water quality standards for the protection of fish and human health. No exceedences were found for drinking water standards; however, fish tissue concentrations exceeded human health protection levels for such substances as dioxin, PCBs, chlordane, mirex, mercury, dieldrin, DDT and its metabolites, octachlorostyrene, and hexachlorobenzene. DDT and its metabolites, hexachlorobenzene, and dieldrin were also found in the water column at levels above EPA guidance values for the protection of human health from fish consumption.

The plan uses four objectives as the means of eliminating these exceedences. First, it relies on reduction of toxic inputs by regulation of industrial and municipal dischargers. Second, it calls for obtaining further reductions through special focus on the three New York, and Province of Ontario, and two shared Areas of Concern in the basin. Third, future reductions will be obtained based on lakewide analyses of pollutant fate to provide grounds for water quality-based regulations. Fourth, the plan calls for zero discharge of toxic substances into Lake Ontario.

During FY 1989, the four agencies completed initial characterization of problem Lake Ontario toxics. Differences in chemical-specific standards for toxics were identified and commitments made for their resolution. Most significantly, Ontario Ministry of the Environment and Environment Canada committed to work with Health and welfare Canada to develop Canada's first water quality criteria for the protection of human health from consumption of contaminants in fish. During FY 1990, work continued on a model of steady-state exposure and bioaccumulation for toxic chemicals in Lake Ontario, including development of a time-response model of exposure and bioaccumulation of toxic substances. FY 1991 activities will include a comprehensive estimation of loadings from groundwater, air, and sediment to test the bioaccumulation model.

During FY 1990, a binational team from EPA, NYSDEC, the New York State Department of Health, the Fish and Wildlife Service, and counterpart Canadian agencies developed ecosystem health objectives for Lake Ontario. The team will develop measurable ecosystem indicators during FY 1991 for nearshore and open-lake water quality (trophic condition), human health, wildlife health, and habitat.

Lake Michigan

The Lake Michigan Toxic Pollutant Reduction Strategy was developed in 1986 as a joint effort of EPA and the States of Illinois, Indiana, Michigan, and Wisconsin, to define the relationship between toxicant loading rates and Lake Michigan toxicant problems, and to implement remedies. The Strategy has a two-phase approach. Phase 1 consists of a series of efforts to quantify and control major toxicant sources to Lake Michigan. Phase 2 involves lakewide pollutant load reductions to address any toxicant water quality problems that have not been corrected under Phase 1.

Some highlights of progress under the Strategy include:

- Water Quality Standards
  - Illinois adopted water quality standards for toxic substances in 1989 and has submitted draft antidegradation procedures to EPA.
  - EPA approved Michigan's antidegradation procedures in 1987. The State has been implementing its procedures for establishing numerical effluent limitations since 1985.
  - Indiana adopted numerical standards for toxic substances in 1990 and will be developing antidegradation procedures during 1991.
  - Wisconsin adopted comprehensive water quality standards and antidegradation rules in 1988.
- States have developed lists of waters impaired by toxic substances and are developing control strategies for these.
- In 1985, EPA vetoed 11 major NPDES permits for pulp and paper mills in Wisconsin, triggering a lengthy process of regulatory revisions by Wisconsin that culminated in the State's adoption of comprehensive toxic water quality standards and antidegradation rules.
- EPA and States identified 11 toxicants as pollutants of concern and have emphasized water quality-based NPDES permitting to control toxic substances.
- EPA began biomonitoring of major facilities on Lake Michigan and its tributaries that were suspected of discharging toxicants. When toxicity has been detected, NPDES permits have been modified or reissued with appropriate limits to address whole-effluent toxicity.
- EPA and the State of Wisconsin are conducting a study of Green Bay to model the fate of several toxic pollutants in order to increase EPA's capability to model the fate of toxic substances in a large water body.

Nutrient Over-Enrichment

By the 1960s, the prevalence of eutrophic conditions (and associated problems, including nuisance levels of algal growth, unpleasant odor and taste in water supplies, and oxygen depletion in open lake waters), particularly near the shores of the lower Great Lakes, provoked wide public concern and was a major factor leading the United States and Canada to affirm the first Great Lakes Water Quality Agreement in 1972. Loadings of phosphorus were the primary cause of eutrophic conditions. Since then, the two nations have taken a number of measures that have reduced phosphorus concentrations to near the desired levels in the open waters of the lakes. Principal among these measures have been construction and improvement of municipal wastewater treatment plants and State laws limiting the content of phosphorus in laundry detergents. EPA has estimated that, in 1972, phosphorus loadings to Lake Erie from United States municipal dischargers amounted to about 14,000 tons; whereas, similar loadings were estimated to be only 2,400 tons in 1986. All Great Lakes States now have, or plan to institute during 1990, a phosphorus limit of 0.5 percent in laundry detergents sold within the Great Lakes basin. Canada's detergent phosphorus limit is 2.2 percent.

EPA considers that additional reductions in phosphorus loadings are necessary to achieve desired water quality in Lake Erie, Lake Ontario, Saginaw Bay, Green Bay, and various nearshore problem areas. In 1983, the United States and Canada agreed to develop and implement "Phosphorus Load Reduction Plans" to further reduce annual phosphorus loadings by 2,650 tons to the two lower lakes and Saginaw Bay (2,000 tons for Lake Erie, 430 tons for Lake Ontario, and 220 tons for Saginaw Bay). These target reductions were calculated from a baseline estimate of phosphorus loadings during 1982. They represented about a 15-percent reduction in Lake Erie phosphorus loadings and a 6-percent reduction in Lake Ontario loadings. Under the United States Phosphorus Load Reduction Plan, target open lake phosphorus concentration levels are 15 parts per billion (ppb) in the western basin of Lake Erie and in Saginaw Bay and 10 ppb in the deeper waters of Lake Ontario and the central and eastern basins of Lake Erie.

Agricultural runoff is a major source of phosphorus and agricultural chemical loadings to the Great Lakes. Nonpoint (including agricultural) loadings of phosphorus during 1986 have been estimated to have been about three times the level of municipal and industrial discharges. Implementation of the United States Phosphorus Load Reduction Plan, launched in 1986 and to continue through 1990, relies on programs aimed at increasing the use of best management practices in agricultural areas, including increased adoption of conservation tillage practices, better management of livestock waste and better management of fertilizers.

Nonpoint loadings of phosphorus to Lake Erie are thought to be the largest of such loadings to any of the lakes. On the United States side of Lake Erie, the greatest loadings are from the many tributaries that receive nonpoint runoff from the intensely cultivated farmlands west of Cleveland. The Phosphorus Load Reduction Plan relies on States and U.S. Department of Agriculture support to local Soil and Water Conservation Districts, especially in Ohio. The Ohio strategy seeks to increase conservation tillage and improve fertilizer management on about one million acres, thereby reducing phosphorus loading to Lake Erie by an estimated 1,230 metric tons per year.

Lake Erie was the first of the lakes to show eutrophic conditions, because it is the shallowest, the warmest, the most productive, and because it has the highest rate of sedimentation. Its drainage basin contains intense agricultural and urban uses. About one-third of the United States Great Lakes population lives within Erie's drainage area, and Erie surpasses other lakes in receipt of effluent from sewage treatment plants.

United States Phosphorus Reduction Plan Progress

The United States Great Lakes Phosphorus Task Force, including members from EPA, U.S. Department of Agriculture (i.e., Soil Conservation Service, Agricultural Stabilization and Conservation Service, and Cooperative Extension Service), and agricultural and environmental agencies in Indiana, Michigan, New York, Ohio, and Pennsylvania, has evaluated plan implementation through 1988. Methods of estimating phosphorus reductions vary by State. In most cases, estimates of agricultural nonpoint source loadings are derived from estimates of conservation tillage adoption, fertilizer and animal waste management practices, and structural improvements (e.g., drainage systems and fertilizer storage facilities). Progress is measured in terms of reductions from estimated 1982 loadings.

Michigan estimates that it has achieved about 78 percent of its load reduction target for Saginaw Bay. Indiana estimates that it has exceeded its target reduction for Lake Erie. Lake Erie, however, requires substantial further reductions in phosphorus loadings from the agricultural sector in both Michigan and Ohio. Ohio estimates that its farmers have reduced phosphorus loadings by 198 metric tons; however, an additional 1,032 tons in reductions are still sought from Ohio's agricultural sector by 1990 under the Phosphorus Load Reduction Plan. At the present rate, this goal will not be met for Lake Erie. Including progress to date by all five States affecting Lake Erie, overall reductions in phosphorus loads to the lake are estimated to be 24 percent of the way to the 1990 goal.

Regarding Lake Ontario, New York State estimates its reductions to date represent 46 percent of the 1990 goal.

Although progress under the Phosphorus Load Reduction Plan has been slow in Lakes Erie and Ontario, States also noted a significant reduction in phosphorus from regulated water dischargers. They estimate that, in relation to 1982 baseline loadings, municipal dischargers in 1987 reduced phosphorus discharge to Lake Erie by 502 tons and to Lake Ontario by 216 tons. These estimated reductions tend to offset some of the slow progress implementing the United States Phosphorus Load Reduction Plan. Based on estimated progress through 1988, an additional reduction of 1,411 tons is needed

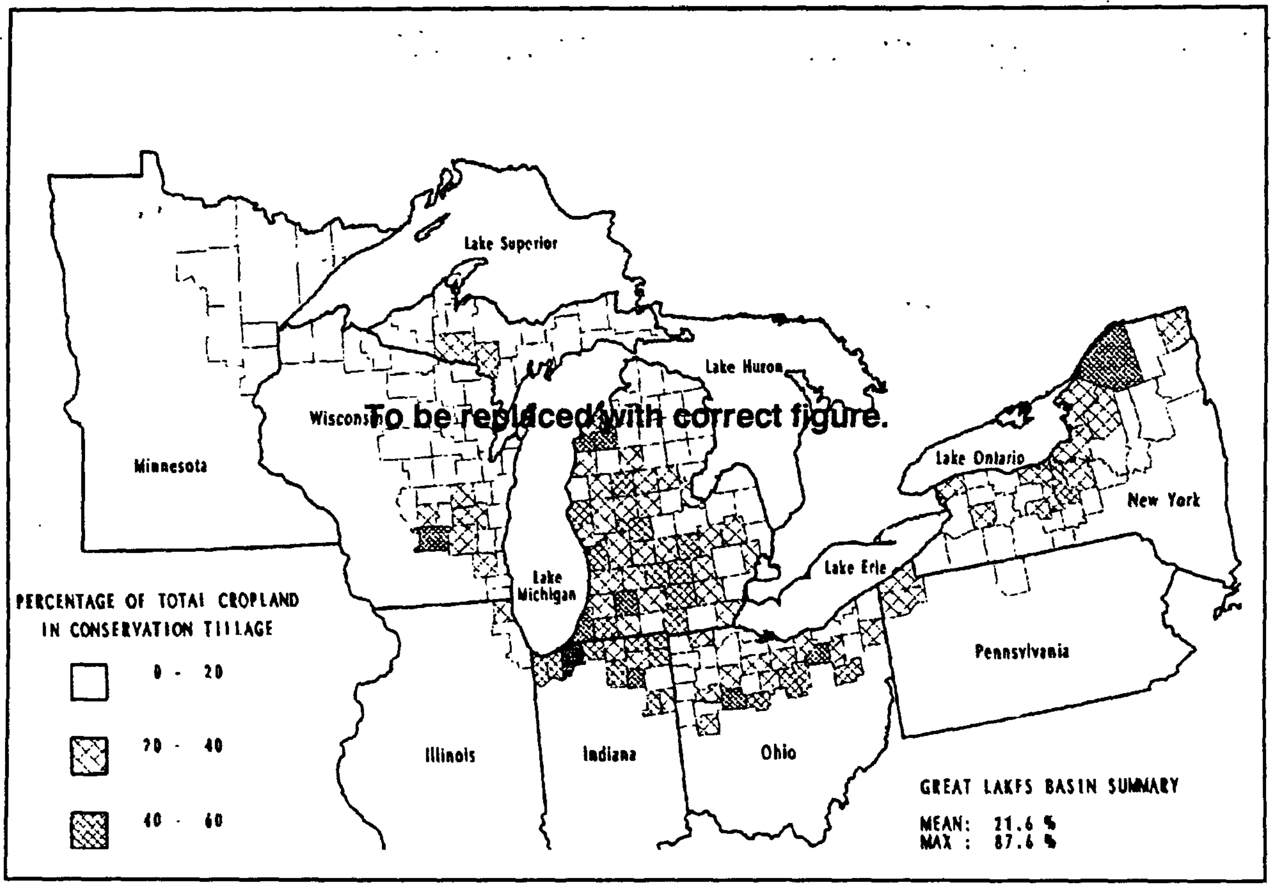


Figure 4-2. Cropland in the Great Lakes Basin.

Source: (43)

under the Plan to achieve 1990 targets. Estimated reductions from water dischargers represent about one-half of this environmental goal.

Conservation Tillage Practices in the Great Lakes

In relation to conventional tillage, conservation tillage reduces runoff of surface water and reduces soil erosion by water and wind. There are four main types of conservation tillage practices: no till, mulch till, ridge till, and strip till. These tillage practices differ in the degree of soil disturbance. No till practices are regarded as the most effective in preventing erosion, because they eliminate mechanical cultivation altogether. The other conservation practices are known collectively as "reduced till." The tillage system selected by the farmer depends on physical circumstances, including soil type; crops; availability of equipment; and his/her understanding of the benefits of conservation tillage.

Although these estimates are inexact, estimates of farm acreage using conservation tillage practices is an important basis for evaluating progress under the United States Phosphorus Load Reduction Plan. From 1987 through 1989, EPA's Great Lakes National Program Office helped sponsor comprehensive visual surveys by the Soil Conservation Service of conservation tillage in counties in Ohio, Indiana, and Michigan that drain to Saginaw Bay and Lake Erie. These surveys essentially confirmed earlier Soil and Water Conservation District best professional judgment estimates regarding no till prevalence, but indicated that other conservation tillage practices have not been adopted as much as previously estimated. Several universities are developing remote, satellite monitoring of tillage practices that may help to obtain more precise estimates in the future. Differing estimation methods over time and around the Great Lakes basin tend to make district-by-district comparisons and historical trend analysis problematic.

While recognizing that estimation techniques are not uniform and may have various degrees of precision, the Program Office has analyzed a comprehensive body of conservation tillage data in order to present an overall picture of basin agricultural practices. The discussion that follows relies on 1988 data from the Conservation Technology Information Center, located in West Lafayette, Indiana. The Center compiles agricultural and tillage data provided by the Soil Conservation Service on a county level nationwide. It is part of the National Association of Conservation Districts.

Cropland accounts for 18 percent of the total area of counties lying fully or partly within the Great Lakes basin (Figure 4-2). The major cropland areas of the basin are northwest Ohio, central Wisconsin, and adjacent to the Saginaw River and Bay. Corn is the

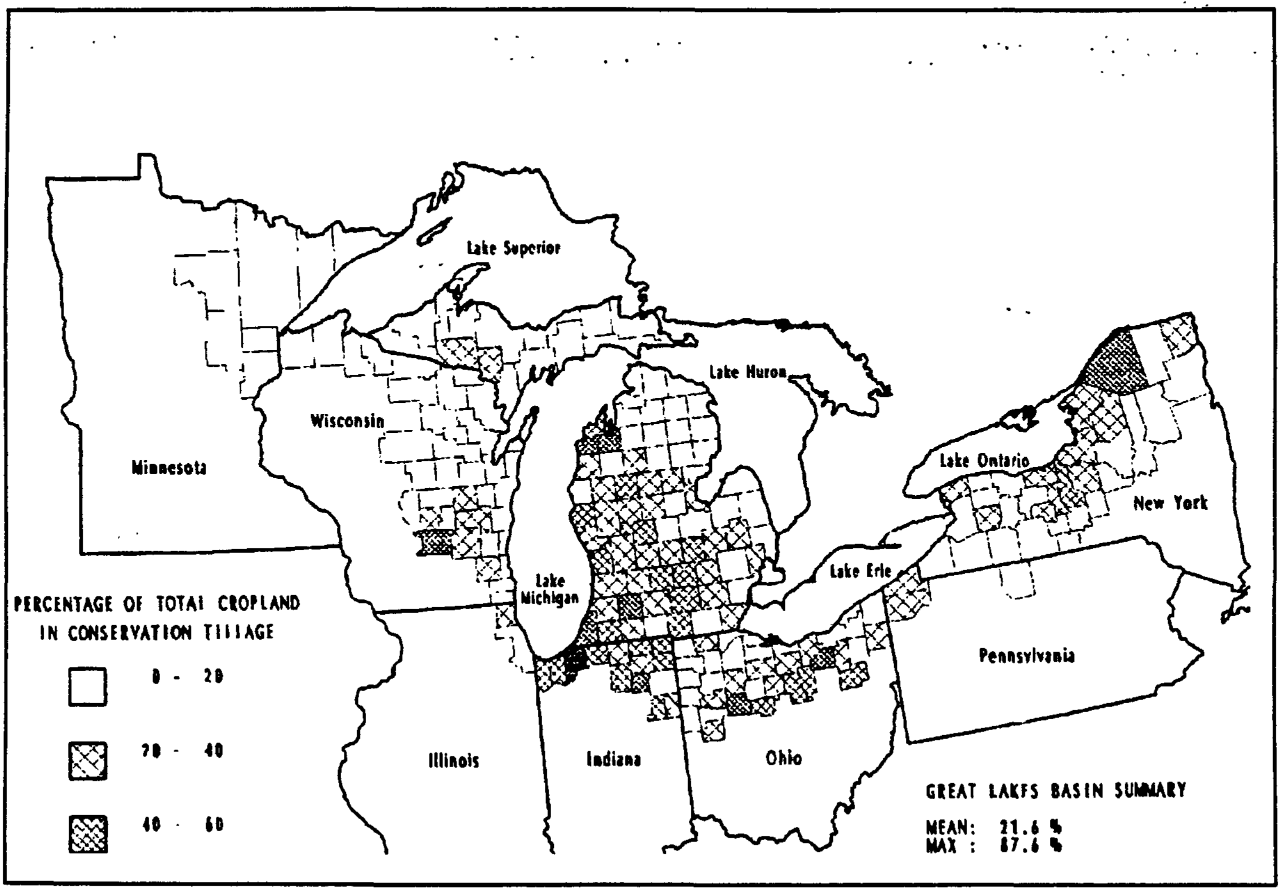


Figure 4-3. Conservation Tillage in the Great Lakes Basin.
Source: (44).

largest crop (42 percent), followed by soybeans (24 percent), and small grains, especially wheat (17 percent). About 30 to 50 percent of the corn and soybean acreage in the Great Lakes basin are in a corn/soybean rotation. Major corn-growing areas are located in east-central and southeast Michigan, northwest Ohio, and central Wisconsin.

The practice of conventional tillage is much more common in the Great Lakes basin than is conservation tillage, which is used on 21.6 percent of cropland (Figure 4-3). Mulch till is the most frequently used method of conservation tillage, accounting for 68 percent of all conservation tillage acres. No till practices are used on 24 percent of conservation tillage acres. Farmers who grow corn use conservation tillage more than those who grow other crops. Conservation tillage is used for about 38 percent of the corn, 21 percent of the soybean, and 16 percent of the small grain crops.

Generally, it appears that, for each of the major crops, conservation tillage practices are lowest in areas of greatest production. For instance, in corn production areas, conservation tillage practices are most prevalent in northwest Indiana, central Wisconsin, and central Michigan. LaPorte and Porter Counties in northwest Indiana have the two highest rates of conservation tillage, averaging about 92 percent in acres producing corn. However, the top 11 counties having the highest proportion of cropland devoted to corn, all in northwest Ohio, have relatively low rates of conservation tillage, averaging about 23.7 percent.

Varying rates of conservation tillage are partly attributable to differences in soil types. Some soils with clay content cannot support conservation tillage practices, since the soil becomes too tight to permit drainage, thereby drowning seed or denying sufficient moisture to near surface soil. During the early 1980s, the Program Office helped to support demonstrations of conservation tillage in the Black Creek, Indiana, watershed in the Maumee River basin. One outcome of these studies was to show that high farm yields were obtainable under conservation tillage in certain high

Conservation Tillage

Conservation tillage can reduce runoff of surface water and reduces soil erosion by water and wind. These factors aid in the retention of fertilizers in the soil and help limit the migration of fertilizers and agricultural chemicals into surface waters. There are several different types of conservation tillage practices which differ in the degree of soil disturbance created. The system selected by the farmer depends on physical circumstances; including soil type, crops, and the availability of the necessary equipment.

clay soils, given sufficient drainage systems. Construction of such systems (e.g., parallel tile outlet terraces) is expensive, however, and the drainage systems require the availability of outlet streams. Although Figure 4-3 does not adjust for soil types, it is useful for displaying the absolute rates of conservation tillage among counties.

Ambient Water Quality

Lakes Michigan, Huron, and Superior continue to remain well below their water quality objectives for phosphorus concentrations (see Figure 2-13). The State of Michigan's 1990 Water Quality Report indicates that a drinking water intake facility on Saginaw Bay has not found taste or odor problems since 1980, whereas this same facility had 56 days of such problems in 1974. Michigan also reports that phosphorus concentrations in the Saginaw River have fallen 73 percent since 1970.

During the period 1971 to 1986, Lake Ontario exhibited an average annual rate of decline in phosphorus concentrations of about 1 ppb, from about 25 to 9.9 ppb. Ontario is the only lake to exhibit a statistically significant decline in phosphorus concentrations between 1983 and 1986. Data from 1987 show a small, but statistically significant increase to 10.3 ppb. This may be partly attributable to an estimated 52 percent increase in phosphorus loadings from the Niagara River in 1986 over the average estimated loadings during 1981 through 1985. Increased Niagara River flows were a reason for the higher 1986 loadings estimate. Spring surveys from 1988 and 1989 found average concentrations of 9.9 and 10.2 ppb, respectively.

During 1978 through 1985, the average phosphorus concentration of Erie's central basin was about 15 ppb. In 1986 and 1987, the annual average phosphorus concentration in this basin declined to about 10 ppb. Preliminary analysis of data from the EPA spring 1988 and 1989 surveys shows ambient concentrations beneath the 10 ppb target level for phosphorus. (Spring surveys are best for detecting long-term trends in lake health since the waters are relatively well-mixed during this season.)

Preliminary results from the same surveys show average concentrations for the eastern basin to be beneath the 10 ppb target as they were on average for all surveys in 1987, in contrast to the period 1978 through 1986, when annual average ambient phosphorus fluctuated around 12 ppb. Phosphorus concentrations in the eastern basin have been consistently lower than those of the central and western basins.

During the 1970s, Erie's western basin had annual average concentrations of phosphorus ranging between 45 to 35 ppb. By 1982 to 1986, the average concentration had declined to about 32 to 24 ppb. The 1988 spring survey found concentrations in the western basin of Erie at 15.1 ppb for total phosphorus, very near the 15 ppb target. However, the annual average of all 1988 western basin surveys will likely be higher than the average of the spring survey once summer and fall results are included.

While oxygen depletion remains a problem in Lake Erie, the gross monthly oxygen depletion rates for the central basin of Lake Erie declined by about one third from 1986 to 1988.

Outlook

Phosphorus concentrations in Lakes Erie and Ontario have improved slightly during 1983 through 1988 to near-target levels, although concentrations in the western basin of Lake Erie remain above the target. Given variance in the monitoring data and small apparent declines in phosphorus, only the decline in Lake Ontario between 1983 and 1986 is statistically significant.

Phosphorus loadings are particularly affected by weather and by agricultural land use. Weather conditions seem to have played an important part in reducing phosphorus loadings and have in particular improved Lake Erie water quality by helping to compensate for low conservation tillage adoption. Without improved agricultural land use, it is likely that Lake Erie phosphorus concentrations will rise in the event of increased rainstorm activity and associated higher tributary flow.

Best management practices are important for protection of long-term farm yield as well as for Great Lakes water quality, especially in Lake Erie and Saginaw Bay. The rate of adoption of best management practices must improve, particularly in northwest Ohio. Although estimates of conservation tillage acreage are not precise and local conditions, including soil types, are variable, it appears that the rate of adoption of conservation tillage practices has been disappointing.

Other land use practices are also important in reducing phosphorus loadings. Programs that improve fertilizer management, protect or restore wetlands, pay farmers not to farm highly erodible land, establish vegetative filter-strips along stream and ditch banks, and reduce direct access to streams by livestock, are among practices that help prevent phosphorus loadings.

Though less significant than agricultural runoff, surface water runoff from the urban environment is a major source of nutrients and contaminants. Many urban communities do not have separate sanitary and storm sewers. High rainfall can exceed the capacity of a community's wastewater treatment system, resulting in overflows or bypasses of the treatment processes and direct discharge of untreated sewage to the Great Lakes. The Agency is pursuing various measures to address these impacts of urban drainage through improvements in stormwater retention, sewer separation, sewer rehabilitation, and improved wastewater treatment system practices. EPA and the States establish compliance schedules for municipal dischargers in order to reduce untreated loadings from this source.

There is a time lag between decreasing lake water phosphorus concentrations and improvements in dissolved oxygen levels. EPA estimates that reduction of most of Lake Erie's zones of oxygen depletion will take up to 5 years beyond the attainment of the desired ambient water column phosphorus objective. Furthermore, it should be emphasized that water quality objectives are only estimates of the chemical conditions necessary for a healthy lake ecosystem. EPA will continue monitoring oxygen depletion, algal bodies, and other indicators of lake health to evaluate whether the ambient phosphorus targets are effective or if further reductions in phosphorus concentrations will be needed.

Over the past 15 years, the United States and Canada have made very significant improvements in reducing Great Lakes phosphorus concentrations. Improved Lake Erie walleye fishery and the reduction of nuisance levels of algae are striking evidence of water quality improvement. Government programs for the lower lakes have provided transferable lessons for other parts of the country that suffer similar environmental problems, including Chesapeake Bay and other near-coastal waters. However, additional progress in reducing phosphorus loads to the lower lakes and Saginaw and Green Bays is needed. Better agricultural land use practices offer the promise for further environmental improvement, and are also essential to maintaining high farm productivity in the long-term.

Table 4-2. Submittals of U.S. Remedial Action Plans to the International Joint Commission (Actual and Projected).

Area of Concern	FY 1988		FY 1989		FY 1990		FY 1991		FY 1992		FY 1993	
	Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2
Illinois												
Waukegan Harbor							×	×				
Indiana												
Grand Calumet River/Indiana Harbor Canal							×			×		
Michigan												
Clinton River			✓	✓								
Deer Lake/Carp River/Carp Creek	✓	✓										
Kalamazoo River												
Manistique River	✓	✓										
Muskegon Lake	✓	✓										
River Raisin	✓	✓										
Rouge River			✓	✓								
Saginaw River/Saginaw Bay			✓	✓								
Torch Lake	✓	✓										
White Lake	✓	✓										
Michigan/Ontario												
Detroit River							×					
St. Clair River							×					
St. Marys River									×			
Minnesota/Wisconsin												
St. Louis River/Bay							×			×		

Key:

✓ = Actual Submittal
× = Estimated

Table 4-2. Submittals of U.S. Remedial Action Plans to the International Joint Commission (continued).

Area of Concern	FY 1988		FY 1989		FY 1990		FY 1991		FY 1992		FY 1993	
	Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2
New York												
Buffalo River					✓					×		
Eighteen Mile Creek											×	×
Oswego River					✓			×				
Rochester Embayment							×			×		
New York/Ontario												
Niagara River											×	×
St. Lawrence River							×			×		
Ohio												
Ashtabula River							×			×		
Black River							×			×		
Cuyahoga River							×			×		
Maumee River							×			×		
Wisconsin/Michigan												
Menominee River							✓	×		×		
Wisconsin												
Fox River/Green Bay	✓	✓										
Milwaukee Estuary							×			×		
Sheboygan Harbor					✓					×		
Cumulative Number Submitted (out of 30 possible)	7	7	10	10	13	10	26	13	27	24	29	26
Cumulative Percent Submitted (%)	23	23	33	33	43	33	87	43	90	80	97	87

Table 4-3. Selected Highlights of Progress in Areas of Concern.

Area of Concern/Major Known Impairments	Pre-1989 Activities in AOC	Fiscal Years 1989-1990 Activities in AOC	Fiscal Year 1991 Activities in AOC	Long Term Agenda
Lake Superior				
St. Louis River/Bay AOC includes Duluth (Minnesota)/Superior (Wisconsin) harbor, upstream past town of Cloquet, and southwestern Lake Superior. Sediments moderately to heavily polluted with metals; some are also contaminated with PAHs, PCBs, mercury and dioxin; fish consumption advisories for walleye; dredging delays over selection of disposal sites for polluted sediments.	Western Lake Superior Sanitary District WWTP was formed in 1978, replacing nine smaller community systems. It constructed an advanced wastewater treatment facility, greatly improving St. Louis River water quality and fisheries. EPA conducted an RI/FS of the Arrowhead Refinery Superfund NPL site in 1986-87 and of the Interlake NPL site in 1987-88. The Interlake site abuts the north bank of the St. Louis River, four miles upstream from Lake Superior. Site contamination includes tar seeping at the ground surface, a residue of coking and other industrial activities that started in the late 1800s and continued to 1950.	**1989:** EPA issued RODs for Arrowhead and Interlake sites. The selected Arrowhead remediation will include pumping and treating contaminated groundwater and incineration of contaminated soil. The selected Interlake remediation will include construction of a slurry wall to prevent coal tar from seeping into the St. Louis River. Minnesota developing RAP with Wisconsin. Active citizens advisory group with five technical committees. **1990:** Stage 1 draft RAP provided to EPA for comment.	MPCA to submit Stage 1 RAP to IJC. Monitoring is planned to further define the extent and causes of problems.	MPCA to submit Stage 2 RAP to IJC in FY 1992.

Key:

AOC	Area of Concern	PAH	Polyaromatic Hydrocarbons
ARCS	Assessment and Remediation of Contaminated Sediments	PCB	Polychlorinated Biphenyls
BMP	Best Management Practice	PRP	Potentially Responsible Party
CSO	Combined Sewer Overflow	RAP	Remedial Action Plan
IDEM	Indiana Department of Environmental Management	RCRA	Resource Conservation and Recovery Act
IJC	International Joint Commission	RI/FS	Remedial Investigation/Feasibility Study
MDNR	Michigan Department of Natural Resources	ROD	Record of Decision
MDPH	Michigan Department of Public Health	SCS	Soil Conservation Service
MPCA	Minnesota Pollution Control Agency	USDA	U.S. Department of Agriculture
NOAA	National Oceanic and Atmospheric Administration	USGS	U.S. Geological Survey
NPDES	National Pollutant Discharge Elimination System	WDNR	Wisconsin Department of Natural Resources
NPL	National Priorities List	WWTP	Wastewater Treatment Plant
NYDEC	New York Department of Environmental Conservation		

Table 4-3. Selected Highlights of Progress in Areas of Concern (continued).

Area of Concern/Major Known Impairments	Pre-1989 Activities in AOC	Fiscal Years 1989-1990 Activities in AOC	Fiscal Year 1991 Activities in AOC	Long Term Agenda
Torch Lake This AOC is located in Michigan's Keweenaw Peninsula. About 200 million tons of copper mine tailings were dumped into 2,718 acre Torch Lake between 1868-1968, filling 20% of the lake's original volume. Sediments are highly contaminated with copper; in late 1970s, tumors were found in mature walleye and sauger; fish consumption advisories for walleye, sauger and larger smallmouth bass.	EPA designated lake as an NPL site in 1984, began search for PRPs in 1985 and concluded negotiations with three in 1988. The site is large -- encompassing Torch Lake, the northern half of Portage Lake, tributaries, and the northern half of the Keewenaw Waterway. It is divided into three "Operable Units." MDNR submitted Stages 1 and 2 RAP to IJC in FY 1988.	1989: EPA and MDNR began RI/FS on operable unit 1 (surface tailings on western shore of Torch Lake). MDNR completed analyses of fish taken from lake in 1988. Tumors were not found and contaminant levels in fish were very low. 1990: EPA and MDNR continued RI/FS for operable unit 1. EPA started RI/FS for operable units 2 (Torch Lake) and 3 (Keweenaw Waterway). Field investigations completed December 1990.	EPA to issue an ROD for operable unit 1 in September.	Implement Superfund remediations.
Deer Lake/Carp River/Carp Creek This AOC in Michigan's Upper Peninsula includes 907 acre Deer Lake and 20 miles of Carp River to Lake Superior. Sediments are highly contaminated with mercury; fish consumption advisories for all fish species since 1981.	Sources of mercury eliminated in early 1980's. Consent Agreement between State and Cleveland Cliffs Iron Company signed in 1984 under which monitoring studies of mercury in fish will be conducted for ten years. Lake drawn down and contaminated fish were killed with rotenone in 1985/1986. Lake restocked with walleye and perch in 1987. New regional WWTP with secondary treatment replaced three primary WWTPs that used to discharge to Deer Lake via Carp Creek. MDNR submitted Stages 1 and 2 RAP to IJC in FY 1988.	1989 and 1990: MDNR conducted fish tissue, water quality, bottom sediment and sedimentation rate studies to monitor recovery. MDNR designated Deer Lake as a catch and release fishery until 1996 to limit consumption of contaminated fish. Levels of mercury in northern pike have fallen by one-half since 1987.	MDNR will continue monitoring contaminants in fish.	Cleveland Cliffs Iron Company and MDNR will continue to monitor concentrations of mercury in fish tissues through 1996.

Table 4-3. Selected Highlights of Progress in Areas of Concern (continued).

Area of Concern/Major Known Impairments	Pre-1989 Activities in AOC	Fiscal Years 1989-1990 Activities in AOC	Fiscal Year 1991 Activities in AOC	Long Term Agenda
Lake Michigan				
Manistique River AOC is the lower 1.7 miles of river flowing into northern Michigan from Michigan's Upper Peninsula. Adjacent town: Manistique (Michigan). Sediments heavily polluted with PCBs and metals; fish consumption advisories for carp.	Manistique WWTP was upgraded to secondary treatment in 1977. In 1986, Manistique Papers Incorporated placed a temporary erosion barrier over soils suspected to be a source of PCBs to the river and upgraded its wastewater quality. Result is greatly reduced oxygen demand and toxic substance loads to the river. MDNR submitted Stages 1 and 2 RAP to IJC in FY 1988.	1989: MDNR analysis of channel catfish from Manistique harbor found PCB levels less than half those that would justify a fish consumption advisory by MDPH. 1990: MDNR and Army Corps of Engineers conducted sediment contamination characterization of river. Michigan Water Resources Commission approved a new five-year NPDES permit for Manistique Papers with stricter limits on zinc, copper and silver. MDNR conducted 28-day caged-fish study to determine uptake of PCBs.		Study effects of dredging contaminated sediments in harbor. Evaluate contaminated sediment effects on biota and evaluate remedial options.

Table 4-3. Selected Highlights of Progress in Areas of Concern (continued).

Area of Concern/Major Known Impairments	Pre-1989 Activities in AOC	Fiscal Years 1989-1990 Activities in AOC	Fiscal Year 1991 Activities in AOC	Long Term Agenda
Menominee River AOC is the lower three miles of river flowing into Green Bay. The river forms the boundary between Wisconsin and the Upper Peninsula of Michigan. Adjacent towns: Menominee (Michigan) and Marinette (Wisconsin). Groundwater grossly contaminated with arsenic near Ansul Company; sediments in river highly contaminated with arsenic and also with mercury and PCBs; fish consumption advisories for smallmouth bass, perch, white bass, white sucker, bullheads, carp, trout, walleye, splake, salmon and pike; dredging delayed due to concerns over disposal of polluted sediments; bacteriological contamination caused by CSOs; loss of fish and wildlife habitat.	Ansul Company began pumping and treating arsenic contaminated groundwater in 1981 under a Consent Order.	1989: Wastewater connection from Menominee Paper to the Menominee WWTP eliminated. This action should improve effluent quality at both facilities. Menominee Paper also started enhanced wastewater treatment at its facility. City of Menominee signed EPA and WDNR Consent Order, agreeing to submit plan for the elimination of CSOs. Wisconsin developed RAP with Michigan in support. Active citizens advisory group, with three technical subcommittees. 1990: EPA and WDNR issued RCRA Consent Order regarding arsenic contamination to Ansul Company. Menominee Paper paid $2.1 million penalty for Clean Water Act violations under Consent Decree. City of Menominee entered into Consent Agreement with EPA to correct its CSOs.	Submit Stage 1 RAP to IJC in October 1990. Continue Stage 2 RAP preparation. Analytical work to support RAP includes: fish contaminants, sediment and water quality monitoring; and toxicity testing of bottom waters. Army Corps of Engineers to conduct sediment quality reconnaissance to prepare for dredging of navigational channel. Ansul Company to conduct RCRA facility investigation with corrective measures study under Consent Order. Ansul Company entered into a RCRA Consent Agreement with State of Wisconsin and EPA to outline and implement corrective actions for arsenic contaminated sediments. Paint sludge from a site owned by Flanders Industries leaches into Green Bay. MDNR to remove sludge and metal in Spring 1991.	WDNR and MDNR plan to submit Stage 2 RAP to IJC in FY 1992. Upgrade municipal sewer systems by correcting combined sewer overflows.

Table 4-3. Selected Highlights of Progress in Areas of Concern (continued).

Area of Concern/Major Known Impairments	Pre-1989 Activities in AOC	Fiscal Years 1989-1990 Activities in AOC	Fiscal Year 1991 Activities in AOC	Long Term Agenda
Fox River/Green Bay Sediments heavily polluted with metals, oil and grease, and PCBs; high tumor incidence in some fish; deformities and reproductive impairments in fish-eating birds; eutrophic conditions in lower bay; bacterial contamination; fish consumption advisories for smallmouth bass, perch, white bass, white sucker, bullheads, drum, channel catfish, carp, trout, walleye, splake, salmon and pike; concerns over polluted sediments have made siting of dredged material disposal facility problematic.	Citizens advisory group met monthly from 1986 to 1988 to assist in RAP development. WDNR submitted Stages 1 and 2 RAP to IJC in FY 1988. During 1987-88, WDNR and EPA, joined by universities and other agencies, designed a major study of the sources and fates of four pollutants (PCBs, cadmium, lead and dieldrin) in Green Bay.	**1989:** Wisconsin established new water quality standards to limit toxics discharges. Green Bay Mass Balance Study field work began. Plans established to upgrade municipal wastewater treatment at Green Bay and Appleton. Nonpoint source control model ordinances drafted and public participation incentives instituted. Wetlands preservation and restoration activities begun. SCS began a ten-year East River Priority Watershed Project. Barrier to sea lamprey migration up Fox River completed. **1990:** Green Bay Mass Balance Study field work finished and analysis of samples continued. EPA started an RI/FS at the Fort Howard Paper *Superfund* NPL site. RAP implementation committee has been meeting regularly since mid-1988 and published two annual reports. City of DePere urban runoff detention ponds begun.	Prepare report on Green Bay Mass Balance Study findings.	Develop approaches for dealing with contaminated sediments. Other emphases are rural and urban nonpoint sources, fish and wildlife habitat, and public access to the shoreline.

Table 4-3. Selected Highlights of Progress in Areas of Concern (continued).

Area of Concern/Major Known Impairments	Pre-1989 Activities in AOC	Fiscal Years 1989-1990 Activities in AOC	Fiscal Year 1991 Activities in AOC	Long Term Agenda
Sheboygan River and Harbor The AOC includes Sheboygan Harbor and about 12 miles of river up to Sheboygan Falls. Sediments heavily polluted with PCBs and metals; fish consumption advisories for bluegill, crappie, rock bass, carp, smallmouth bass, walleye, pike, trout, catfish and salmon; waterfowl consumption advisory; bacterial contamination in water column; navigational dredging discontinued in 1969 due to lack of acceptable disposal site for polluted sediments.	Kohler landfill site designated Superfund NPL site in 1984. RI/FS begun in 1986. River and harbor designated Superfund NPL site in 1985. In April 1986, EPA and WDNR signed Consent Order with Tecumseh Products Company, a PRP, to conduct the RI/FS for the Superfund site. WDNR began drafting RAP in June 1987. WDNR prepared draft RAP during 1988.	**1989:** WDNR held public meetings and hearings to obtain public comment on draft RAP. Tecumseh Products Incorporated, a PRP, continued the RI/FS of the river and harbor. **1990:** WDNR submitted Stage 1 RAP to IJC. About 2,000 cubic yards of sediments were removed from the upper river in December 1989 as part of the RI/FS. These were placed into a confined treatment facility for biodegradation studies that will use bacteria to try to decompose PCBs in the sediments. The RI/FS also continued to study other remedial alternatives. Kohler landfill RI/FS continued.	Continue RI/FS of Superfund NPL site. WDNR to stock Sheboygan River with steelhead trout for study of PCB uptake. Re-establish Sheboygan County Water Quality Task Force as citizen advisory committee and establish committee structure to work towards Stage 2 RAP. Complete Sheboygan River Priority Watershed Plan addressing nonpoint sources of pollution. Continue to implement Onion River Watershed Project.	WDNR plans to submit Stage 2 RAP to IJC in FY 1992. Superfund proposed cleanup plan due in Spring 1992. Clean up sediments, protect wetlands, improve sewage systems to reduce bacterial contamination, control sources of toxics.

Table 4-3. Selected Highlights of Progress in Areas of Concern (continued).

Area of Concern/Major Known Impairments	Pre-1989 Activities in AOC	Fiscal Years 1989-1990 Activities in AOC	Fiscal Year 1991 Activities in AOC	Long Term Agenda
Milwaukee Harbor Water and sediment contamination with conventional pollutants; sediments heavily polluted with metals and PCBs and also contaminated with pesticides; eutrophic conditions; fish consumption advisories for crappie, perch, carp, northern pike, smallmouth bass, redhorse sucker, white sucker and rock bass; waterfowl consumption advisories; dredging restrictions; absence of desirable fish and aquatic species; loss of habitat; beach closings.	Over $500 million in sewage system upgrades have been made since 1972. Moss-American site, a source of PAHs to Little Menominee River, was designated a Superfund NPL site in 1983. RI/FS begun in 1987.	1989: Major combined sewer overflow abatement project and upgrade of WWTP by Milwaukee Metropolitan Sewerage District underway. WDNR implementing 5 priority watershed nonpoint source control projects in the basin. Corps of Engineers conducted harbor sediment sampling program including chemical and bioassay testing. 1990: WDNR provided Stage 1 draft RAP to EPA for comment. Public meeting held in June to obtain comments. Continued sewage system improvements. Study of causes of contaminant levels in resident waterfowl underway.	WDNR plans to submit Stage 1 RAP to IJC. Continue improvements to sewage system. Technical Advisory Committee to develop a monitoring strategy.	WDNR plans to submit Stage 2 RAP to IJC in FY 1993. Startup of deep-tunnel to increase wet weather treatment capacity. Corps of Engineers may develop a second confined disposal facility for dredged material from the harbor.

Table 4-3. Selected Highlights of Progress in Areas of Concern (continued).

Area of Concern/Major Known Impairments	Pre-1989 Activities in AOC	Fiscal Years 1989-1990 Activities in AOC	Fiscal Year 1991 Activities in AOC	Long Term Agenda
Waukegan Harbor Waukegan is located on the west shore of Lake Michigan, about 40 miles north of Chicago, Illinois. Gross PCB contamination of sediments; fish consumption advisories for all fish species; dredging delayed by problems in siting disposal facility for polluted sediments.	RAP deferred due to legal activity over cleanup liability. Legal actions undertaken against Outboard Marine Corporation (OMC) starting in 1978. Site included on original Superfund NPL in 1982. EPA conducted RI/FS and issued ROD in 1984 to commence cleanup of site.	1989: OMC agreed to Consent Order that stipulated it would clean up (under EPA supervision) areas of Waukegan harbor and of OMC property containing PCB contamination. Cleanup plans call for dredging parts of the harbor, constructing containment cells for less contaminated soil and sediment, and extracting PCBs from soil and sediment for incineration. More than 99% of the mass of PCBs in the harbor will be removed and either confined or destroyed. 1990: OMC continued cleanup plan implementation. Construction of a new slip was delayed by discovery of unrelated site of PAH contamination near intended location of new slip.	Illinois EPA plans to submit Stage 1 RAP to IJC. OMC to continue cleanup activities. Illinois EPA plans to submit Stage 2 RAP to IJC in FY 1991.	Cleanup actions by OMC to be completed during 1993.

Table 4-3. Selected Highlights of Progress in Areas of Concern (continued).

Area of Concern/Major Known Impairments	Pre-1989 Activities in AOC	Fiscal Years 1989-1990 Activities in AOC	Fiscal Year 1991 Activities in AOC	Long Term Agenda
Grand Calumet River/ Indiana Harbor Canal AOC is 13 miles long. The river flows into the southernmost part of Lake Michigan. Sediments heavily contaminated with metals, conventional pollutants, PCBs and PAHs; water quality problems due to conventional pollutants; fish tumors and fin rot found; fish consumption advisory for all fish species; dredging delayed over problems in siting disposal facility for polluted sediments.	EPA and IDEM completed N.W. Indiana Environmental Action Plan in 1987.	**1989:** USGS completed study of groundwater flow in the area. EPA ARCS study sampled contaminated sediments. **1990:** Consent Order calls for USX to undertake $34 million in sediment studies and cleanup. EPA ARCS study sampling continued.	IDEM plans to submit Stage 1 RAP to IJC.	IDEM plans to submit Stage 2 RAP to IJC in FY 1992. Address problems posed by large quantity of highly toxic sediments and by combined sewer overflows during rain storms.

Table 4-3. Selected Highlights of Progress in Areas of Concern (continued).

Area of Concern/Major Known Impairments	Pre-1989 Activities in AOC	Fiscal Years 1989-1990 Activities in AOC	Fiscal Year 1991 Activities in AOC	Long Term Agenda
Kalamazoo River AOC is the lower 28 miles of river that flows into southeastern Lake Michigan. Sediments heavily polluted with PCBs; fish consumption advisories for all fish species.	MDNR finished a Michigan Act 307 RI/FS of the Kalamazoo River in 1986. This study recommended remedial actions at Bryant Mill Pond and at three impoundments (Plainwell, Otsego, and Trowbridge), and further study of Otsego City and Allegan impoundments, and of Lake Allegan. Second draft of RAP completed in December 1987.	1989: EPA proposed Bryant Mill Pond/ Portage Creek/Kalamazoo River for Superfund NPL. RAP deferred due to legal actions. Three PRPs identified: Allied Paper Incorporated, Georgia Pacific Corporation, and Simpson Plainwell Paper Company. Under federal court supervision, Allied Paper is developing plans for interim remedial actions at Bryant Mill Pond on Portage Creek. Georgia Pacific is developing remedial plan for the Willow site. MDNR developed plans for interim remedial measures for former impoundments at Plainwell, Otsego and Trowbridge. 1990: MDNR began interim remedial measures for Plainwell, Otsego and Trowbridge. MDNR conducted studies to identify extent of contamination and feasible remedial actions at Lake Allegan and at the Allegan and Otsego impoundments. Three PRPs agreed to conduct RI/FS for Kalamazoo River NPL site. Allied Paper began removal action at Bryant Mill Pond.	PRP to begin Superfund RI/FS in 1991 under EPA and MDNR supervision. Georgia Pacific Corporation to complete investigation of PCB disposal site "A". Georgia Pacific to submit proposed remedial action at the Willow site and to complete investigation of PCB disposal site at Kings Highway. Follow-up studies on sediment burial, partition coefficients and erosion rates for Otsego City Impoundment, Allegan City Impoundment and Lake Allegan to be completed in June.	Complete RAP with results from Superfund RI/FS. RI/FS will take three to five years to complete. While Superfund RI/FS is underway, public will be consulted pursuant to the *Superfund* process.

Table 4-3. Selected Highlights of Progress in Areas of Concern (continued).

Area of Concern/Major Known Impairments	Pre-1989 Activities in AOC	Fiscal Years 1989-1990 Activities in AOC	Fiscal Year 1991 Activities in AOC	Long Term Agenda
Muskegon Lake Lake is 4,150 acres in size located along east shore of Lake Michigan just north of City of Muskegon. Eutrophication; some shoreline sediments heavily polluted with metals; fish consumption advisories for carp, largemouth bass, large walleye.	Diversion of municipal and industrial wastewater discharges from the lake and its tributaries to the Muskegon County Wastewater Treatment System and implementation of an industrial pretreatment program have greatly reduced waste loads to the lake and improved water quality and fish habitat. EPA listed the Ott/Story/Cordova Chemical Company site on the Superfund NPL in 1982. Contaminated groundwater from the site was found to be contaminating sediments and water in Little Bear Creek which flows into Bear Lake which connects to Muskegon Lake. EPA began an RI/FS at the site in January 1988. MDNR submitted Stages 1 and 2 RAP to IJC in FY 1988.	1989: MDNR collected fish from Lake Michigan off the mouth of Muskegon Lake in 1988. These fish were also found with unacceptable levels of PCBs and mercury which may indicate a regional phenomenon like atmospheric deposition of contaminants rather than one localized to Muskegon Lake. EPA completed remedial investigation at the Ott/Story/Cordova Chemical Co. site and began feasibility study. EPA and MDNR proposed a cleanup plan to pump, treat and monitor groundwater. Average Spring phosphorus concentrations have fallen below desired goal. 1990: EPA completed feasibility study at the Ott/Story/Cordova Chemical Co. site.	MDNR to complete analyses of sediment and benthic samples.	The RAP recommends continued implementation of ongoing programs and additional studies of stormwater runoff effects on Ryerson and Ruddiman creeks, Division Street stormwater discharge, sediment and benthic health, and fish tissues.

Table 4-3. Selected Highlights of Progress in Areas of Concern (continued).

Area of Concern/Major Known Impairments	Pre-1989 Activities in AOC	Fiscal Years 1989-1990 Activities in AOC	Fiscal Year 1991 Activities in AOC	Long Term Agenda
White Lake Lake is 2,570 acres in size located along east shore of Lake Michigan near the communities of Montague and Whitehall. Groundwater contaminated with organic solvents; some sediments are heavily polluted with chromium; fish consumption advisory for carp due to PCBs and chlordane.	Diversion of municipal and industrial wastewater discharges from the lake and its tributaries to the Muskegon County Wastewater Treatment System and implementation of an industrial pretreatment program have greatly reduced waste loads to the lake and improved water quality and fish habitat. A 1979 Consent Judgement between Hooker Chemical Company and the State of Michigan required company to halt flow of contaminated groundwater to the lake. Company installed purge wells and a carbon absorption treatment system. In 1985, the State filed to enforce provisions of the Consent Judgement to force company to improve its purge well system. MDNR submitted Stages 1 and 2 RAP to IJC in FY 1988.	**1989** Hooker Chemical Company continued treatment of contaminated groundwater. **1990** System of cluster wells was installed to monitor static water levels and to assure the contaminant plume did not reach the lake. Data collected from March 1987 to January 1990 for the purge-well system indicated that the plume is being captured.	MDNR to complete analyses of sediment and benthic samples.	

Table 4-3. Selected Highlights of Progress in Areas of Concern (continued).

Area of Concern/Major Known Impairments	Pre-1989 Activities in AOC	Fiscal Years 1989-1990 Activities in AOC	Fiscal Year 1991 Activities in AOC	Long Term Agenda
Lake Huron				
Saginaw River/Saginaw Bay Bay is 1,143 square miles, with an 8,709 square mile drainage basin, the largest in Michigan. Water contaminated with metals, PCBs, dioxins and phenols; sediments moderately to heavily polluted with metals and PCBs; eutrophic conditions; apparent reproductive impairments and deformities in fish-eating birds; fish consumption advisories for trout, carp and catfish in the bay and for all species in the river; dredging in upper river delayed over problems in siting disposal facility for polluted sediments; bacterial contamination.	Ban on the use of high phosphate detergents in 1977 and wastewater treatment improvements have greatly reduced phosphorus loads to the river and bay. RAP was completed in September 1988 and identified 101 actions over a ten-year period that should be taken to address environmental problems. Surveys of benthic macroinvertebrate communities by NOAA and MDNR (1986-89). 1987 ongoing: MDNR has purchased $7 million worth of land in the Saginaw Bay area for the preservation of habitat and to improve recreational access.	**1989:** MDNR submitted Stages 1 and 2 RAP to IJC. MDNR and U. of Michigan continued extensive sediment sampling in the river and bay to assess the impacts of the severe flood in 1986 on the distribution of sediment contamination (1988-93). MDNR began stocking mayfly eggs in Saginaw Bay to reestablish this native benthic macroinvertebrate (1989-ongoing). General Motors Grey Iron facility ended direct discharge to Saginaw River and began wastewater pretreatment before delivery to Saginaw WWTP.	EPA plans to sample sediments as part of ARCS study. EPA Saginaw Bay Watershed Project to characterize aquatic biota impacts from impaired streams and formulate remedial strategies. EPA, USDA, and MDNR to implement nonpoint source control measures in the Saginaw Bay watershed including BMPs for agricultural nonpoint pollution control, urban stormwater management and sedimentation control (1991-ongoing). USDA will also begin a five-year program to encourage agribusinesses to use BMPs to decrease phosphorus, nitrate and pesticide runoff. Saginaw Township to construct retention basin to control CSOs.	Develop approaches to address contaminated sediment problems. Locate sources of ongoing pollutant loadings, including inflow of contaminated groundwater. There are a large number of discontinued waste disposal sites along the Saginaw River. Continued use of USDA BMP efforts. Continued implementation of nonpoint source BMPs. Construct retention basins for CSOs.

Table 4-3. Selected Highlights of Progress in Areas of Concern (continued).

Area of Concern/Major Known Impairments	Pre-1989 Activities in AOC	Fiscal Years 1989-1990 Activities in AOC	Fiscal Year 1991 Activities in AOC	Long Term Agenda
Saginaw River/Saginaw Bay (continued)	1987 ongoing: At its Engine Division site, General Motors has constructed a 65-ft. deep slurry-wall to stop PCB migration into the Saginaw River via groundwater flow. Contaminated sediments have been removed from facility sewers. EPA study of Saginaw Bay confined disposal facility assessed whether contaminant transport through dike walls posed ecological risk. Results indicated that transport could not be demonstrated (1987-89). Saginaw township constructed new WWTP in 1988. MDNR and U. of Michigan began surveys of walleye larvae and young to evaluate walleye natural reproduction.	1990: Interpreted results of MDNR/U. of Michigan sediment survey of river and bay conducted in previous year. EPA ARCS *study collected* Saginaw Bay sediment samples for their chemistry, biological toxicity and benthic community structure. The U.S. Fish and Wildlife Service began to survey fish (bullheads) for tumors. City of Saginaw's new discharge permit mandates construction of six retention basins for CSOs. Two to be completed by 1992. Restocking of benthic macro-invertebrates in *selected* Saginaw Bay locations. NOAA's Sea Grant Program opened Saginaw Bay Research Institute at Saginaw Valley State. NOAA began a multi-year study to characterize the Saginaw Bay plankton community before and after the expected invasion of zebra mussels.	DOW Chemical Company is operating under a MDNR Order to conduct additional studies to reduce dioxin discharge. MDNR to nominate Saginaw Bay *for inclusion in* EPA's National Estuary Program. MDNR to continue atmospheric deposition monitoring. MDNR will continue investigation of the Act 307 landfill site on Middle Ground Island, two miles upstream from Saginaw Bay. Bay City, a PRP, is cooperating.	

Table 4-3. Selected Highlights of Progress in Areas of Concern (continued).

Area of Concern/Major Known Impairments	Pre-1989 Activities in AOC	Fiscal Years 1989-1990 Activities in AOC	Fiscal Year 1991 Activities in AOC	Long Term Agenda
Lake Erie				
Clinton River The Clinton River flows north of Detroit and empties into Lake St. Clair. Sediments are moderately to heavily polluted with PCBs, metals, oil and grease; eutrophication and bacterial problems in water column; fish consumption advisory for carp.	G & H Landfill, adjoining the Clinton River near Utica, Michigan was placed on Superfund NPL in 1983. EPA and MDNR conducted an RI/FS of the nearby Liquid-Disposal NPL site from 1984-87. This property is one-quarter mile from the Clinton River and was the site of an industrial waste incinerator from 1967 until closed by EPA in 1982. EPA conducted four removal actions between 1982-85 to end immediate threats to human health. EPA issued ROD for the Liquid-Disposal site cleanup in 1987. Improvements to WWTPs of seven towns made during the 1980's have greatly reduced conventional pollutant and bacterial contamination.	**1989:** MDNR submitted Stages 1 and 2 RAP to IJC. MDNR conducted caged-fish study to evaluate PCB uptake at the mouth of the Clinton River. Results expected in 1991. EPA and MDNR continued RI/FS for G & H Landfill site. 500 PRPs agreed to sign Consent Decree for completion of the remedy at Liquid Disposal, Inc. site. **1990:** EPA and MDNR proposed cleanup plan for G & H Landfill site. Corps of Engineers dredged navigation channel, placing sediments in confined disposal facility. Armada and Mt. Clemens WWTPs completed upgrades to reduce the discharge of both conventional and toxic pollutants.	MDNR plans to investigate the sources of PCBs to the Clinton River from Mt. Clemens to its mouth. This river segment is designated an Act 307 site. MDNR to determine BMPs to control nonpoint sources of pollution to Gallagher Creek. Army Corps of Engineers plans dredging project in navigation channel. Complete remedial design and begin its implementation at Liquid-Disposal site.	Correction of combined sewer overflows in Red Run drainage will require large capital investment.

Table 4-3. Selected Highlights of Progress in Areas of Concern (continued).

Area of Concern/Major Known Impairments	Pre-1989 Activities in AOC	Fiscal Years 1989-1990 Activities in AOC	Fiscal Year 1991 Activities in AOC	Long Term Agenda
Rouge River The Rouge River watershed is the longest and most densely populated and industrialized area in southeastern Michigan. About 40 miles of river flowing through metropolitan Detroit do not meet water quality standards. Some eutrophication problems in the water column; bacteriological contamination of water column; sediments heavily polluted with metals, PCBs and other organics; fish consumption advisories for carp, pike, largemouth bass, white suckers and catfish.	Development of RAP (1985-1988) with assistance of Southeast Michigan Council of Governments.	**1989:** MDNR submitted Stages 1 and 2 RAP to IJC. Since 1988, local, State and federal governments have agreed to fund over $450 million in sewer improvements. *Wayne County Health Department* began to investigate illegal discharges via storm sewers. **1990:** EPA awarded $400K for studies of Rouge River combined sewer overflow/stormwater. Studies of Rouge indicate water column toxicity follows rainstorms, indicating that CSOs, stormwater and nonpoint runoff are major sources of problems. MDNR issued CSO permits issued to all Rouge River municipalities with CSOs. All are being contested in court.	SCS to implement BMPs in a three county area, including the Lower Branch of the Rouge River. Town of Farmington to complete separation of combined sewers.	PCB contamination appears to be the result of discontinued discharges, of spills, and of CSOs. CSOs and nonpoint source stormwater runoff are the largest sources of pollutants to the river. Large long-term sewer system improvements needed to reduce combined sewer overflow loads to river. MDNR plans annual updates of RAP Executive Summary. Development of regional GIS system.

Table 4-3. Selected Highlights of Progress in Areas of Concern (continued).

Area of Concern/Major Known Impairments	Pre-1989 Activities in AOC	Fiscal Years 1989-1990 Activities in AOC	Fiscal Year 1991 Activities in AOC	Long Term Agenda
River Raisin AOC is the lower 2.6 miles of river and extending one-half mile into western Lake Erie. Numerous landfills and industrial sites border the river. Metals and PCB contamination of water column; sediments heavily polluted with metals and PCBs; fish consumption advisories for carp and large white bass.	MDNR submitted Stages 1 and 2 RAP to IJC in FY 1988. Michigan designated the lower portion of the river an Act 307 site in August 1986. MDNR removed 300 PCB-contaminated barrels and transformers from Consolidated Packaging site. MDNR completed Phase One of remedial investigation of east side of the Port of Monroe landfill.	MDNR conducted sediment sampling of river. Cleanups pending at five waste sites along river: Port of Monroe Landfill, Ford Motor Company property, Consolidated Packaging - South Plant, Detroit Edison property and City of Monroe Landfill. All have documented overland and suspected groundwater routes for movement of metals and toxic organics (PCBs). Sediment sampling in 1988-89 showed the most impacted area to be from the turning basin to the mouth. Caged-fish studies showed River Raisin fish to have PCB uptake rates greater than Kalamazoo or Saginaw Rivers.	Remedial investigation of the west side of the Port of Monroe Landfill scheduled for Spring. Remedial investigation to begin for entire Consolidated Packaging Plant. Ford Motor Company is developing cleanup plan for its hazardous waste site. MDNR to begin RI/FS for Consolidated Packaging site. MDNR to begin RI/FS for west side of Port of Monroe Landfill.	Reduce loadings from waste and industrial sites along the river. Field studies to determine the lateral and vertical extent of sediment contamination and transport of contaminants from shore. Conduct remedial investigations of Detroit Edison property and City of Monroe Landfill.
Maumee River AOC is the lower 21 miles of river flowing into western Lake Erie. Water quality problems due to ammonia, metals and bacteria; sediments moderately to heavily polluted with metals, PCBs and PAHs.	City of Toledo CSO abatement program began in 1985, to be completed in 1996. Dura and Stickney landfills were investigated and cleanup begun in 1986. Upgrades of Toledo WWTP completed in 1988. Ohio EPA contracted with Toledo Metropolitan Area Council of Governments to provide assistance with public involvement in RAP process (1985-ongoing).	1989: Nonpoint source and combined sewer overflows control measures instituted. Remedial investigations and actions underway at several landfills and dump sites in river basin. 1990: Ohio EPA continued RAP development activities. Continued WWTP improvements and combined sewer overflows projects.	Ohio EPA plans to submit Stages 1 and 2 RAP to IJC.	Continue development of Swan Creek Wetland Recreation Project. Investigate contamination from landfills, dumps, and waste sites. Continued public education and involvement, establish a committee to review the success of remedial actions.

Table 4-3. Selected Highlights of Progress in Areas of Concern (continued).

Area of Concern/Major Known Impairments	Pre-1989 Activities in AOC	Fiscal Years 1989-1990 Activities in AOC	Fiscal Year 1991 Activities in AOC	Long Term Agenda
Black River Water quality problems due to metals, ammonia, phenol, bacteria and cyanide; sediments heavily polluted with metals, oil and grease and PAHs; fish consumption advisories for all fish species; bacteriological contamination of water column.	Agreement reached between EPA and U.S. Steel in 1985 under which the company will dredge PAH contaminated sediments around one of its outfalls.	**1989:** New westside Lorain WWTP put into operation to relieve the overloaded eastside plant. Upgrades to Elyria WWTP under a Consent Judgement from U.S. District Court. **1990:** U.S. Steel (now USX) began dredging of contaminated sediments.	Ohio EPA plans to establish a local advisory board and begin public involvement process. Oberlin College received a grant from the Nord Family Foundation to produce public information materials and to begin compiling available data for the phase I draft.	Ohio EPA plans to submit Stage 1 RAP to IJC in FY 1992. Ohio EPA plans to submit Stage 2 RAP to IJC in FY 1993. Ohio EPA plans to conduct an intensive survey of the river in 1992.
Cuyahoga River The lower six miles of the river flowing through Cleveland is most degraded. Water quality problems due to metals, cyanide, ammonia, phenol and bacteria; sediments heavily polluted with metals, oil and grease, PCBs, DDT, PAHs and phthalates.		**1989:** A three-year fish tissue sampling program developed and started. Study conducted of bacterial contamination of the river downstream of Akron. **1990:** Monitor bacterial conditions in river near Cleveland. LTV Steel began a new wastewater biological treatment process, a $20 million investment, to reduce loadings of ammonia, phenols and cyanide.	Ohio EPA plans to submit Stage 1 RAP to IJC. Ohio EPA plans to continue fish tissue sampling program and bacterial monitoring program.	Ohio EPA plans to submit Stage 1 RAP to IJC in FY 1992. Continue studies and education projects for nonpoint source, stormwater and combined sewer overflow sources.

Table 4-3. Selected Highlights of Progress in Areas of Concern (continued).

Area of Concern/Major Known Impairments	Pre-1989 Activities in AOC	Fiscal Years 1989-1990 Activities in AOC	Fiscal Year 1991 Activities in AOC	Long Term Agenda
Ashtabula River The AOC includes the lower two miles of the river, the harbor, adjacent shore, and Fields Brook. Water quality problems due to metals; sediments heavily polluted with metals and PCBs; fish consumption advisories for all fish species; dredging delayed due to problems in siting disposal facility for polluted sediments.	In 1985-1986, EPA conducted an RI/FS of Fields Brook, a tributary to the river. EPA issued an ROD in 1986. Navigation dredging by Corps of Engineers deferred due to lack of acceptable disposal site for heavily contaminated river sediments.	**1989:** Biological study of river conducted by Ohio EPA as part of natural resource damage assessment of the river, harbor, nearshore and Fields Brook. EPA issued Administrative Order for PRPs at Fields Brook Superfund site to conduct studies to determine impacts from the site on the river and a drinking water intake in Lake Erie. Other studies conducted to further assess cleanup needs. **1990:** Fields Brook PRPs continue studies.	Ohio EPA plans to submit Stage 1 RAP to IJC. Corps of Engineers plans to conduct interim dredging to relieve navigation problem. Continuing investigation on Fields Brook pursuant to RI/FS. Continue search for toxic sediment disposal site.	Ohio EPA plans to submit Stage 2 RAP to IJC in FY 1992. Dredging and disposal of contaminated river sediments.
Lake Ontario **Buffalo River** Water quality problems with metals, dieldrin, BHC and chlordane; sediments heavily polluted with metals, oil and grease, PAHs and pesticides; fish consumption advisory for carp.		**1990:** NYDEC submitted Stage 1 RAP to IJC.	Investigations are underway to determine remedial recommendations related to contaminated sediments, sediment transport, dissolved oxygen, and fish habitat.	Annual RAP implementation updates will be prepared and investigations will be conducted where data gaps exist.
Eighteen Mile Creek Water quality problems due to metals, DDT, dieldrin and trichlorofluoromethane; sediments moderately to heavily polluted with metals.	Treatment upgrades by numerous municipal and industrial dischargers.			NYDEC plans to submit Stages 1 and 2 RAP to IJC in FY 1993.

Table 4-3. Selected Highlights of Progress in Areas of Concern (continued).

Area of Concern/Major Known Impairments	Pre-1989 Activities in AOC	Fiscal Years 1989-1990 Activities in AOC	Fiscal Year 1991 Activities in AOC	Long Term Agenda
Rochester Embayment Water quality problems due to ammonia and phosphorus; sediments moderately to heavily polluted with metals and cyanide; fish consumption advisory for carp from Irondequoit Bay.	City of Rochester began combined sewer overflows abatement program in 1977. Sewage from numerous small WWTPs in the basin was consolidated and conveyed to the Irondequoit Bay Pure Waters District from 1977 to 1987.		NYDEC plans to submit Stage 1 RAP to IJC.	NYDEC plans to submit Stage 2 RAP to IJC in FY 1992. City of Rochester combined sewer overflows abatement program to be completed in mid 1990s.
Oswego River Water quality problems due to metals, ammonia and chloroform; sediments are contaminated with mirex and moderately to heavily polluted with metals; fish consumption advisory for channel catfish.		1990: NYDEC submitted Stage 1 RAP to IJC.	NYDEC plans to submit Stage 2 RAP to IJC.	Annual RAP implementation updates will be prepared and investigations will be conducted where data gaps exist.

Table 4-3. Selected Highlights of Progress in Areas of Concern (continued).

Area of Concern/Major Known Impairments	Pre-1989 Activities in AOC	Fiscal Years 1989-1990 Activities in AOC	Fiscal Year 1991 Activities in AOC	Long Term Agenda
International Connecting Channels				
St. Marys River This 70 mile long river connects Lakes Superior and Huron. Water quality problems due to phenols, iron, zinc, cyanide, ammonia and bacteria; sediments in some areas are contaminated with oil and grease, PCBs, PAHs, iron and zinc; fish consumption advisories for large walleye, white suckers, longnose suckers, northern pike and lake trout, mainly due to levels of mercury. Water quality and sediment problems are most pronounced along the Ontario shoreline downstream of Ontario discharges. Sediments are also heavily polluted with cadmium near the old Cannelton Tannery.	Algoma Steel (Canada) reduced its loadings of ammonia, cyanide and phenols to the river. St. Marys Paper (Canada) has reduced loadings of suspended solids. Municipal wastewater treatment plants have improved removal of phosphorus and organic matter. In 1988, EPA proposed Cannelton Industries site be added to Superfund NPL. The site borders the St. Marys River in the City of Sault Ste. Marie, Michigan. From 1900 to 1958, a tannery operated at the site. EPA, MDNR, and other agencies in U.S. and Canada joined in an extensive study of the St. Marys River and biota in 1986-87.	**1989** EPA began RI/FS and removal action at Cannelton Industries site. Algoma Steel began investigations of possible seepage of toxics into river via groundwater from Algoma slag piles. **1990** Algoma Steel completed wastewater treatment plant.	MDNR and Province of Ontario to submit Stage 1 RAP to IJC. Sault Ste. Marie, Michigan to develop and implement a plan to treat discharges from CSOs. Start remedial actions at the Cannelton Industries tannery waste site. Short term remedial actions include building a dike along the river and installing sprinklers to contain fires caused by spontaneous combustion. Michigan DNR and EPA are continuing RI/FS.	U.S. Abate CSOs and remediate Cannelton Industries site. **Canada** Abate CSOs and industrial discharges.

Table 4-3. Selected Highlights of Progress in Areas of Concern (continued).

Area of Concern/Major Known Impairments	Pre-1989 Activities in AOC	Fiscal Years 1989-1990 Activities in AOC	Fiscal Year 1991 Activities in AOC	Long Term Agenda
St. Clair River This 39 mile long river connects Lake Huron and Lake St. Clair. The largest petrochemical complex in Canada is located along the eastern shore of the river. The benthic fauna along the Canadian shore in the Sarnia area are impaired. Water quality problems due to organic solvents and bacteria; sediments contaminated with metals, PCBs, TCDD and other trace organics; State fish consumption advisories for carp, large gizzard shad and freshwater drum.	Loadings from petrochemical industries in Sarnia area are much reduced from the 1960s. Ontario and Michigan agreed to undertake a joint RAP in 1985. Binational Public Advisory Committee formed in 1988. EPA, MDNR, and other federal agencies completed an extensive study of the St. Clair River and its biota in 1986-87. Investigations following a large spill of perchloroethylene in 1985 from Dow Chemical (Canada) disclosed additional sources requiring abatement.	Actions to reduce CSOs in Marine City, Marysville, St. Clair, and Port Huron, Michigan are ongoing. Dow Chemical (Canada) pledged to invest $10 million on environmental improvements. Binational RAP team began drafting RAP in 1989.	MDNR and Province of Ontario plan to submit Stage 1 RAP to IJC in FY 1991. MDNR to continue fish contaminant trend monitoring.	**U.S.** Elimination or adequate treatment of CSOs. **Canada** Reductions of industrial loadings to river.

Table 4-3. Selected Highlights of Progress in Areas of Concern (continued).

Area of Concern/Major Known Impairments	Pre-1989 Activities in AOC	Fiscal Years 1989-1990 Activities in AOC	Fiscal Year 1991 Activities in AOC	Long Term Agenda
Detroit River This 32 mile long river connects Lake St. Clair to Lake Erie. Water quality problems due to phosphorus and bacteria; sediments in some nearshore areas are heavily polluted with metals, PCBs and other organics; fish consumption advisories for carp, large freshwater drum, walleye and rock bass; elevated incidence of liver tumors in five fish species (walleye, bowfin, bullhead, redhorse sucker and white sucker); degraded benthic communities along the Michigan shoreline from the Rouge River to Lake Erie; restrictions on dredging.	Over $500 million has been spent in Michigan since 1972 to upgrade municipal WWTPs along the Detroit River. Municipal WWTPs in Windsor have improved removal of phosphorus. U.S. and Canada started RAP development in 1986, forming binational Public Advisory Committee in 1988, and began drafting RAP in 1989.	MDNR began fish contaminant monitoring in 1990.	MDNR plans to submit Stage 1 RAP to IJC. MDNR to conduct biological assessments on three tributaries.	Long-term sewer improvements needed to reduce combined sewer overflows to river.

Table 4-3. Selected Highlights of Progress in Areas of Concern (continued).

Area of Concern/Major Known Impairments	Pre-1989 Activities in AOC	Fiscal Years 1989-1990 Activities in AOC	Fiscal Year 1991 Activities in AOC	Long Term Agenda
Niagara River This 37 mile long river connects Lake Erie and Lake Ontario. Water quality problems due to metals and organics; sediments in some nearshore areas and at the river mouth in Lake Ontario are contaminated with metals and PCBs; fish consumption advisories for carp and smallmouth bass, American eel, channel catfish, lake trout, large salmon, and rainbow and brown trout.	Niagara River Toxics Study by EPA, New York State, Ontario Ministry of Environment and Environment Canada concluded in 1984. In 1987, the four agencies agreed to reduce toxics loads from point and nonpoint sources to the river by 50% over ten years. Cleanups at significant U.S. hazardous waste sites started: **Love Canal** - the landfill was capped and isolated with a liner and leachate collection system; dioxin-contaminated sediments removed from Black and Bergholtz Creeks. **Hyde Park Landfill** - Consent Decree against Occidental Chemical Corporation (OCC) filed in 1979. **102nd Street Landfill** - Consent Decree filed by EPA, New York State and OCC in 1984. **S-Area Landfill** - Settlement Agreement between EPA, New York State and OCC in 1984.	**1989:** Pursuant to the 1987 agreement, the agencies developed a joint Lake Ontario Toxics Management Plan. EPA issued an Administrative Consent Order to PRPs of Niagara County Refuse Disposal site hazardous waste site requiring them to conduct an RI/FS. **1990:** Cleanup activities at Hyde Park Landfill including construction of on-site leachate storage and treatment system; incineration of collected non-aqueous phase liquid; installation of source control extraction wells; and construction of containment collection systems. OCC and Olin Corporation completed an RI/FS for 102nd Street Landfill. EPA issued ROD for S-Area Landfill.	Record of Decision planned for Dupont Necco Park site. Cleanup of Hyde Park Landfill to be completed.	NYDEC plans to submit Stages 1 and 2 RAP to IJC in FY 1993. Cleanups of Niagara County Refuse Disposal site, 102nd Street Landfill site, and S-Area Landfill to be completed in 1994.

Table 4-3. Selected Highlights of Progress in Areas of Concern (continued).

Area of Concern/Major Known Impairments	Pre-1989 Activities in AOC	Fiscal Years 1989-1990 Activities in AOC	Fiscal Year 1991 Activities in AOC	Long Term Agenda
St. Lawrence River This AOC includes the Cornwall, Lake St. Francis and Maitland areas in Canada and Massena, New York. Water quality problems due to metals, bacteria, phenols, pesticides and PCBs; sediments in some areas are heavily polluted with metals and PCBs; fish consumption advisories for American eel, channel catfish, lake trout, large salmon, rainbow and brown trout.	Mercury loadings to river from Cornwall (Canada) chloralkali plant of CIL, Incorporated and pulp and paper plant of Domtar Fine Papers Limited (Canada) were substantially reduced by 1970.	NYDEC supervising ongoing investigative and cleanup actions to be taken on PCB-contaminated sediments and groundwater resulting from operations by General Motors, Aluminum Company of America and Reynolds Metal Company in Massena area.	NYDEC and Province of Ontario submitted Stage 1 RAP to IJC. EPA issued an ROD for the General Motors hazardous waste site.	NYDEC and Province of Ontario plan to submit Stage 2 RAP to IJC. Annual RAP implementation updates will be prepared and investigation will be conducted where data gaps exist.

Chapter 5

Selected EPA Programs

In addition to pursuing Great Lakes Water Quality Agreement-specific activities like Remedial Action Plans, EPA and the States more broadly pursue a wide range of programs that have the effect of preserving or enhancing the environmental quality and natural resources of the Great Lakes. This chapter discusses selected EPA and State environmental activities and related achievements pertaining to the Great Lakes during FY 1989 and FY 1990, as well as activities planned for FY 1991. When available, specific measures of achievements are provided.

In general, States carry out many elements of Federal environmental legislation in partnership with EPA or other Federal agencies. States also enact their own environmental programs, creating jurisdictional diversity. Discussion of the complete range of State and Federal programs that, to various degrees, pertain to the Great Lakes would be prohibitively lengthy. For this reason, the chapter is a selected, rather than an absolutely comprehensive, discussion of U.S. environmental programs.

Water Programs

The National Pollutant Discharge Elimination System

Under the Federal Water Pollution Control Act, known as the Clean Water Act (CWA), the discharge of pollutants into the surface waters of the United States through point sources is prohibited unless a permit is issued by EPA or a State under the National Pollutant Discharge Elimination System (NPDES). EPA has

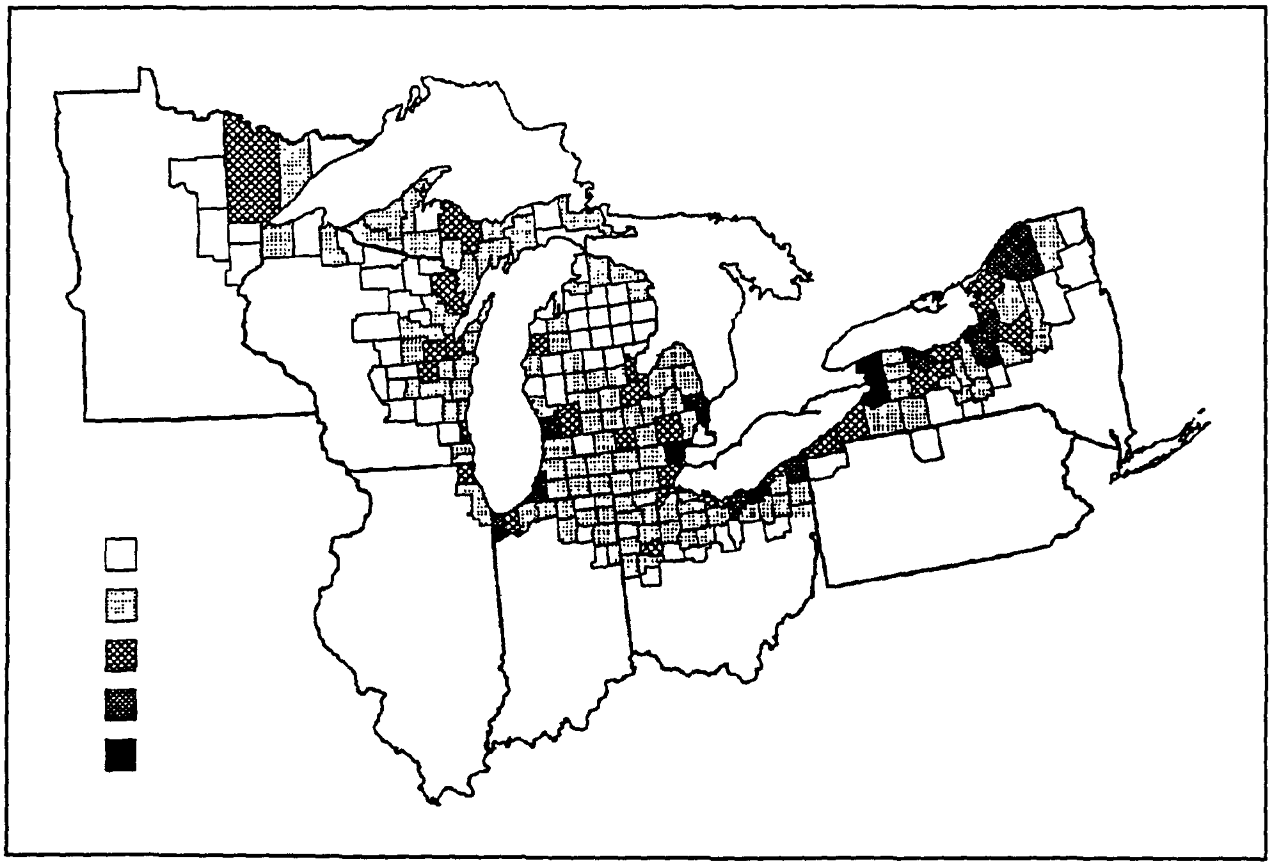


Figure 5-1. Major NPDES Dischargers in Great Lakes Basin.
Source: USEPA, 19__

Table 5-1. Number of NPDES Dischargers by Lake Basin.
Source: USEPA, Permit Compliance System, July 1990 (#).

Basin	Majors	Minors*	Total
L. Erie	189	1,185	1,374
L. Huron	39	261	300
L. Michigan	190	1,179	1,369
L. Ontario	146	284	430
L. Superior	22	134	156
Total	586	3,043	3,629

*The term Minors represents only those minor dischargers listed in PCS.

delegated NPDES permit approval authority to each of the eight Great Lakes States.

NPDES permits set limits on the quantity and concentration of certain contaminants that are discharged, the treatment that effluent (wastewater) must receive prior to discharge, and a deadline to attain that level of treatment. There are two primary types of dischargers: municipal wastewater treatment facilities and industrial facilities. Dischargers are further classified as majors and minors. Majors include municipal sewage treatment plants with discharges greater than one million gallons per day and those industrial dischargers that have the most significant potential for polluting receiving waters, according to an EPA ranking scheme. Minors are all other permitted dischargers. The "major" designation is a basis for setting priorities regarding permit processing and enforcement.

As of July 1990, there were 586 major NPDES dischargers in the Great Lakes basin and 3,019 minor dischargers. Figure 5-1 shows the distribution of the major dischargers. From this figure, it can be seen that the heaviest concentrations of major United States dischargers are located on Lakes Erie, Ontario, and Michigan and on three international connecting channels, the St. Clair, Detroit, and Niagara Rivers. Table 5-1 shows the number of NPDES dischargers by Lake basin. Table 5-2 breaks down major dischargers by facility types (municipal, industrial, and Federal).

An NPDES permit may require a facility to monitor its effluent on a daily, weekly, or monthly basis and to report results. NPDES permits have a maximum duration of five years. When a permit expires, a discharger must apply for a new permit that sets more restrictive limits based on advances in treatment technology. The CWA prohibits, except under certain situations, "backsliding" in the reissue or modification of NPDES permits through limitations less stringent than those in a previous permit.

There are two general principles that govern the setting of NPDES limits. One is that dischargers meet technology-based standards. These are *minimum standards of performance* that are set according to industrial category, (e.g., paper mills, steel mills, or chemical manufacturers), without regard to the quality of the receiving waters. EPA develops these limits based on engineering and economic judgments as to the most efficient treatment technologies. The second principle is that more stringent limits be imposed to protect water quality wherever technology-based limits are not sufficient to do this. States establish water quality standards that designate intended uses of their waters, such as fishing and swimming, and set chemical and biological conditions necessary to sustain these uses. To assist States with establishing water quality standards, EPA prepares criteria to define the maximum amounts of a pollutant that are safe for human health and aquatic life based on the latest scientific information.

Where technology-based limits are *not sufficient to achieve a designated* use, more stringent limits must be set. A "total maximum daily load" of a pollutant must be calculated, based on the capacity of the water body to assimilate the pollutant. Where total loadings exceed the maximum assimilative load, the assimilative capacity must be allocated among dischargers. The 1987 revision to the CWA requires that States identify water bodies not achieving water quality standards because of toxic pollutants. In 1989, States completed control strategies for restoring these waters within three years.

After an NPDES permit is issued, EPA and the States monitor the discharger's compliance with permit conditions and take enforcement action when appropriate. Permit violations are usually detected through self-monitoring reports by the permittee or by State inspections. In the event of violations, the States or EPA can take administrative or judicial action depending on the severity of the violation and the past record of the discharger. Administrative penalties can be assessed at $10,000 per day of violation, up to $125,000. Civil actions can assess up to $25,000 per day of violation. Criminal actions can assess $25,000 per day for the first violation or $50,000 per day for a second violation owing to negligence. A discharger who knowingly endangers the environment through a permit violation is subject to a fine of $250,000 per individual or $1,000,000 per firm. Table 5-3 shows the status of NPDES com-

Table 5-2. Categorization of Major NPDES Dischargers by Lake Basin.
Source: USEPA, Permit Compliance System, July 1990 (#).

Basin	Municipal	Industrial	Federal	Total
L. Erie	106	82	1	189
L. Huron	21	18	0	39
L. Michigan	91	99	0	190
L. Ontario	85	61	0	146
L. Superior	11	11	0	22

pliance in the Great Lakes basin as of January 1990.

Municipal Wastewater Treatment

The 1972 CWA greatly increased Federal funding to publicly owned treatment works (municipal dischargers). During subsequent amendments to the Act, the State role has increased steadily. Pursuant to the 1987 reauthorization of the CWA, States are encouraged to set aside funds for revolving loans to communities in need of sewage treatment systems. The State funds "revolve" in the sense that municipalities repay loans with interest, allowing the recapitalized fund to make further loans. Over the period 1989 to 1994, EPA is providing money to help capitalize revolving funds.

The CWA originally established a deadline for all municipal dischargers to achieve secondary treatment by July 1977. Primary wastewater treatment entails removal of most materials that float or settle and results in about a 30 percent reduction in biochemical oxygen demand. Secondary treatment involves consumption of organic components of the wastewater by bacteria. It results in about a 90 percent reduction in oxygen-demanding substances and suspended solids. Advanced, or tertiary, treatment is additional processing of secondary treatment effluents. For a variety of reasons, including inflation in construction costs, the 1977 deadline for secondary treatment was met by only about 37 percent of United States municipalities. By June 1983, the percentage of United States facilities that employed secondary treatment reached 69 percent.

Improvements to U.S. wastewater treatment facilities have significantly improved Great Lakes water quality. The number of people in Michigan, for instance, served by a municipal sewage system increased from 900,000 in 1967 to 6,500,000 in 1986, through a total investment of $2.5 billion by EPA and $1 billion by the State. By April 1990, 98 percent of municipal dischargers in Michigan used at least secondary treatment. One measure of the success of this investment is that phosphorus concentrations in the Detroit River have declined by 89 percent since 1972.

Table 5-3. Great Lakes Basin Major NPDES Permits Compliance Status as of January 1990.
Source: USEPA, Permit Compliance System, July 1990 (#).

State	Major Municipals*	Major Industrials*	Federal Facilities*
Illinois	None in basin	6/7 (86%)	None in basin
Indiana	16/21 (76%)	16/21 (76%)	None in basin
Michigan	79/92 (86%)	95/101 (94%)	None in basin
Minnesota	5/5 (100%)	4/4 (100%)	None in basin
New York	80/95 (84%)	61/64 (95%)	0/1 (0%)
Ohio	43/66 (65%)	46/52 (88%)	None in basin
Pennsylvania	0/3 (0%)	0/2 (0%)	None in basin
Wisconsin	30/32 (94%)	25/30 (83%)	None in basin
Total	253/314 (81%)	253/281 (90%)	0/1 (0%)

*Numbers represent the total of facilities in compliance/total number of facilities and (percent of facilities in compliance).

The United States has invested a total of over $8 billion in sewage system improvements in the Great Lakes basin since 1972. EPA has funded about $4.9 billion of this infrastructure investment. About $2.7 billion of the Federal expenditures went for municipal wastewater treatment in the Lake Erie basin and $1.4 billion was spent on improvements in the Lake Ontario basin.

While municipal sewage systems primarily receive household wastewaters from toilets, showers, and sinks, in many towns, industrial facilities are also connected to municipal systems. For example, 20,000 industrial firms discharge to municipal systems in the State of Michigan alone. Many industrial firms deliver effluent that contains toxic substances to the municipal system. Municipal treatment plants are usually not able to adequately treat these substances, and they are released to the Great Lakes ecosystem or they contaminate the sludge that is a byproduct of the treatment process. Some toxic substances also reduce the effectiveness of treatment processes for conventional pollutants.

The Clean Water Act provides for controls on industrial dischargers to municipal systems through pretreatment requirements. Of the 314 major municipal dischargers within the Great Lakes basin, over 65 percent are required to implement industrial pretreatment programs. The provisions of these programs are incorporated into NPDES permits. Less than five percent of these facilities do not yet have approved programs. EPA, or a State that has been delegated pretreatment program oversight, inspects municipal wastewater treatment facilities on an annual basis and conducts a comprehensive audit of the pretreatment program at a facility every five years. New York State, for example, has 33 pretreatment programs in effect within the Great Lakes basin. The State conducted 14 pretreatment comprehensive audits and 24 compliance inspections during FY 1989 in the basin. In addition, EPA and/or New York took enforcement actions against four municipal systems in the basin for failing to implement their pretreatment programs adequately: the City of Dunkirk, the City of Watertown, the Niagara County Sewer District (No. 1), and Onondaga County.

Particularly in many older urban areas, stormwater runoff and sanitary flows are delivered to municipal treatment facilities through common (combined) sewers. During rainstorms, the flow of water to a treatment facility exceeds its capacity, leading to releases of untreated wastewater to receiving waters. The significance of combined sewer overflows (CSOs) varies around the Great Lakes basin. Michigan regards CSOs as a major source of impairment to 317 miles of its rivers, making this the second leading source of impairments in the State. Michigan estimates that 170 CSO outfalls routinely release an annual volume of 7.8 billion gallons into the Rouge River, which flows through Detroit. On the other hand, Wisconsin does not consider CSOs to have a major impact on any of its streams, although it estimates that CSOs have a moderate or minor impact on 20 miles of its Great Lakes shoreline. This relatively small impact is in part the result of a longstanding commitment by Wisconsin to separate its sanitary and storm sewers. Milwaukee has the largest sewerage project in Wisconsin. Between 1972 and 1988, about $309 million in Federal funds and $200 million in State funds have been invested in this project. The State estimates that another $500 million will be required to complete the project by 1992. The project entails upgrades for two treatment plants and CSO abatement, including construction of 17 miles of deep tunnels to store untreated wastewater collected during heavy rains so it can be treated later during dry weather when the treatment facilities have adequate capacity.

EPA treats CSO outfalls as point sources that must meet NPDES permit requirements. This allows EPA or the States to establish compliance schedules with municipalities to adequately treat or to eliminate their CSO discharges. The cost of reaching compliance varies. Michigan estimates that the total cost of all improvements for CSOs that discharge into the Rouge River to be $1 billion and for those that discharge into the Detroit River to be $2.6 billion.

Nonpoint Source Pollution Program

Nonpoint source (NPS) pollution does not originate at a specific point or discharge and has no outfall structure to which the input to a receiving water body can be attributed. Nonpoint source loads enter surface waters through atmospheric deposition or runoff, and by their very nature are difficult to identify or quantify.

The magnitude of NPS pollution varies among the geographical areas of the Great Lakes Basin, depending largely on land use practices, soil types, and topography. Nonpoint source pollution in the Great Lakes Basin can be separated into five major source categories: agriculture activities, silviculture practices, mining, construction projects, and urban development. Sediments and nutrients are the most serious NPS pollutants in the Great Lakes Basin. Other NPS pollutants of concern include: salts, pesticides and herbicides, metals, bacteria, sulfates, and those that create biochemical oxygen demand.

Under Section 319 of the CWA, the States have primary responsibility for developing, implementing, and enforcing nonpoint source controls. The States are responsible for assessing their nonpoint source pollution problems and developing management programs that will be effective in restoring and maintaining water quality. EPA is responsible for program oversight, and for providing technical and financial assistance to the States.

Responsibilities of other Federal agencies, particularly the U.S. Department of Agriculture (USDA), also have important implications for the control of agricultural and silvicultural nonpoint sources. In particular, provisions of the Food Security Act of 1985, including those relating to the Conservation Reserve Program, Swampbuster, Sodbuster, and Conservation Compliance, were established to influence the land management practices that contribute to the control of NPS pollution.

Section 319 first mandates a comprehensive assessment to document where nonpoint sources are causing water quality degradation or threaten water quality. The initial State Assessment Reports (SARs) were based on existing information. In order to get Federal financial assistance, States had to develop EPA-approved NPS management plans establishing a four-year framework to address identified water quality problems. By the summer of 1990, all Great Lakes States' NPS management plans had received EPA approval.

In developing their management plans and SARs, EPA required the Great Lakes States to provide linkages between Phosphorus Reduction Plans and Remedial Action Plans for Areas of Concern. This information confirmed that phosphorus reduction goals could be achieved in the Upper Great Lakes through existing programs and that plans would need to be developed for Lake Erie, Saginaw Bay, and Lake Ontario.

For FY 1990, over six million dollars (Federal and match) were committed to the Great Lakes Basin for NPS activities under Section 319. Most of the funds were directed toward nutrient and sediment control, and, generally, projects address the agriculture, mining, construction, and urban runoff categories. For example, the Soil Conservation Service of the U.S. Department of Agriculture and Soil Conservation Districts in the Lake Huron Basin are working together to introduce Best Management Practices (BMPs) for the control and reduction of sediments and phosphorus into the South Branch of the Kawkawlin River from current agricultural practices.

The Coastal Zone Management Act Reauthorization Amendments of 1990 include a new Section 6217, entitled Protecting Coastal Waters, which requires each coastal State (including Great Lakes States) with an approved coastal zone management program to develop coastal nonpoint pollution programs. State coastal zone management programs must now contain enforceable policies and mechanisms to implement the requirements of coastal nonpoint pollution programs. EPA is currently working with the National Oceanic and Atmospheric Administration to develop guidance for the States to assist with their nonpoint pollution programs. Federal guidance is expected to be issued in mid-1991.

The Great Lakes Water Quality Initiative

During FY 1989, EPA and the Great Lakes States began an important project to further protect Great Lakes water quality. In view of the unique features of the Great Lakes system, EPA and States believe that site-specific criteria are necessary to protect Great Lakes aquatic biota and wildlife, and human health — primarily from fish consumption risks — on a long-term basis. The "Great Lakes Water Quality Initiative" will develop EPA guidance to States regarding water quality criteria for the Great Lakes, a Great Lakes antidegradation policy, implementation procedures, and pollution prevention measures. EPA is responsible for developing national water quality criteria that numerically define maximum allowable concentrations of certain pollutants in surface waters across the Nation. These criteria are used by States as a basis for State water quality standards and their resulting water quality-based regulation under the NPDES program. In view of the unique features of the Great Lakes system, EPA and States believe that in some cases, criteria specific for the Great Lakes are necessary to protect aquatic biota and wildlife, and human health — primarily from fish consumption risks — on a long-term basis.

Water quality guidance developed under the initiative will represent an interim accomplishment. Over the long term, EPA and the States will seek to minimize loadings of toxic substances, particularly persistent, bioaccumulative pollutants, with a goal of virtual elimination. Technology-based regulatory requirements will supplement water quality requirements to prevent pollution.

The Great Lakes Water Quality Initiative will fulfill a number of important purposes. It will help ensure that Great Lakes environmental needs are incorporated into the water quality programs of Great Lakes States, thereby providing a sound scientific basis for enhanced water quality-based protection of the Great Lakes by the United States under the CWA. The Great Lakes Water Quality Initiative will improve the overall consistency among the water quality standards of the Great Lakes States. It will help define water quality objectives for future Lakewide Management Plans. Finally, the guidance will provide a basis, consistent with EPA's regulatory posture, for the setting of revised "specific objectives" under the Great Lakes Water Quality Agreement with Canada. To this end, Canadian regulatory observers have been invited to attend meetings of the initiative work groups.

Representatives from environmental groups, academia, business associations, and municipalities will provide comments during the development process. A public record is being developed and public hearings will be held once findings and recommendations are reached. Proposed guidance will be available for public review and comment in the Federal Register.

In FY 1991, the initiative will continue the development of acute and chronic aquatic life criteria, human health criteria, wildlife criteria, and other work pertaining to anti-degradation, pollution prevention, and implementation. EPA envisions that the Great Lakes water quality guidance will be completed in time to be incorporated into the next triennial State water quality standard review process (1991 to 1993).

Wetlands Protection

Wetlands are marshes, swamps, bogs, and fens, which are areas where the water table is above the land sur-

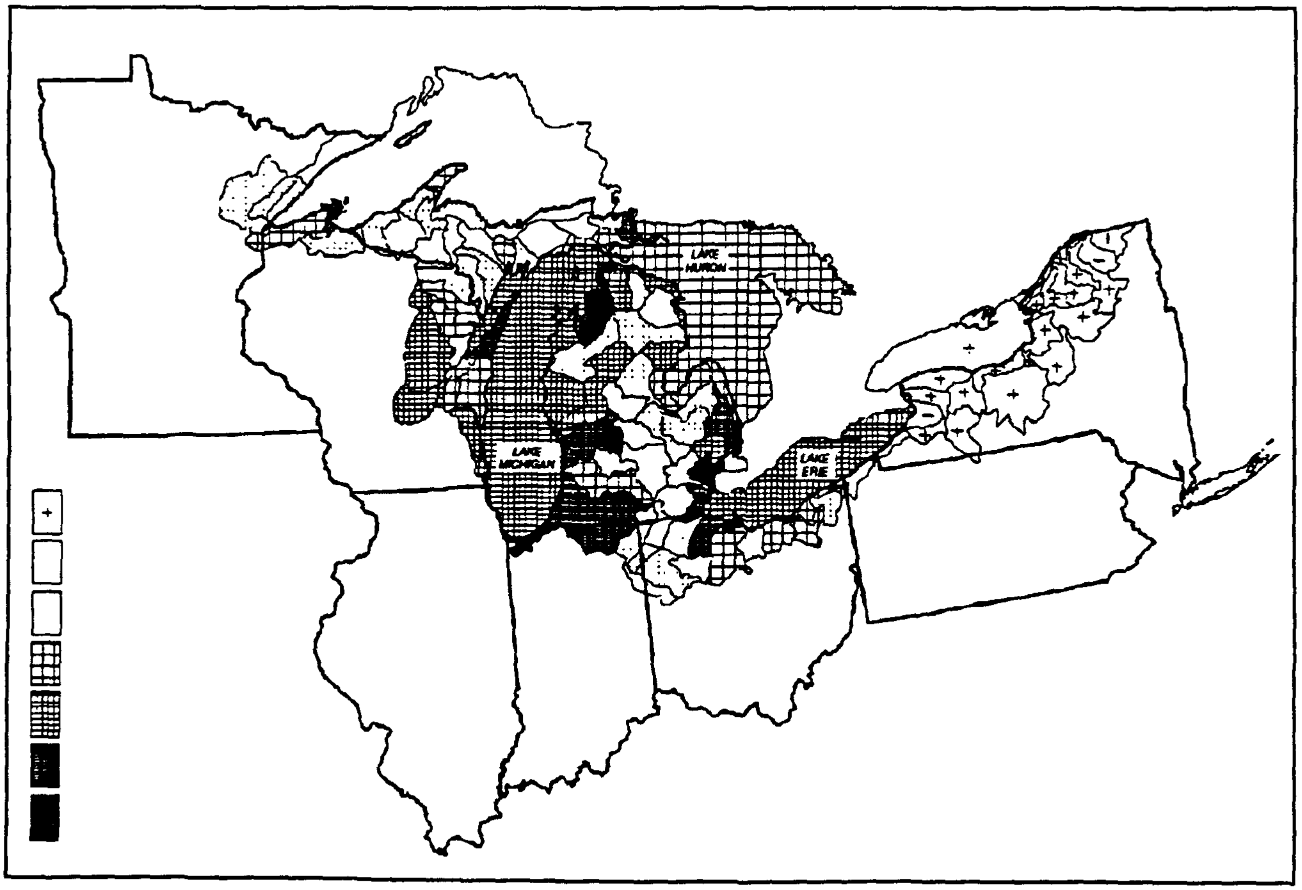


Figure 5-2. Dredge and Fill Permit Applications.

face for at least part of the year, although most vegetation rises above the surface of the water. When open water is present, it tends to be less than seven feet deep and slow moving. Coastal wetlands have vital ecological functions: filtering wastes; serving as nursery, resting, and breeding locations for birds, fish, and mammals; and acting as buffers against floods and erosion. Wetlands also serve as a critical element in the habitat and survival of many aquatic species. They are in effect "farmlands for the aquatic environment," since they provide great amounts of food for these species. Thus, wetlands indirectly serve as an important source of food for people, who consume the fish, shellfish, and waterfowl that wetlands sustain.

Approximately two-thirds of the original Great Lakes basin wetlands have been drained or filled since 1800. The vast (1,500 square mile) Black Swamp of northwest Ohio was almost entirely converted to farmland by the early 20th century. It is thought that wetlands once constituted 60 percent of southwest Ontario and 30 percent of the land area of Michigan. The Fish and Wildlife Service inventoried the nation's wetlands in the mid-1970s. This inventory categorized Minnesota as the Great Lakes State with the highest percentage of remaining wetlands, which constitute between 15 to 25 percent of its land area. By the same survey, Michigan and Wisconsin had between 5 and 15 percent wetlands; the other Great Lakes States had less than 5 percent wetlands.

The principle Federal regulatory program concerning wetlands is jointly administered by the Army Corps of Engineers and EPA in partnership with State and local governments, pursuant to Section 404 of the CWA. This section establishes a permit program to regulate the discharge of dredged or fill materials into the waters of the United States, including most wetlands. Figure 5-2 shows the distribution of Section 404 dredge and fill permit applications in the Great Lakes basin. The Fish and Wildlife Service and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service have important advisory roles in the permit review process. It should be noted that the Section 404 program does not provide comprehensive wetlands protection. Some activities that can damage wetlands, such as drainage and groundwater pumping, are beyond the scope of this program. However, EPA and States have designated wetlands that border directly on the Great Lakes as "priority" wetlands for protection under the 404 program (with the present exception of New York, which is in the process of revising its designation of priority wetlands).

In addition, EPA and States identify certain wetlands prior to permit reviews under an Advance Identification (ADID) program. ADID entails collecting data in areas that have especially high resource value or are under development pressure. The program identifies wetland areas of the highest ecological value and informs landowners of the likelihood of permit issuance or denial. During FY 1989, EPA and States completed ADID projects for Northwest Indiana/Grand Calumet River and southeast Wisconsin. During FY 1990, EPA and States revised an ADID study of Lake County, Illinois; continue a wetlands study of Oswego County, New York; and initiated an ADID study of Green Bay, Wisconsin.

Assessment and Remediation of Contaminated Sediments (ARCS) Program

During FY 1989, EPA's Great Lakes National Program Office continued its sponsorship of a major effort, the Assessment and Remediation of Contaminated Sediments (ARCS) study, to assess Great Lakes sediments that are contaminated by toxic pollutants and to develop technologies and methods for restoring such sediments. Five areas within the Great Lakes basin are receiving priority consideration in this study: Ashtabula River (Ohio), Buffalo River (New York), Grand Calumet River (Indiana), Saginaw Bay (Michigan), and Sheboygan Harbor (Wisconsin).

The Program Office is joined in this endeavor by experts from various organizations, including the Army Corps of Engineers; Fish and Wildlife Service; EPA Headquarters and Regions II and V; EPA's Environmental Research Laboratories in Duluth, Minnesota and Athens, Georgia; EPA's Large Lakes Research Station in Grosse Ile, Michigan; the Michigan Department of Natural Resources; the New York State Department of Environmental Conservation; the National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Laboratory in Ann Arbor, Michigan; and the U.S. Bureau of Mines.

All 30 United States Areas of Concern are suspected to have contaminated sediments problems. Developing scientific grounds for planning remedial measures for these sediments will be critical to the development of successful RAPs. The five areas receiving attention under the ARCS study are all designated Areas of Concern, and will have developed RAPs by the end of FY 1991.

Assessments of Contaminated Sediments

During FY 1989, the ARCS study sponsored sampling of surface sediments in Indiana Harbor/Grand Calumet River, Indiana, and in the Buffalo River, New York. Preliminary data from Indiana Harbor indicates acute toxicity to the test organisms. The sediments are among the most toxic ever sampled in the Great Lakes. Because the samples are from the surface of the sediments, the implication is that the contamination is continuing from sources in the area. In the Grand Calumet River, the surface sediments were also found to be extremely toxic. ARCS sponsored sediment probings in the Grand Calumet River found that contaminated sediment deposits were 12 to 17 feet deep in many places. In the southern reaches of Indiana Harbor, early indications are that sediments are up to 50 feet deep. Ten surficial sediment samples were taken in the Buffalo River. Preliminary laboratory results indicate that toxicity levels were lower than in Indiana Harbor.

During FY 1990, the ARCS study continued site assessments. In November 1989, surficial sediment samples were taken in Saginaw Bay to analyze for chemistry, biological toxicity, and benthic community structure. In the Grand Calumet, Saginaw, and Buffalo Rivers, ARCS took take cores to conduct chemical analysis and microtox® (toxicity) evaluations at various depths and to assess the quantity of contaminated sediment present. Chemical analyses of samples from the Grand Calumet River, Indiana Harbor, and the Buffalo River continued. The Fish and Wildlife Service surveyed fish (bullheads) for tumors and abnormalities in Saginaw, the Grand Calumet River, and Buffalo River. The Service also studied the transfer of contaminants in sediment to fish in these three locations.

In addition, ARCS used Superfund activities in Ashtabula River to obtain samples and chemical analyses, both surficial and with depth. ARCS conducted bioassays and benthic community structure analyses on Ashtabula sediment collected by the potentially responsible parties at this Superfund site. Sheboygan Harbor also contains a Superfund site, allowing the ARCS study to make use of Superfund bioassays and chemistry analyses.

Hazard Evaluations

During FY 1990, the ARCS study continued assessment and modeling to assess and predict human and ecological health impacts of cleanup options. ARCS completed evaluations, initiated in FY 1989, of the hazards under the "no action" alternative at each of the five priority locations. At two of the five sites, Buffalo River and Saginaw Bay, ARCS also began comprehensive hazard evaluations to describe the risks under various remedial alternatives. ARCS started a synthesis of all site-specific information on hazard evaluation, gathered during FYs 1989 and 1990, into a numerical ranking system for Great Lakes sediments to assist in identifying and addressing areas with the most severe problems.

At Buffalo River and Saginaw Bay, ARCS conducted week-long contaminant sampling surveys to analyze sources and fates of contaminants. Many industrial firms along the Buffalo River have closed since the 1970s or directed their discharges to municipal treatment facilities; thus, the Buffalo River analysis will likely prove less complex than that of Saginaw Bay, which contains more current sources of pollutants and a much larger drainage basin. ARCS also used sediment investigations associated with a regulatory enforcement action in Black River, Ohio where PAH-contaminated sediments are being dredged by a local steel company, to learn about the recovery rate of benthic organisms after sediment cleanup.

Technology Evaluations

In FY 1990, ARCS conducted eight to ten different small-scale (i.e., a few kilograms of sediment) laboratory tests of treatment technologies on sediments collected at the five priority sites. These tests will provide preliminary feasibility and design data for ensuing field demonstrations. Types of treatment technologies to be evaluated in laboratory tests include solidification/stabilization, extraction, chemical treatment, and biological treatment. Also, ARCS will sponsor a workshop on biological treatment of sediments contaminated by PCBs, PAHs, and metals.

Public Communication

The ARCS study will continue to make current information available to the public. Among the public outreach activities for FY 1990 is the development of slide-show/video presentations and sponsorship of public meetings to inform residents living near the priority areas about the ongoing field work, research activities, and results obtained from the ARCS study.

The Superfund Program

Superfund Sites in the Great Lakes Basin

Figure 5-3 shows the distribution of all candidate Superfund waste sites by county in the Great Lakes basin. The distribution of a subset of Figure 5-3 sites—final and proposed Great Lakes NPL sites—is displayed in Figure 5-4. (The counties displayed on these maps are those that are wholly or partly located within the Great Lakes basin. A geographic area larger than that of the Great Lakes basin is used, since information from the Agency's Superfund data base can best be extracted by county.) Figures 5-3 and 5-4 provide an approximation of the universe of Superfund sites of potential significance to the Great Lakes. It should be noted that the potential impact of different sites upon the Great Lakes varies enormously.

As can be seen in Figure 5-3, as of January 1990, within the Great Lakes counties there was a total of 4,109 waste sites that the Superfund program either has assessed or will assess in the future. The 4,109 sites include candidate sites for which preliminary assessments, site investigations, and RI/FSs are not completed; sites that have been investigated and that do not qualify for Superfund cleanup; and a small subset that do qualify for cleanup (NPL sites). Of the total of 4,109 sites, there are 3,935 non-NPL sites, 140 NPL sites, and 23 proposed for the NPL. Thus, the NPL presently includes about four percent of the candidate sites in the Great Lakes basin. The distribution by county of these NPL sites can be seen in Figure 5-4.

On a nationwide basis, there are about 1,200 final and proposed NPL sites from more than 33,000 candidate sites. With 163 final and proposed NPL sites, the Great Lakes basin counties, representing about 5.4 percent of the continental United States land area, hold about 13.5 percent of the Nation's Superfund sites. This disproportionate share of NPL sites is a result of the Great Lake basin's industrial heritage.

As shown in Table 5-4, the distribution of candidate Superfund sites appears to correlate closely with concentrations of population, although the distribution of final and proposed NPL sites does not seem to follow population concentrations as closely. The table shows the top twelve counties in terms of number of candidate sites. Counties containing the major cities of Chicago, Buffalo, Detroit, and Cleveland have the most candidate sites. However, the distribution of NPL sites does not follow population concentrations as closely. For example, the counties containing Detroit and Cleveland do not have

The Superfund Program

The Federal Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 and the Superfund Amendments and Reauthorization Act (SARA) of 1986 authorized the Superfund program. CERCLA was enacted to (1) institute a comprehensive national program to identify and clean up the most threatening hazardous waste sites, (2) make responsible parties pay for cleanups whenever possible, and (3) set up a trust fund, popularly known as Superfund and endowed by taxes on oil and chemical industries, for the twin purposes of performing cleanups in cases where responsible parties cannot be held accountable and for responding to emergency situations involving hazardous substances. SARA increased the trust fund from $1.6 billion to $8.5 billion. It should be noted that certain industrial sectors have degrees of exemption from CERCLA, including pulp and paper mills (seepage lagoons) and petroleum refining facilities.

Under CERCLA, EPA and States may clean up sites where hazardous wastes from abandoned or otherwise inactive waste sites endanger public health, welfare, or the environment. Whenever possible, EPA requires Potentially Responsible Parties (PRPs) to clean up hazardous waste sites that they have contaminated. PRPs are one or more individuals or companies, including owners, operators, transporters, or generators of waste, potentially responsible for, or contributing to, the contamination problems at a Superfund site. All work done by PRPs is closely monitored by EPA or the States.

EPA and the States may themselves act to cleanup hazardous sites when responsible companies or individuals do not do so. Cleanup costs are paid by Superfund, with a contribution of 10 percent by the State for cleanups of privately owned sites and 50 percent for those that are publicly owned. EPA can later sue to recover its costs from responsible parties.

Once a potential hazardous waste site is identified, EPA or a State carries out a multi-step assessment procedure to determine the risk to public health, welfare and the environment, and what cleanup actions are appropriate. The first step is to perform a preliminary assessment of the size and potential hazards of a site. If the preliminary assessment suggests that the site may pose a threat to human health or the environment, the site is inspected. EPA uses a Hazard Ranking System (HRS) to score and compare sites. Factors that are considered under the HRS include the type, quantities, and toxicity of the wastes; the number of people potentially exposed; the likely pathways of exposure; and the importance and vulnerability of the underlying supply of groundwater.

After sites have been assessed, the Agency places the most significant ones on its National Priorities List (NPL) as targets for Superfund cleanup. The NPL is updated at least once a year. Once a site is placed on the NPL, EPA conducts a remedial investigation/feasibility study (RI/FS). The remedial investigation is a long-term study entailing extensive sampling and laboratory analyses in order to develop precise data on the types and quantities of wastes, soil types, water drainage patterns, and resulting human and environmental risks. Based on the results of the remedial investigation, the feasibility study evaluates the alternatives for remediating the site contamination, also considering relative efficacy and cost of remedial alternatives. EPA chooses the most appropriate alternative as a remedy for the site and issues a Record of Decision (ROD) to set forth its selection. The public has an opportunity to comment on the Record of Decision.

The final step is site remediation. Cleanup actions are aimed at a permanent remedy and may include such measures as taking wastes to another site for safe disposal; "capping" the original site with waterproof clay; installing drains, liners, or grout "curtains" to prevent groundwater contamination; providing alternate sources of drinking water; or relocating residents.

At any time during this process, EPA may conduct short-term removal actions if a site is found to present an imminent hazard, such as its potential for fire or its contamination of drinking water. Removal actions do not require that the site already be designated on the NPL. Removal actions include installing fences to isolate the site and actual removal of the wastes for safe disposal.

In mid-1989, EPA issued an assessment of the nationwide Superfund program during its first nine years. This assessment noted that EPA and the States had, to that date, identified over 30,000 sites as candidates for Superfund cleanup, of which over 27,000 had been subjected to preliminary field review and classification. About 16,000 sites had been evaluated as not qualifying for the NPL. The NPL included nearly 1,200 sites, with 250 financed to start cleanup. At present funding levels, EPA could begin cleanup at about 40 sites per year and potentially responsible parties could begin cleanup at about 50 additional sites per year. The Agency expects to add NPL sites at a rate of about 75 to 100 per year. The average cost per site is about $25 million and is expected to grow as more complex sites move into the cleanup phase.

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Figure 5-3. CERCLA Sites in Great Lakes Basin Counties.
Source: USEPA, 199_.

any NPL sites, whereas several relatively less populated counties have far more NPL sites: Kent County (Michigan) has ten NPL sites (the most of any Great Lakes county) and adjacent Muskegon County has nine NPL sites.

The significance of the distribution of NPL sites across the Great Lakes basin would seem to be that, to date, the Superfund program has been relatively more important in addressing waste sites lying outside the major, lakefront United States cities in the Great Lakes basin. This is a general pattern and is the result of greater human health risks outside of these lakefront cities. The ranking of Superfund sites depends on the specific characteristics of each site. Waste sites in lakefront cities have been proposed for the NPL when their risks warrant.

Most present NPL sites were determined under the HRS as it was originally defined under CERCLA's 1980 authorizing legislation. Under this legislation, the Agency's site assessment process, resulting NPL designations, and remedial plans have tended not to consider risks associated with transport of contaminated groundwater into surface water, such as the Great Lakes; food chain risks to wildlife and humans; release of contaminants from surface-water sediments; and cumulative effects of loadings from multiple sites. There are good reasons why these factors have not been considered in many cases. Each of these factors is usually difficult to assess, entails extensive study, and studies of them would provide results with substantial uncertainty. Given the imperative to reduce risk and make timely environmental progress, the Agency has set practical bounds in site assessments and rankings. In general, it has given primacy to readily quantifiable human risks over those substantially more difficult to assess.

Under the current HRS and its proposed revisions, one major factor in assessing the hazards of a waste site is the reliance of a local population on groundwater for its drinking water. Large lakefront cities, like Buffalo, Chicago, Cleveland, and Detroit, obtain drinking water from the Great Lakes rather than from groundwater. Therefore, sites in these counties have tended to not score as high under the HRS formula as sites in counties where more of the population relies on groundwater for drinking water.

In the future, major lakefront urban areas may be given greater priority for Superfund cleanups. Under the Superfund legislation of 1986, EPA was required to revise the HRS to include consideration of food-chain risks. EPA proposed revisions to the HRS in 1988, including assessment of risks associated with the aquatic food chain. If adopted, these revisions may give higher priority to lakefront urban waste sites in the Great Lakes basin.

Table 5-5 summarizes Superfund activities in the Great Lakes basin during FY 1989. Activities are broken down by types of activities (e.g., inspections, negotiations, removals).

Superfund Activities in Great Lakes Area of Concern

A considerable number of Superfund cleanup activities are in progress or are planned in the Great Lakes basin. Eight Areas of Concern that contain NPL sites include:

Niagara River, New York

Love Canal

The passage of the initial Superfund legislation was, in part, inspired by the notoriety of a site called Love Canal, near the Niagara River. The following cleanup measures have been taken at the Love Canal site:

- The landfill itself has been covered with an impermeable liner.
- A leachate collection system has been operating since 1979.
- Pursuant to an October 1987 ROD regarding dioxin-contaminated sediments in sewers and creeks near Love Canal, the contaminated sediments have been excavated from the Black and Bergholtz creeks, sewers have been cleaned, and all residuals will be incinerated.
- A habitability study has been conducted to determine if the Emergency Declaration Area surrounding Love Canal is suitable for habitation. The study found that four areas are suitable for residential use, and three areas are suitable for commercial or industrial use.
- Pursuant to an ROD, a cap will be constructed over solidified and stabilized contaminated soils for the 93rd Street School portion of the site.

Of the remaining waste sites estimated to contribute the greatest amount of toxicants to the Niagara River from the United States, four of the top eight are on the NPL. These four are:

Niagara County Refuse Disposal Site

EPA issued an Administrative Consent Order on March 30, 1989, that requires the responsible parties to undertake an extensive remedial investigation and feasibility study. Pending issuance of an ROD, EPA's target date for start of cleanup activities is late 1994.

Hyde Park Landfill

The initial consent decree against Occidental Chemical Corporation (OCC) was filed in 1981 and amended with respect to the remedy in 1986. Since then EPA, New York State, and OCC have agreed that OCC will clean up the site under EPA/State oversight. An Enforcement Decision Document has been signed and an RI/FS performed. The following actions were started or accomplished during FY 1990:

- Construction of an on-site leachate storage and treatment system was completed
- Incineration of the non-aqueous phase liquids at OCC's Niagara Falls facility began
- Installation of source control extraction wells began
- Construction of containment collection systems was completed.

102nd Street Landfill

The initial lawsuit against OCC and Olin Corporation was filed in 1979. A Consent Decree was filed by EPA, New York State, Olin Corporation, and OCC in 1984. Olin Corporation and OCC completed a remedial investigation and feasibility study. EPA issued a Record of Decision in September 1990. EPA's target date to start cleanup actions is late 1992.

S-Area Landfill

A Settlement Agreement (for on-site remedial action and off-site study) between EPA, New York State, OCC, and the City of Niagara Falls was reached in 1984. Since then, an investigation and design study has been completed. An amended Settlement Agreement was filed in September 1990 for an expanded on-site remedy, an off-site remedy, and a new water treatment plant for the City of Niagara Falls. Remedial construction began in late 1990.

Dupont Necco Park

This waste site, considered to be an important source to the Niagara River, is not on the NPL, but is the target of joint Superfund/Resource Conservation and Recovery Act

Table 5-4. Candidate Superfund Sites vs. NPL Sites for Selected Great Lakes Basin Counties.
Source: USEPA, CERCLIS, January 1990 (#).

County (Largest City)	State	Number of Candidate Sites	Number of NPL Sites	Ratio of NPL Sites To Candidate Sites (%)
Cook (Chicago)	Illinois	306	1	0.3
Erie (Buffalo)	New York	150	1	0.7
Wayne (Detroit)	Michigan	147	0	0
Niagara (Niagara Falls)	New York	141	5	3.5
Cuyahoga (Cleveland)	Ohio	133	0	0
Lake (Gary)	Indiana	131	5	3.8
Erie (Erie)	Pennsylvania	113	2	1.8
St. Joseph (South Bend)	Indiana	91	3	3.3
Muskegon (Muskegon)	Michigan	84	9	10.7
Monroe (Rochester)	New York	73	0	0
Oakland (Troy)	Michigan	71	5	7.0
Kent (Grand Rapids)	Michigan	62	10	16.1

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Figure 5-4. Final and Proposed NPL Sites in Great Lakes Basin Counties.
Source: USEPA, 199_

(RCRA) enforcement. EPA and New York State issued an Administrative Order to Dupont under RCRA in 1988 and under CERCLA in 1989. An RI/FS will begin in 1991, and an ROD is planned for early 1992.

Waukegan Harbor, Illinois

Sediments in the harbor and nearby "North Ditch" are grossly contaminated by PCBs. Discovered in 1976, this is the largest known reservoir of PCBs in the Great Lakes. From about 1961 to 1972, the Outboard Marine Corporation (OMC), a maker of outboard motors for boats, used a hydraulic fluid containing PCBs in die-casting processes. EPA estimates that there are more than 700,000 pounds of PCBs on the property of Outboard Marine Corporation and about 300,000 pounds in Waukegan Harbor. Past loadings of PCBs to Lake Michigan from this site are estimated to be in the hundreds of thousands of pounds.

Under the terms of the Superfund cleanup to be carried out by OMC, cleanup actions are scheduled through late 1993. Actions will include dredging the harbor in areas having PCB concentrations in excess of 50 parts per million, constructing three containment cells for less contaminated soil and sediment, and using extraction technology to remove PCBs from soil and sediment. Extracted PCBs will be taken off-site for destruction by incineration. More than 99 percent of the mass of PCBs in the harbor will be removed and either destroyed or confined on-site.

St. Lawrence River, New York

Industrial sources in Massena, New York, have contributed large loadings of PCBs to the St. Lawrence River, which have transboundary effects. It is estimated that 23,000 cubic yards of sediments adjacent to General Motor's plant are heavily contaminated with PCBs, which were used at the facility during the late 1960s to mid-1970s in die-casting. During FY 1990, EPA proposed a remedial action to include dredging of contaminated sediments of the St. Lawrence and Raquette Rivers and preventing the transport of contaminants via groundwater from the site. Cleanup is planned to begin during 1991. At the onset of FY 1990, EPA also issued Superfund Administrative Orders to the Aluminum Company of America and the Reynolds Metal Company to perform remedial investigations, designs, and cleanups of PCB-contaminated sediments in the St. Lawrence River system. These three Superfund actions are part of a focused effort by EPA, New York State, and the St. Regis Mohawk Tribe to restore the St. Lawrence River. Because of contamination, the Mohawks have had to cut back on eating fish and waterfowl, which have traditionally been important parts of their diet.

Ashtabula River, Ohio

The upper two miles of this river contain sediments heavily contaminated by PCBs, toxic metals, and other toxic substances that primarily came from past industrial discharges to Fields Brook, which empties into the Ashtabula River. Parts of the Ashtabula River have not been dredged since 1962, resulting in impeded navigation. Fields Brook, including adjacent properties, is a Superfund NPL site. During FY 1989, EPA issued an Administrative Order for Fields Brook that potentially responsible parties conduct a "Downgradient Contamination Investigation" of the Ashtabula River and Harbor. Results of the river sampling were expected in June 1990. This investigation will provide information to help determine whether the Ashtabula River itself should be a Superfund site. Thus far, 6 of 19 potentially responsible parties for the Fields Brook site have agreed to undertake the design of a sediment cleanup plan. The remaining 13 parties have yet to comply with the Administrative Orders. The selected remedy for Fields Brook entails thermal treatment of the sediment contaminated with the most mobile organic pollutants, and the solidification and burial of the remainder.

Kalamazoo River, Michigan

The 28-mile stretch of river from the city of Kalamazoo to Lake Michigan has sediments heavily contaminated with PCBs. EPA proposed an Allied Paper Incorporated site for the Superfund NPL during FY 1989. The Kalamazoo River NPL site has seven sub-sites. All have PCB contaminants in sediments. EPA began an RI/FS of this site during FY 1990.

Sheboygan River and Harbor, Wisconsin

The harbor and lower 12-mile stretch of the river contain contaminated sediments, most notably containing PCBs. In 1985, the lower Sheboygan River and Harbor were designated as a Superfund site. A major source of PCB contamination was identified as a site owned by Tecumseh Products Incorporated. As a PRP, Tecumseh conducted an RI/FS that continued during FY 1989. During FY 1990, EPA studied specific remedial alternatives. In order to evaluate the potential of remedial technologies, EPA, the State of Wisconsin, and the PRP have removed 2,000 cubic yards of sediments to test various treatments including biodegradation. This study is scheduled for completion in the summer of 1991. EPA plans to issue an ROD in late 1992. Remedial actions are expected to begin in mid-1993.

Saginaw River and Bay, Michigan

This Area of Concern is large and its environmental problems are complex. The bay itself is 51 miles long and between 13 and 26 miles wide. Its drainage basin contains about 15 percent of Michigan's total land area. Three-quarters of the hydraulic input to the bay comes from the Saginaw River, which itself has four major tributaries. The sediments of the bay contain various persistent toxicants, including metals and PCBs. No consumption of bottom-feeding fish (carp and catfish) is advised. Fish-eating bird populations have had reproductive failures and birth defects.

As of mid-1988, Michigan indicated that there were 189 waste sites within the Saginaw Bay basin, including 13 that were on the Superfund NPL. About one-fourth of these sites have documented impacts on surface water. Their impact on groundwater and its loading to surface waters is generally not well understood. One NPL site of known significance is the Shiawassee River site. Michigan is now conducting a remedial investigation of this site, which contains sediments contaminated with PCBs.

Torch Lake, Michigan

For more than 100 years, this lake within the Keweenaw Peninsula received copper mine tailings and other wastes that now fill more than 20 percent of its original volume. Torch Lake is a NPL site. A Superfund RI/FS is in progress.

Other Sites

The Superfund program is likely to have an important restorative impact on other Areas of Concern, as well. During FY 1990, EPA started a remedial investigation of a Fort Howard Paper NPL site that is of potential importance to the Green Bay Area of Concern. EPA also plans to complete a remedial investigation of a St. Louis River, Minnesota, NPL site which includes river sediments contaminated by PAHs. During FY 1989, EPA began a removal action at the Cannelton Industries NPL site in Saulte St. Marie, Michigan; this site is adjacent to the St. Marys River Area of Concern. There are four NPL sites in Gary, Indiana of potential relevance to the Grand Calumet River/Indiana Harbor Area of Concern. Remedial investigations were completed on three of these sites during FY 1989. The River Raisin

Table 5-5. Great Lakes Superfund Activities in FYs 1989 and 1990.
Source: USEPA, 199_.

Activity	Number of Actions*	
	FY 1989	FY 1990 (Planned)
Conduct Initial Inspections	30	-
Begin RI/FS Studies	11	8
Complete RI/FS Studies	16	19
Begin Negotiations with PRPs	11	17
Begin Remedial Designs	13	20
Begin Remedial Actions	3	7
Begin Removal Activities	4	2
Complete Removal Activities	6	-
NPL Deletion	1	-
Begin Non-NPL Site Removal	17	3
Complete Non-NPL Site Removal	6	2

*These figures do not include Superfund activities in New York or Pennsylvania.

Area of Concern in southeastern Michigan has adjacent landfills that are suspected sources of contaminated groundwater and land runoff of PCBs and heavy metals. Some of these may become NPL sites after assessments are completed.

Resource Conservation and Recovery Act Program (Subtitle C)

RCRA, first passed in 1976 and amended in 1980 and 1984, established a shared EPA and State program (under Subtitle C) to regulate newly generated municipal and industrial solid waste disposal and (under Subtitle I) certain underground storage tanks. Whereas the mission of Superfund is to clean up past uncontrolled hazardous wastes, RCRA sets guidelines for current and future hazardous waste management from generation through ultimate disposal ("cradle-to-grave"), so as eventually to preclude the need for a Superfund program. Hazardous waste is defined as solid waste that meets one of four conditions: it is ignitable, corrosive, reactive, or toxic.

Subtitle C regulations define requirements that businesses and governments must follow in their management of hazardous waste from generation through transportation and ultimate treatment, storage, and disposal. Generators must obtain an EPA identification number for each site at which hazardous waste is created. In practice, most hazardous waste is treated or disposed of at its site of generation. If a generator transports hazardous waste, however, the generator must verify its receipt at its intended destination and notify EPA if the waste does not arrive.

Treatment, storage, and disposal facilities must obtain a permit to ensure that they meet RCRA standards for waste management. There are four classes of facilities: storage and treatment, land disposal, underground injection, and incinerators. Treatment facilities alter the character or composition of hazardous waste. Storage facilities hold waste, pending treatment or disposal. Land disposal sites include landfills, surface impoundments, application to land, and underground injection. Underground injection wells are shafts into the earth into which hazardous wastes are deposited under pressure and are the most common method of land disposal. RCRA requirements for land disposal facilities include banning underground injection near a drinking water well; structural requirements for landfills and surface impoundments; cleanup of hazardous waste releases; and location standards that set hydrogeologic conditions for disposal facility siting. RCRA regulations also require treatment, storage, and disposal facilities to prepare for the eventual closure of their facilities.

To ensure that governments and businesses comply with RCRA regula-

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Figure 5-5. Large Quantity Generators.

tions, program personnel inspect facilities and take enforcement measures when necessary. All treatment, storage, and disposal facilities are inspected at least once every two years. Hazardous waste facilities owned by governments are inspected on an annual basis. Facilities are also inspected when EPA or a State has basis for believing that a permit violation has taken place. During inspections, program personnel review groundwater monitoring records and obtain waste samples. In the event of noncompliance, EPA or the State takes enforcement actions that may result in civil and criminal penalties, orders to correct the permit violation, fines, or imprisonment.

RCRA Activities in the Great Lakes Basin

This section summarizes some activities of the RCRA program in the Great Lakes basin. RCRA activities and sites were selected based on their location within counties that are wholly or partly located within the Great Lakes basin. A geographic area larger than that of the basin is used, since information from the Agency's pertinent data base can best be extracted by county.

Figure 5-5 shows the distribution of 14,107 large quantity generators in the counties of the Great Lakes basin. Cook County, Illinois, has the highest number of generators. Other counties with high concentrations include Wayne County, Michigan, and two adjacent counties, Macomb and Oakland, and the counties containing Cleveland, Ohio, and Buffalo, Rochester, and Syracuse, New York.

Figure 5-6 illustrates the distribution of over 16,443 small and very small quantity generators. Many of the same counties that have high concentrations of large generators have high concentrations of smaller ones. Additional notable concentrations are the counties containing Milwaukee, Wisconsin; Duluth, Minnesota; Grand Rapids, Michigan; and Toledo, Ohio.

Figure 5-7 presents the distribution of 463 treatment and storage facilities in Great Lakes basin counties. Their distribution seems to follow the population distribution. Cook County, Illinois (Chicago) has the greatest number of storage and treatment facilities. Wayne County, Michigan (Detroit) and Cuyahoga County, Ohio (Cleveland) have the next highest concentrations.

Figure 5-8 shows the distribution of 173 land disposal facilities in Great Lakes basin counties. The highest concentrations of land disposal facilities are in Lake County, Indiana (which contains the Grand Calumet River Area of Concern) and Wayne County, Michigan (which has two Areas of Concern, the Rouge and Detroit Rivers). Other counties with large concentrations of disposal facilities are Cook County, Illinois; Cuyahoga County, Ohio; and Niagara County, New York.

During FY 1989, EPA and the States conducted 1,651 RCRA inspections in the Great Lakes basin coun-

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Figure 5-6. Small and Very Small Quantity Generators.

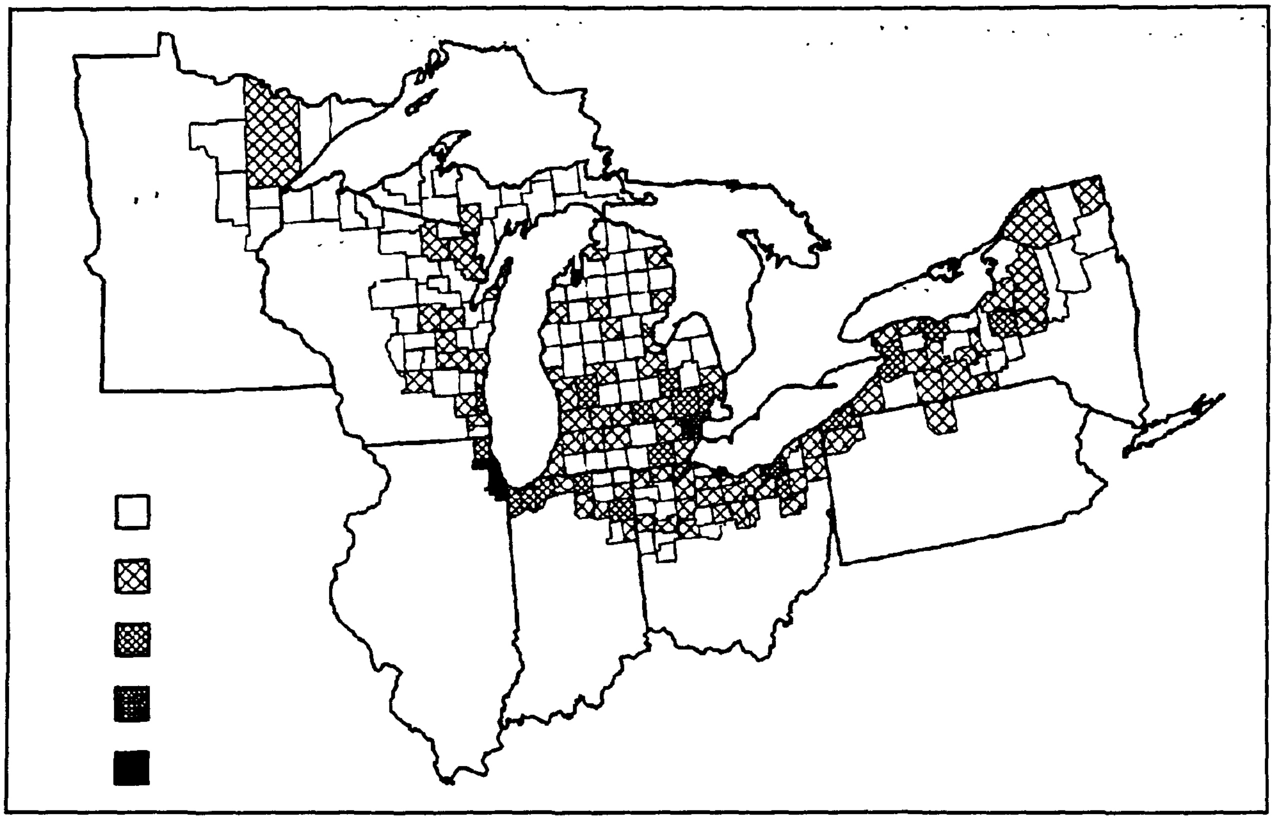

Figure 5-7. Treatment and Storage Facilities.

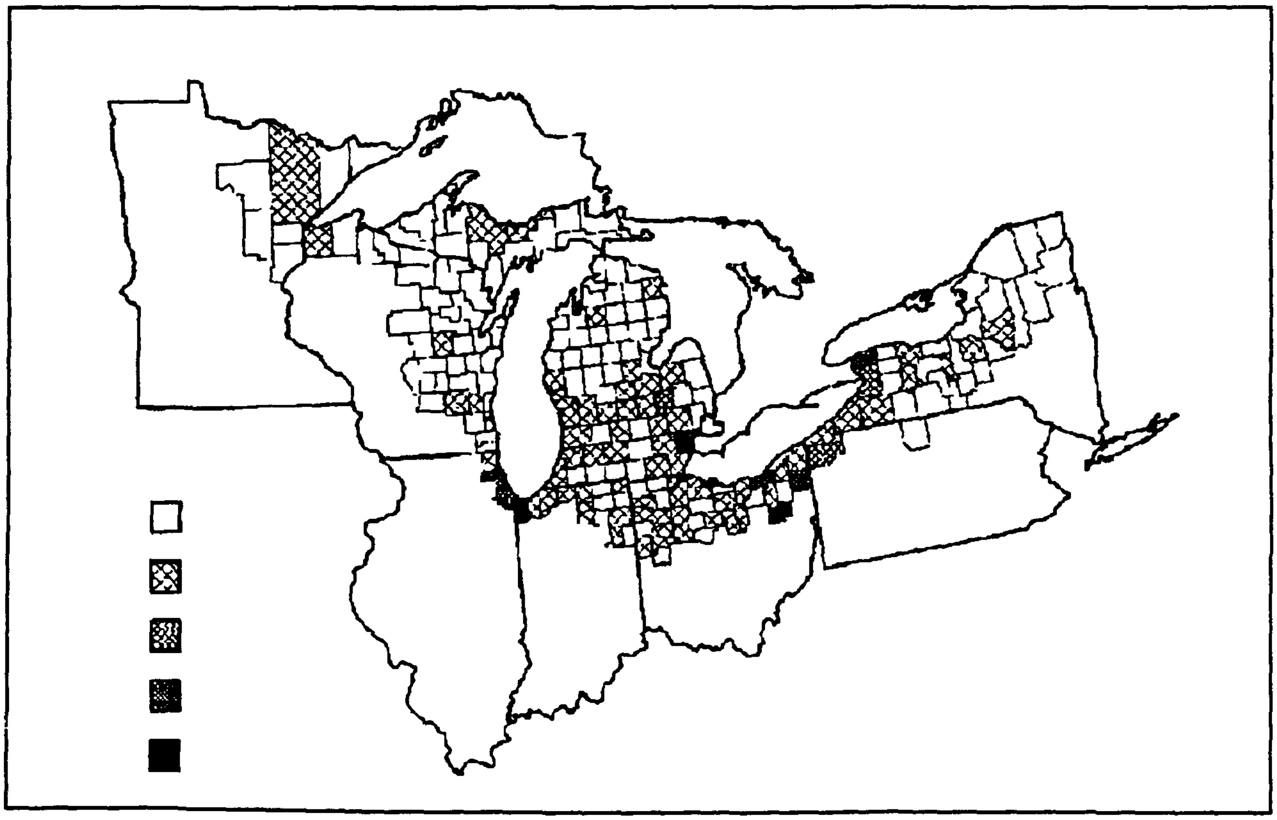

Figure 5-8. Land Disposal Facilities.

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Figure 5-9. Compliance Evaluation Inspections in FY 1989.

ties. Counties with the highest concentration of facilities — Cook, Wayne, and Cuyahoga counties — also had the highest concentration of inspections. Figure 5-9 shows the distribution of compliance evaluation inspections.

Beginning in FY 1990 and continuing into FY 1991, EPA, Illinois, and Indiana plan a RCRA enforcement project dedicated to a specific geographic region — southeast Chicago and Lake and Porter Counties in northwest Indiana. This initiative will include inspections at treatment, storage, and disposal facilities, and increased inspections of generators. Where violations of permits are found, State/Federal enforcement actions will be taken.

The RCRA program can have substantial impact on improving Great Lakes water quality. New York State and EPA are using RCRA authorities to ensure that responsible companies clean up four of the top eight waste sites that release contaminants into the Niagara River. These four sites include the site that is the source of the largest estimated loadings, the Occidental Chemical Corporation's Buffalo Avenue Plant (corrective measure completion target date is December 1996); the CECOS International Incorporated hazardous waste disposal facility (corrective measure completion target date is December 1996); the Bell Aerospace Textron plant (corrective measure completion target date is December 1996); and the BTL Specialty Resins Corporation, owned by Occidental Chemical Corporation (corrective measure completion target date is December 1996).

Air Programs

Under the Clean Air Act, EPA has set National Ambient Air Quality Standards for six air pollutants that are common nationwide—ozone, carbon monoxide, total suspended particulates, sulfur dioxide, lead, and nitrogen dioxide. States monitor ambient atmospheric concentrations of these criteria pollutants. Where air quality standards are not met, States develop plans to attain them. Mobile sources, such as automobiles, produce the majority of air pollution emissions. EPA and the States limit emissions from mobile sources by setting design requirements for car manufacturers and by periodic inspections of vehicle emissions. EPA and the States reduce emissions from major stationary sources, such as utilities and industrial facilities, by issuing permits that limit emissions of the six criteria pollutants by requiring best demonstrated control systems. EPA also regulates certain "hazardous air pollutants," including asbestos, beryllium, mercury, and vinyl chloride. In 1989, revisions to the Clean Air Act were proposed that provided strengthened measures for reducing emissions of toxic substances by requiring permittees to use more effective control technologies.

Some States have established programs expressly aimed at limiting airborne toxic substances. New York State, for example, has set acceptable ambient levels (AALs) for approximately 200 toxic chemicals. The State models potential emissions of these substances from new or modified air point sources to determine whether AALs would be exceeded. If any would be exceeded, the new or modified facility must reduce its potential emissions so that is complies with the AAL. Regulation is usually based, in effect, on indirect modeling of environmental conditions rather than on direct measures of ambient air concentrations of toxic substances because atmospheric concentrations are very low and difficult to measure. However, New York State augments its modeling by operating monitoring sites for certain toxic air pollutants, including monitoring for methylene chloride in Rochester and dioxin near the Niagara River. In FY 1989, New York issued about 600 air permits in its 30 Great Lakes basin counties.

Airborne Toxic Substances in the Great Lakes Region

During the last several years, EPA and the States have conducted studies concerning airborne toxic substances in the Great Lakes region. One of these studies estimated cancer risks attributable to the inhalation of air pollution in southeast Chicago. Southeast Chicago has both intense industrial activity and a high population density. The study estimated the emissions of 30 substances that are considered potentially carcinogenic. Based on these emissions, the study estimated that airborne potential carcinogens were likely to induce 77 additional cases of cancer over 70 years in a human population of 393,000. For the persons living within the study area, inhalation of the study's air pollutants increased the likelihood of cancer during their lifetimes by two chances in 10,000. Major sources of potentially cancer-causing air pollutants were steel mills (37 percent); other industries (18 percent); motor vehicles (16 percent); consumer sources, such as home heating, dry cleaning, and auto refueling (8 percent); and background pollutants (21 percent).

During FYs 1988 and 1989, EPA's Great Lakes National Program Office sponsored two studies that inventoried air emissions and modeled atmospheric contaminant transport in both the Detroit/Windsor and southern Lake Michigan areas. The States of Michigan, Indiana, Illinois, and Wisconsin joined EPA in conducting these studies.

The southern Lake Michigan study, covering 21 counties, addressed a total of 58 substances known to be deposited atmospherically into Lake Michigan or known to pose a carcinogenic or other human health risk. Three different sources of information were used to estimate emissions around southern Lake Michigan. The primary source was a 1985 Agency national estimation of emissions of the six criteria pollutants from known emission points based on the type of emitting technology. "Calculation factors" were applied to these emissions to derive estimates concerning the study's pollutants. The estimation method was augmented by data on facilities obtained under permit programs and by emission information reported by large firms for 1987 under the Emergency Planning and Community Right-to-Know Act (i.e., Title III of the Superfund Amendments).

One result of this study is that there are few emissions near southern Lake Michigan of such critical Great Lakes persistent toxic substances as dioxins, furans, and PCBs. This result should be viewed from several perspectives, however. First, the study obtained estimates of emissions in counties immediately adjacent to the lakes. Sources outside the study area may be significant. Second, substances like PCBs are known to volatilize off the earth's surface. Estimation of this type of PCB uptake into the atmosphere was beyond the scope of study. Third, facility and pollutant-specific emission information, if available, is inherently preferable to indirect estimation methods.

The Integrated Atmospheric Deposition Network (IADN) (see Chapter 7) that the United States and Canada have agreed to establish around the Great Lakes will provide more direct information on the atmospheric loadings of certain toxic substances to the Great Lakes than estimates obtained from emissions inventories and modeling. IADN results will also allow assessment of the efficacy of predictive deposition models. Due to the difficulty of monitoring the deposition of some substances, however, emissions inventories and modeling will continue to be an efficient way of estimating atmospheric loadings of a wide range of toxic substances to the Great Lakes.

Chapter 6

Reports from Other Federal Agencies

This chapter presents FY 1989 and 1990 accomplishments and FY 1991 plans pertaining to the Great Lakes as reported by five federal agencies: the Army Corps of Engineers, the Coast Guard, the Fish and Wildlife Service, the National Oceanic and Atmospheric Administration, and the Soil Conservation Service.

Army Corps of Engineers

The Corps is responsible for several programs related to Great Lakes water quality, including maintenance of navigation channels and harbors, civil works programs, construction projects, and identification and cleanup of hazardous and toxic materials.

Under the Rivers and Harbors and Flood Control Acts, the Corps is required to maintain adequate depths for navigation in authorized harbors and river channels of the Great Lakes. Periodic dredging of bottom sediments is necessary to maintain authorized depths of the navigation channels. In conducting these navigation dredging projects, the Corps has dredged approximately four million cubic yards of sediments per year from Great Lakes projects in recent years (1986-1988). Because approximately half of this volume is contaminated and unsuitable for open water disposal, confined disposal facilities have been constructed by the Corps for disposal of these sediments.

Also among the Corps' programs with the greatest potential effect on Great Lakes water quality is the Clean Water Act Section 404 permit program, requiring the permitting of dredge and fill activities in nearshore areas. In addition, the Corps is responsible for specific construction projects authorized by Congress or under continuing authorities. These projects are in various stages of planning, design, construction, operations and maintenance, for flood damage reduction, shoreline protection, and navigation.

Through the Defense Environmental Restoration Program (DERP), the Corps is responsible for the identification and cleanup of hazardous and toxic materials at formerly used defense sites (FUDS).

The Corps also provides engineering and/or construction support to the USEPA for four additional environmental programs that potentially affect Great Lakes water quality. These are: the construction grants program for wastewater treatment facilities; the Superfund program; the Great Lakes National Program Office's Assessment and Remediation of Contaminated Sediments (ARCS) study; and the EPA Region 5 enforcement initiative.

Finally, the Corps assists in planning, development and implementation of remedial action plans (RAPs) for States, and supports the International Joint Commission (IJC) by participating on boards and committees such as International St. Lawrence River Board of Control, the International Niagara Board of Control, the Great Lakes Levels Reference Study Board, the International Lake Superior Board of Control, the Sediment Subcommittee to the IJC Water Quality Board, and the IJC Council of Great Lakes Research Managers.

FY 1989 Accomplishments

- Administration of the regulatory permitting program and enforcement for construction in navigable waters under Section 10 of the Rivers and Harbors Act and for the discharge of dredged and fill material into U.S. waters within the Great Lakes basin under Section 404 of the Clean Water Act. Permit applications were reviewed in cooperation with Federal and State agencies, public comments were reviewed, environmental impacts were assessed, and mitigation requirements were determined.
- The Corps analyzed bottom sediments at 19 navigational projects in the Great Lakes: Ashtabula Harbor, Cleveland Harbor and West Harbor in Ohio; Manistique Harbor, Saginaw River, Rouge River, St. Clair River, Keweenaw Waterway and Lake St. Clair in Michigan; Buffalo Harbor and Olcott Harbor in New York; Chicago River and Waukegan Harbor in Illinois; Erie Harbor in Pennsylvania; Indiana Harbor in Indiana; Milwaukee Harbor, Sheboygan Harbor and Green Bay in Wisconsin; and Duluth/Superior Harbor in Minnesota-Wisconsin.

Sediment analyses included physical, chemical, and biological testing. The results of sediment testing conducted by the Corps represents the largest data base of its kind on the Great Lakes. Results have been made available to Federal and State agencies, and have been widely used for RAP development. Sediment analyses are applicable to a wide range of Great Lakes water quality issues, including bench-top investigations on the feasibility of advanced treatment technologies for contaminated sediments at Indiana Harbor, studies of the microbiological degradation of PAHs in sediments, and comparative analysis of sediment bioassays.

- Navigational dredging and confined disposal removed nearly two million cubic yards of polluted sediments from the Great Lakes. Navigation projects where polluted sediments were removed and disposed of in a confined disposal facility in FY 1989 included: Calumet River and Harbor in Illinois; Cleveland Harbor and Toledo Harbor in Ohio; Monroe Harbor, Rouge River, Saginaw River and Keweenaw Waterway in Michigan; Milwaukee Harbor and Green Bay Harbor in Wisconsin; and Duluth/Superior Harbor in Minnesota-Wisconsin.
- A new confined disposal facility (CDF) was completed at Clinton River, Michigan.
- Corps personnel participated in the development of RAPs for several Areas of Concern, including Ashtabula, Buffalo, Cleveland, Grand Calumet River/Indiana Harbor, and Milwaukee. In some Areas of Concern, Corps research and/or confined disposal facilities have been integral to RAP implementation.

FY 1990 Accomplishments

- Continuing administration of the dredge and fill permit program. Permit applications were reviewed in cooperation with Federal and State agencies, public comments were reviewed, environmental impacts were assessed and mitigation requirements determined. Approximately 6,500 permits were issued and 343 enforcement actions were taken by Corps districts within the Great Lakes basin during FY 1990.
- Sampling and analysis of bottom sediments from 19 Great Lakes navigation projects to determine disposal means. Sediment investigations were completed for: Waukegan Harbor in Illinois; Cleveland Harbor, Conneaut Harbor, Rocky River, and Sandusky Harbor in Ohio; Black River, Grand Traverse Bay Harbor, Manistique Harbor, Ontonagon Harbor, and Saginaw River in Michigan; Ashland Harbor, Bayfield Harbor, Cornucopia Harbor , LaPointe Harbor, Manitowoc Harbor, and Milwaukee Harbor in Wisconsin; Duluth-Superior Harbor in Minnesota/Wisconsin, Oswego Harbor, and Rochester Harbor in New York.
- Navigational dredging of approximately 4.1 million cubic yards of bottom sediments. Approximately 2 million cubic yards were determined to be unsuitable for open-water disposal and placed in existing CDFs. Such navigational dredging projects included: Buffalo Harbor in New York; Cleveland Harbor, Huron Harbor, Lorain Harbor, and Toledo Harbor in Ohio; Detroit River, Holland Harbor, Keweenaw Waterway, Monroe Harbor, Saginaw River, and St. Clair River in Michigan; Duluth-Superior Harbor in Minnesota/Wisconsin; Green Bay Harbor, and Milwaukee Harbor in Wisconsin. Activities associated with this dredging and disposal include CDF operation, maintenance, and water quality monitoring.
- Monitoring studies of contaminant loss and biomonitoring at the Saginaw CDF, and field studies of PCB bioaccumulation and volatilization at the Chicago CDF.
- Initiation of construction of the Maumee Bay Shoreline erosion and Beach Restoration and Reno Beach/Howard Farms Flood control projects in Ohio.
- Participation in the Onondaga Lake management conference and representation on the Onondaga Lake technical advisory committee.
- Initiation of construction of two major flood damage reduction projects. The Chicagoland Underflow Plan and the Little Calumet River Flood Protection and Recreation Project. The Chicagoland Underflow Plan is the reservoir portion of Chicago's Tunnel and Reservoir project (TARP). The overall TARP project will reduce the backflow of stormwater and sewage from Chicago area rivers into Lake Michigan. Construction was also initiated on the Little Calumet River Flood Protection and Recreation Project in northwest Indiana. This project includes significant wetland mitigation and enhancement and will provide a major recreational corridor along the river.
- Underground storage tanks and transformers were removed from a site near Sault St. Marie, Michigan under the DERP FUDS program. Remedial Investigations and Feasibility Studies (RI/FS) are ongoing at this and other sites.
- Water level impacts on wetlands of the St. Marys River were evaluated in support of the IJC Levels of Reference Study.
- Design and construction oversight support were provided to the EPA Superfund project at the Sinclair Oil Site in Wellsville, New York.
- Technical review of a sediment sampling plan for the Fields Brook/Ashtabula River Superfund site in Ashtabula Ohio.
- Technical review of remediation designs conducted for the OMC Superfund cleanup at Waukegan, Illinois.
- Support provided to the EPA Great Lakes National Program Office (GLNPO) for the Assessment and Remediation of Contaminated Sediments (ARCS) program. Corps participation included providing technical support, bench-scale testing of treatment technologies, development of plans for pilot scale demonstrations, development of

procedures for estimating contaminant losses, development of concept plans for full-scale remediation, and participation in five ARCS work groups.

- Provided support to the State of Wisconsin in the development of management alternatives for contaminated sediments.
- Studied wetland mitigation, restoration projects, and environmental management of CDFs for the State of Michigan.
- Assisted in the development and implementation of RAPs at a number of the Areas of Concern (AOCs) of the Great Lakes.
- Initiated a study of the movement of dredged material placed in Sandusky Bay, Ohio on Lake Erie under the Corps Dredging Research Program.

FY 1991 Plans

- Corps administration of the CWA Section 404 and Section 10 (dredge and fill) permit programs will continue.
- The EPA/Corps task group on 404(b)(1) implementation will meet to develop regional guidance on dredged material testing and decision-making.
- Routine sampling and testing of bottom sediment will be conducted at the following navigation projects: Arcadia Harbor, Au Sable Harbor, Caseville Harbor, Detroit River, Holland Harbor, Lexington Harbor, Ludington Harbor, Manistee Harbor, Manistique Harbor, Port Sanilac Harbor, St. Clair River in Michigan; Waukegan Harbor in Illinois; Burns Waterway Harbor, and Michigan City Harbor in Indiana, Dunkirk Harbor, in New York, Erie Harbor in Pennsylvania; Fairport Harbor, Huron Harbor, Port Clinton Harbor, and West Harbor in Ohio; and Sheboygan Harbor in Wisconsin.
- Maintenance dredging of polluted sediments and confined disposal is planned for the following sites: Bolles Harbor, Clinton River, Detroit River, Lake St. Clair, Rouge River, and Saginaw River in Michigan; Buffalo Harbor in New York; Cleveland Harbor, Huron Harbor, Lorain Harbor, and Toledo Harbor in Ohio; Duluth-Superior Harbor in Minnesota/Wisconsin; Green Bay Harbor and Manitowoc Harbor in Wisconsin.
- Construction of new CDFs, offloading facilities, of major modifications or expansions to existing confined disposal facilities are planned at: Erie Harbor in Pennsylvania; Duluth-Superior Harbor in Minnesota/Wisconsin; Green Bay Harbor and Sturgeon Bay in Wisconsin, St. Josephs Harbor in Michigan; and Toledo Harbor in Ohio.
- Routine maintenance and water quality monitoring will be performed at other CDFs.
- Major construction starts are planned for small boat harbors in Buffalo, New York, and in Little Calumet River, Indiana; and for the Chicagoland Illinois Underflow Plan flood damage reduction projects.
- The Corps will continue activities to identify and remediate hazardous and toxic wastes at former defense sites. An initial analysis of a sampling of barrels from over 1400 barrels of unclassified material dumped into Lake Superior over 30 years ago will be completed.
- The Corps will continue its support to the IJC through participation on IJC boards and committees during FY 91.
- Support to the Construction Grants and Superfund programs will continue in FY 91.
- Support to the ARCS program will continue with the execution of pilot scale demonstrations of sediment remediation technologies.
- The Corps will provide support in a GLNPO project to remove contaminated sediments from the Buffalo River.
- The Corps will participate in a U.S. Fish and Wildlife Service assessment of the management and restoration needs of Great Lakes fisheries resources.
- The Corps will conclude its planning assistance to the State of Wisconsin in the development of management alternatives for contaminated sediments.
- The Corps will fund a study of the wetlands restoration at the Point Mouilee CDF in Michigan under the Wetlands Research Program.
- The Corps will serve on the IJC Aquatic Nuisance Species Task Force to develop a research and technology development program aimed at controlling the zebra mussels in and around public facilities.

U.S. Coast Guard

The U.S. Coast Guard has responsibilities under the Port and Tanker Safety Act, the Clean Water Act and other statutes that focus on the active reduction of the potential for pollution, and ensuring that effective countermeasures and cleanup operations are conducted for accidental discharges as the Federal On-Scene Coordinator. The Coast Guard also enforces sewage discharge regulations onboard vessels in conjunction with other types of inspections such as boating safety and law enforcement boardings. Finally, the Coast Guard plays a role under the Fisheries Conservation and Management Act in mitigating pollution as it affects natural resources.

Two important issues in the Great Lakes with which the Coast Guard is involved are accidental spills of hazardous substances and the introduction of exotic species through ballast water discharges.

Spills of Hazardous Substances

Because a large amount of vessel traffic in the Great Lakes carries shipments of hazardous materials, accidental spills of hazardous substances from vessels are potentially important sources of contamination to the Great Lakes. Shipments of hazardous materials and petroleum amount to 6 million metric tons in 1987 and 4.2 million metric tons in 1988. In that same year, shipments of oil were 1.8 million tons, chemicals were 1.1 million tons, and gasoline, 0.6 million tons. (The tankers that carry such cargo vary in size; for perspective, the largest tend to be about 15 percent the size of the *Exxon Valdez*.

Land-based sources are also a threat. A large oil or chemical spill from either source could cause both economic and long-term environmental damage, injuring fish, waterfowl, plankton, and habitat.

The U.S. Coast Guard reports that over the period from 1980 to late 1989 there were 5,003 known spills of oil or toxic substances into the U.S. waters of the Great Lakes (Figure 6-1). During the calendar year 1989, there were 262 verified pollution incidents in U.S. waters of the Great Lakes. Most of these spills consisted of oil, and most were small in volume. However, there have also been oil spills of up to a million gallons and toxicant spills of up to 200,000 gallons. Approximately 80 percent of these larger spills were from land-based facilities such as oil storage tanks and pipelines; the remainder came from vessels.

Spill Programs

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) requires a National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and Regional Contingency Plans (RCPs) to coordinate Federal and local responses to oil and hazardous material spills. The U.S. Coast Guard is principally responsible for addressing spills in the Great Lakes as the Federal On-Scene Coordinator. The On-Scene Coordinator is responsible for monitoring the cleanup and for actually conducting it when the responsible party does not do so. The Coast Guard operates nine marine safety units on the Great Lakes to perform pollution response and investigation functions.

EPA also has a role in spill prevention, related to non-transportation spills. Pursuant to the Clean Water Act, EPA issues non-transportation related oil pollution prevention regulations for onshore and offshore facilities. These regulations require facilities that might discharge oil to navigable waters to prepare a Spill Prevention Control and Countermeasure (SPCC) Plan; EPA inspects these facilities for compliance.

1989 Accomplishments

In April 1989, the Coast Guard promulgated regulations to implement Annex V of the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78). These regulations prohibit the discharge of garbage into the navigable waters of the United States, and apply to all vessels, including recreational boats. These regulations were amended in May 1990 to require maintenance of waste management plans and display of MARPOL Annex V placards on all oceangoing vessels greater than 26 feet in length. This amendment is to ensure that all persons on board are aware of the garbage pollution laws and penalties and to promote proper disposal.

The U.S.-Canada Joint Marine Pollution Contingency Plan (JCP) was amended to include provisions for periodic meetings and exercises of the Joint Response Team and On-Scene Coordinator organizations. A binational exercise of the JCP took place at St. Catherine's, Ontario in February 1989.

1990 Plans

EPA plans to perform 85 SPCC inspections in the Great Lakes watershed.

Partially as a result of the 1989 *Exxon Valdez* spill in Alaska, the Coast Guard is reviewing all oil and hazardous substances contingency plans, including those for the Great Lakes. The review will consider preparedness to respond to the most catastrophic potential incidents given shipping patterns and cargos.

The Canadian and U.S. Coast Guards agreed to compare regulations that implement pollution prevention standards for onshore and offshore facilities. They also agreed

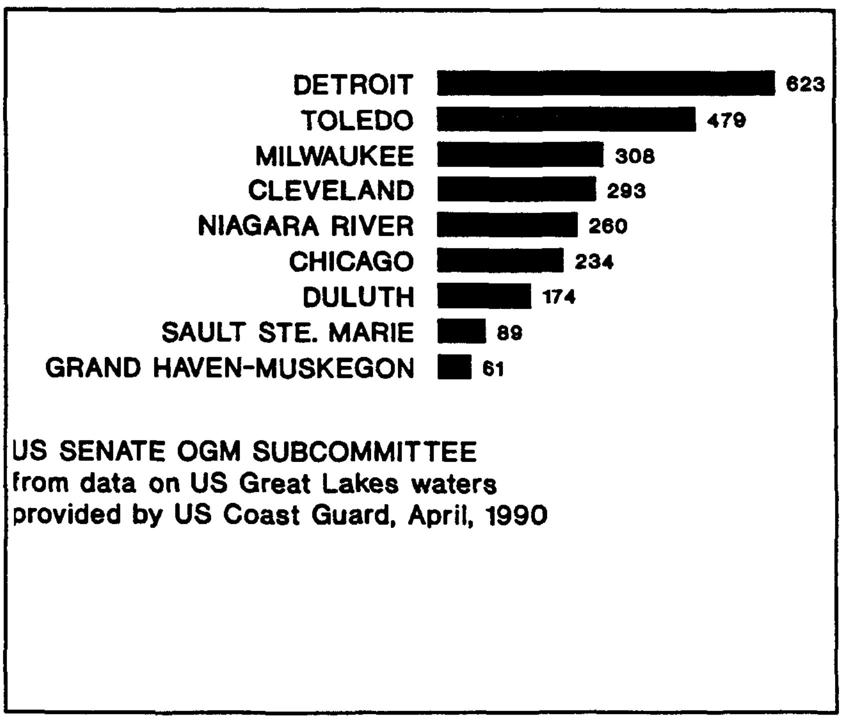

Figure 6-1. Great Lakes Spills from 1980 to September 1989.

that oil and hazardous substance spills coming from such facilities will be discussed at their 1990 annual meeting.

The Canadian and U.S. Coast Guards also agreed to study the potential problem of non-toxic cargo residues, now considered garbage under MARPOL Annex V. Representation will be made to the IJC requesting information regarding the scope of this potential problem.

Exotic Species

As many as 577 ocean-going vessels entered the Great Lakes during the navigation season of 1987 alone. Recent years show that hundreds of these vessels enter carrying ballast water when their cargo holds are empty, since the added ballast weight enables them to draw an optimum depth for safe and efficient passage. Often, the vessels are weighted by millions of gallons of ballast water.

Sometimes, fish and other organisms are inadvertently taken aboard vessels with ballast water when it is pumped from a river, harbor, or the open ocean. When the ballast is discharged (in order to take on new cargo, for instance), they can be transferred to a new waterbody. Organisms that can survive in ballast tanks are frequently very adaptable and aggressive; when they are transferred to an ecosystem in which they have few natural predators, they can proliferate and severely affect the existing balance between species.

As recently as 1988, the introduction of foreign species by discharges of ballast water into the waters of the United States first began receiving national attention, with the discovery of the presence of the zebra mussel. This species is a major fouling pest species that can locate in mass quantities on and in pipes, screens, conduits, boat bottoms, floats, buoys, rocks, submerged objects, and native animals and plants. It also consumes vast quantities of planktonic organisms that are critical to the native species' food supply. Originally native to areas of Russia, the zebra mussel is a hardy species with no known predator in North America. Other plant and animal species have also been introduced to the Great Lakes with affects on the ecological balance of natural communities, as well.

The problem can be essentially prevented by requiring ocean vessels to exchange their ballast water at sea before entering the Great Lakes, since open ocean organisms are unlikely to survive in the Great Lakes. Inspection of ship records and sampling of ballast water salinity help to ensure that the required exchange has been conducted.

1989 Accomplishments

In 1989, the U.S. Coast Guard collaborate with the Canadian Coast Guard to establish voluntary guidelines to protect the Great Lakes from further introduction of exotic species. Under these guidelines, which were introduced in May 1989, ships scheduled to enter the Great Lakes system are advised to exchange their ballast water beyond the continental shelf, or if this is not possible, in the Gulf of St. Lawrence. These guidelines were distributed by the International Maritime Organization to its 133 member governments and organizations. The St. Lawrence Seaway Authority is monitoring compliance with the guidelines, and the Canadian Coast Guard plans to evaluate the continued effectiveness of the guideline, with the help of the U.S. Coast Guard as necessary.

Fish and Wildlife Service

The U.S. Fish and Wildlife Service (FWS) collects and interprets diverse information on fish and wildlife species, populations and habitats to assist resource managers in making decisions about the protection and restoration of the Great Lakes ecosystem. The Service's responsibilities generally fall into a number of functional areas: refuges and wildlife, fisheries, law enforcement, fish and wildlife enhancement, and public affairs. Major activities include: permit review; land acquisition and habitat management; management of migratory birds, anadromous[1] fish, and endangered species; and research on causes and effects of habitat change and chemical contaminants. As part of the permit review process, FWS will review Federal Energy Regulatory Commission hydroelectric projects, dredge and fill permits, Farm Bill habitat easements and wetland restorations.

FWS also manages the National Fishery Center-Great Lakes; five National Fish Hatcheries in support of the Great Lakes lake trout restoration effort; and several National Wildlife Refuges, including the Iroquois and Montezuma in New York, the Erie in Pennsylvania, the Ottawa in Ohio, and the Seney and Shiawassee in Michigan. In addition, FWS conducts surveys of wetlands to support the National Wetlands Inventory Program.

FWS is responsible for maintaining the fish and wildlife resources in the United States and for providing public access to those resources. Accomplishments in FY 1989 and FY 1990 are discussed in terms of functional areas. The Service continued its base program activities in FY 1990. Any significant new activity in FY 1990 is noted. Reduced activities in FY 1990 include: flood damage restoration at Ottawa and Shiawassee Refuges, surveillance and monitoring, and research.

Listed by topical area, highlighted FY 1989 and FY 1990 accomplishments and FY 1991 plans are as follows:

Fisheries

The Fish and Wildlife Service's (FWS) National Fishery Research Center (NFRC)-Great Lakes in Ann Arbor, Michigan focuses on aquatic resources. Loss or degradation of fish habitats in the Great Lakes basin is a major concern. Generally, FWS research addresses specific needs of the Service, but also responds to the needs of other Federal agencies, Indian tribes, States and international groups such as the International Joint Commission and the Great Lakes Fishery Commission.

FY 1989 Accomplishments

- Stocked approximately 6.4 million lake trout into the five Great Lakes. This native species serves as a biological indicator of water quality because of its need for

1 Fish that spend their adult life in the sea but swim up rivers to reproduce.

clean water and its long life span (up to 40 years).

- An offshore stocking vessel (the M/V *Togue*) was used to stock fish over traditional offshore spawning reefs to enhance fish survival.
- Provided fish to support investigations by universities and government laboratories.
- Continued monitoring bloater chubs from Lake Michigan for DDT congeners and dieldrin, PCBs and chlordane.
- FWS is responsible for the United States sea lamprey control program. The Service applied lampricides to 31 Great Lakes tributaries. Parasitic and spawning adult populations, larval populations, and non-target organism populations were also evaluated. Operational fishery research was conducted on alternate control techniques, registration of lampricides, and special problems encountered by field crews.
- Fishery assistance biologists continued to study exotic aquatic organisms that appear in the Great Lakes.

FY 1990 Accomplishments

- Continued the lake trout stocking program. More than two million lake trout were stocked offshore to increase the likelihood of their survival.
- Applied lampricides to 28 Great Lakes tributaries.

FY 1991 Plans

- Continue the lake trout stocking programs.
- Apply lampricides to 39 Great Lakes streams.
- Continued monitoring bloater chubs from Lake Michigan for DDT congeners and dieldrin, PCBs and chlordane.
- Conducted PCB and chlordane congener analysis on archived fish samples to better interpret contaminant trends in Lake Michigan bloater chubs.
- Developed an interactive computer program that uses the structure of an organic molecule to predict acute toxicity to aquatic life. The system is being used to estimate toxicity of chemicals before initiating bioassays.
- Increase activities with State officials and tribal leaders for the assessment of fish populations.

Wildlife and Refuges

FY 1989 Accomplishments

- Increased wetland acreage in the Montezuma National Wildlife Refuge and provided a link with New York State Refuge as part of the North American Waterfowl Management Plan, a cooperative effort among the Fish and Wildlife Service and U.S. Forest Service to preserve waterfowl habitats.
- Under the North American Waterfowl Management Plan, conducted a waterfowl breeding survey and developed a waterfowl management plan for the Fort Drum Military Base.
- Funded three studies that assessed the impacts of contaminants on Great Lakes wildlife. The first study, the St. Lawrence River Contaminants Study, collected samples of water and bird eggs to analyze for levels of PAHs. The other studies, conducted in cooperation with Patuxent Wildlife Research Center, studied the levels of contaminants in two Great Lakes migratory birds: the double-crested cormorant and black-crowned night heron.
- Collected samples of water, sediment, and biota in the national refuges for analysis of chemical contamination. In FY 1989, samples were collected in the Apostle Islands National Lakeshore, Grassy Island-Wyandotte National Wildlife Refuge, Michigan Islands National Wildlife Refuge, Iroquois Refuge, and Montezuma Refuge.
- Substantial pump, levee, and dike restorations were made at the Ottawa and Shiawassee Refuges to repair flood damage.

FY 1990 Accomplishments

- Restoration of eight separate wetlands totalling 109 acres in the counties adjacent to Lake Erie.
- Restoration of an additional 308 acres of wetlands in the Great Lakes area.

FY 1991 Plans

- Continuation of introduction of common terns at Ottawa Refuge.
- Continuation of funding restoration of wetlands on private lands.
- Monitoring of bald eagles and black ducks on Lake Erie.

Fish and Wildlife Enhancement

FY 1989 Accomplishments

- Several Fish and Wildlife Service laboratories and offices participated in the IJC Water Levels References Study, looking at wetland changes during low water-level years and high water-level years from 1979 to 1988 and the resulting ecosystem effects. Among the sites examined by the Service were Lake Superior (Kakagon Slough, WI), Lake Michigan (Cecil Bay Marsh, MI), Lake Huron (Fish Point, MI), Lake St. Clair (Dickinson Island, MI), and the St. Lawrence River, Sage Creek, and Campbell marshes, New York.
- Began working with EPA to include the development of water quality criteria for wildlife as part

of the Great Lakes Water Quality Initiative.

- Prepared natural resource damage surveys for two Superfund sites (General Motors Central Foundry located along the Saint Lawrence River and Hooker Chemical located along the Niagara River) and reviewed a report on fish tumors at the 102nd Street Dump Site on the Niagara River.
- Supported EPA's ARCS study by conducting surveys of fish (bullheads) and sediments in Saginaw, Grand Calumet, and Buffalo River for tumors and abnormalities. The sediment collected will be used to study bioaccumulation of chemicals in fish collected at these three locations.
- Continued Great Lakes fish surveillance programs.
- In New York State, participated in the relicensing effort for 23 hydroelectric projects, recommending changes in operation or shutdown of three projects and minimum flow requirements at six plants, because the projects were causing adverse effects on fish populations. Approximately 26 projects were reviewed by the East Lansing Field Office.
- Also in New York State, reviewed about 300 dredge and fill permits, requesting modifications to approximately 100 projects to reduce habitat impacts and recommending denial of 10 projects due to unacceptable impacts.
- Under the conservation provisions of the Farm Bill, the Service obtained easements on about 700 acres of valuable wildlife habitat, transfers of approximately 500 acres of wetlands, and a wetland restoration project on a former muck farm in New York. In the East Lansing Field Office, conservation easements were staked for 36 proposals, and no restorations were approved. Twenty-one restorations under the Conservation Reserve Program were inspected—all are filled with water, and wildlife have been observed on most.
- Conducted endangered species consultations under Section 7 of the Endangered Species Act on about 30 projects in New York.
- Began an ongoing effort with the U.S. Forest Service to reduce beaver pond destruction and to develop small forest ponds to improve black duck breeding habitat.
- Supported the development and review of RAPs for Sheboygan, Marinette, Milwaukee, Oswego, the Niagara River, the St. Lawrence River, Duluth-Superior Harbor, and Saginaw River and Bay.

FY 1990 Accomplishments

- The major new emphasis was on the Great Lakes Initiative, Phase II. This phase details specific resource needs of FWS for a ten-year period beginning in FY 92 for the functional areas of law enforcement, enhancement, fisheries, research, refuges, Federal aid, and public affairs.
- Worked with EPA on a special wetlands inventory study of wetlands in the Green Bay watershed. The information will be available to planning and regulatory agencies to assist them in making decisions on permit issuance, zoning, etc.
- Worked with the University of Minnesota on a pre-assessment of natural resource damages for Waukegan Harbor, Illinois.
- Began a natural resources damage assessment for Saginaw Bay.
- Reports on the contaminant surveys of Seney National Wildlife Refuge, Wyandotte National Wildlife Refuge, and Michigan Islands National Wildlife Refuge were completed. Studies of contaminants in Great Lakes waterfowl, bald eagles, colonial water birds, mink, and otter continued.

FY 1991 Plans

- Identification of lands along and within ten miles of the U.S. Lake Erie shoreline have potential for wildlife habitat, public recreation areas, environmental education areas, and sites for preservation of unique natural, historical, and scenic features.
- Continue involvement with four Ohio RAPs and the Advanced Identification of Disposal Areas in northwest Ohio.
- Begin natural resource damage assessment for Indiana Harbor and Canal/Grand Calumet River and promote the RAP process for Indiana Harbor.
- Complete preliminary Lake Erie shoreline study with recommendation for a comprehensive study.

Enforcement

During FY 1990, FWS planned an enforcement initiative against illegal taking of lake trout.

Public Affairs

The Fish and Wildlife Service plans to develop a volunteer wetland watch program. In addition, the Service plans to initiate a public relations program to inform the agricultural community and the general public of the fish and wildlife benefits to be derived from the Farm Bill.

National Oceanic and Atmospheric Administration

The National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Laboratory (GLERL) in Ann Arbor, Michigan carries out a significant research program on Great Lakes issues including ecosystem dynamics, persistent toxic substances, ecological processes, and benthic populations.

Ecosystem Dynamics

Much research on Great Lakes ecosystem dynamics and physical processes is undertaken by the GLERL. It conducts integrated, interdisciplinary research in support of resource management and environmental services in coastal and estuarine waters, with special emphasis on the Great Lakes.

GLERL's research program includes both basic and applied studies and combines experimental, theoretical, and empirical approaches. Field, analytical, and laboratory investigations are performed to improve understanding and prediction of environmental interdependencies between atmosphere, land, water, and sediments. The Laboratory places special emphasis on a systems approach to environmental problems and the development of environmental service tools. Assistance is provided to resource managers and others who want to apply the Laboratory's findings.

Persistent Toxic Substances

GLERL continues to work with EPA, the Fish and Wildlife Service, and various Canadian agencies to improve understanding of the processes that control the distribution, cycling, and fate of organic contaminants, their toxicology, and the kinetics of transfer. A major focus is the association of toxic organics with suspended and deposited sediments. The adsorption of organic contaminants onto sediment particles, followed by settling and eventual burial, commonly controls the residence time and concentration of these compounds in the water column. Understanding the interactions between different types of suspended matter and dissolved organic contaminants is critical to modeling the behavior of such contaminants in the environment. Resuspension of bottom sediments in the Great Lakes is a primary process that introduces nutrients and contaminants into the water. Direct exchanges between bottom sediments and overlying water are also important processes, but are poorly understood.

The Laboratory uses radiotracers to identify and model sediment transport processes, due to their relative ease of measurement and dating. Radiotracer measurements in sediment material are used to discriminate between resuspended and fresh materials and to study horizontal sediment transport and the movement of sediments into ultimate depositional zones, the seasonal resuspension of sediments and geochemical changes to sediments over time.

GLERL has collected and analyzed sediment cores from all of the Great Lakes over the past 15 years and has deployed sediment traps to obtain samples of suspended sediments from the water column. Sediment traps have been deployed for 10 years, primarily in Lake Michigan and to a lesser extent in Lakes Superior and Huron. Extensive resuspension of sediments has been found in all three lakes, especially during winter months. Data are being integrated with data obtained by Canada in Lakes Erie and Ontario that will permit a comprehensive view of Great Lakes sediment resuspension.

GLERL's various sediment projects provide understanding that can be applied in the development of mass balance models and Remedial Action and Lakewide Management Plans. Better understanding of the physics, toxicology, and availability of Great Lakes sediments can be used to help define the assimilative capacity of the lakes for certain pollutants, the hazards that the reservoir of contaminated sediments pose to aquatic life, and the effects of alternative ways of dealing with sediments. The effects of possible contaminated sediment remediation measures are poorly understood and are one of the fundamental unresolved issues to long-term restoration of the Great Lakes.

FY 1989 Accomplishments

During FY 1989, some of GLERL's projects in the area of toxic organics addressed:

- The sediment resuspension process, using radiotracers to identify fundamental sediment transport processes;
- The physics of the bottom 25 meters of the Lake Michigan water column, with focus on bottom currents and resuspension of sediments;
- The toxicology and bioavailability of contaminated Great Lakes sediments; and
- Case studies on the long-term costs of environmental damage.
- The Laboratory developed a 28-day mortality bioassay using a benthic organism to assess the presence of toxic organic compounds.
- It tested a gamma scan system to measure the porosity of sediments in a nondestructive manner; and
- Studied the development of tolerances to toxic substances by exposing benthic worms collected from offshore sites in Lake Michigan near Grand Haven and Benton Harbor to sediments collected from these two sites. The Benton Harbor sediments were toxic to the organisms from Grand Haven, whereas the same type of organisms from Benton Harbor were unaffected by Grand Haven sediments. These results indicated, but seldom demonstrated, that organisms collected off Benton Harbor have developed tolerance to the generally higher concentrations of contaminants found in their habitat.

GLERL conducted three projects that contribute to the major interagency study of Green Bay. These were partly funded by EPA's Great Lakes National Program Office:

- A project that addressed water volume movement through the bay and between the bay and Lake Michigan;
- A project that addressed the food web of fish in Green Bay so as to understand the relative importance of the various food and water pathways of PCB accumulation by fish; and
- A project that measured the relationship between current velocity and sediment resuspension in Green Bay.

FY 1990 Accomplishments

In FY 1990, GLERL activities included:

- Completed the initial examinations of major variables that could affect the bioavailability of sediment associated toxicants to the food chain;
- Measured the water volume exchange between the upper and lower parts of Green Bay;
- Quantified the seasonal flux of resuspended sediments and estimated particulate and POC settling velocities within Green Bay.

FY 1991 Plans

During FY 1991, some of GLERL's projects will address analysis of trap samples for organic carbon and PCBs; development of empirical sediment resuspension models for Green Bay; and the completion and submission of the Green Bay Mass Balance Study to EPA.

Ecological Processes

In addition to physical processes, GLERL research focuses on ecological processes and mechanisms. In general, knowledge of many ecosystem processes is at an early stage. Food web processes have a dominant influence on the transfer of energy and contaminants throughout the ecosystem, yet predictive and simulation models of these processes are rudimentary. The Laboratory conducts research on both pelagic (i.e., water column) and benthic ecosystem dynamics to advance understanding of the flow of materials and energy within the food web.

FY 1989 Accomplishments

In FY 1989, research in the area of ecological processes included:

- A project on the effects of contaminants on the fisheries and water quality of Lake St. Clair. Lake St. Clair food web models, developed in previous years, indicate that the benthic food chain is twice as important to fish productivity as the pelagic grazing food chain and that four times more carbon is available for aquatic food chains from external particulate sources as from aquatic vegetation and algae.
- A study of the interactions between phosphorus, phytoplankton, and bacteria in Lake Michigan to help develop a better understanding of the seasonal succession of algae.
- A project that studied at the feeding dynamics of zooplankton to better understand the seasonal succession of plankton.
- A project addressing benthic ecology and sediment nutrient/energy transformations. Benthic invertebrates feed on material settled from the water column and are in turn consumed by most species of Great Lakes fish.

FY 1990 Accomplishments

In FY 1990, some of the research projects conducted by the Laboratory included:

- Analysis of two non-indigenous species to the Great Lakes ecosystem: the zebra mussel and the spiny water flea;
- A study in which the GLERL sampled phytoplankton, zooplankton, and benthic populations in Saginaw Bay to determined the impact of the zebra mussel on the lower food web;
- A study of the seasonal oxygen consumption, nitrogen (ammonia) excretion of zebra mussels collected from Lake St. Clair;
- A study, using aquaria and fish holding tanks to demonstrate the development of aversion conditioning in perch to attacking the spiny water flea;
- GLERL began analyzing the results of in situ feeding experiments performed over the past two years on the selectivity and predation rates of the spiny water flea on zooplankton in Great Lakes, and determine the effect of the spiny water flea on the food web structure; and
- The GLERL began observing ecosystem components to demonstrate the variability in time and space and to improve predictions of food web dynamics that support the Great Lakes salmonid fishery.

FY 1991 Plans

During FY 1991, GLERL will continue many studies initiated in FY 1990, including the identification of causes of ecosystem variability and continued seasonal research on oxygen consumption, nitrogen excretion, and lipid content in zebra mussels of Lake St. Clair and Saginaw Bay. New projects initiated in FY 1991 include the examination of toxicokinetics and bioaccumulation analysis of organic contaminants in the zebra mussel and the examination of nutrient changes in zebra mussels and the development of eutrophication models.

Benthic Populations

A third area of research by GLERL is long-term trends in benthic populations and the relation of these to water quality. Benthic communities are excellent indicators of trophic trends in the Great Lakes. Because of their limited mobility and relatively long life (compared to plankton), benthic fauna form stable communities that reflect the effects of environmental conditions over long periods of time.

FY 1990 Accomplishments

In FY 1990, the Laboratory:

- Identified benthic organisms collected from Saginaw Bay during 1989. Identification of the organisms collected showed a twofold increase in pollution-tolerant worms since the early 1970s which may be evidence of a degraded habitat since that time.
- Collected additional benthic samples from inside and outside fish enclosures placed in Lake Superior during FY 1986.
- Completed a study of long-term trends in mussel abundance over

the past three decades in western Lake Erie.

- Assembled and began to use of a PC-based microscope/digitizer system that allows for rapid and reliable completion of body length measurements needed to estimate the energy budget in Great Lakes amphipods.

FY 1991 Plans

During FY 1991, GLERL's projects include a determination of whether nutrient sufficient cells are preferred as food by copepods over nutrient deficient cells at high algae concentrations. In addition, the Laboratory plans to observe feeding mechanisms of tethered copepods to make generalizations about appendage use patterns and sensory clues.

Soil Conservation Service

The Soil Conservation Service (SCS) of the U.S. Department of Agriculture (USDA) provides technical and financial assistance to land users, including farmers, ranchers, and foresters, and other government agencies on a variety of natural resource issues. The Service contributes to conserving the Nation's soil, water, plant, and animal resources by informing land users of best management practices and resource management systems that control erosion, protect the quality of surface water, and reduce the contamination of groundwater by agricultural chemicals.

Through its nationwide network of conservation specialists, the SCS provides assistance on topics such as pesticide and nutrient management, reduced tillage practices, fish and wildlife habitat development, soil mapping and interpretation, and watershed protection. It also conducts natural resource inventories and maintains extensive data on soil erosion, land use and cover, conservation practices, and land treatment needs. To assist land users in protecting natural resources, the USDA (through the SCS and the Agricultural Stabilization and Conservation Service) also administers cost-sharing programs to pay land users for following certain conservation practices, protecting wetlands, and improving water quality. The Soil Conservation Service is working with States in their development of Nonpoint Source Management Plans pursuant to Section 319 of the Clean Water Act.

Seven major Department of Agriculture projects with SCS participation are currently underway or planned in the Great Lakes basin. Five of these are Water Quality Special Projects (WQSP): Cattaraugus Creek in New York; LaGrange County Lake Enhancement Program in Indiana; Vermillion River and the West Branch of the Black River, Ohio; and the Clam River, Michigan. The reduction of excess nutrients (phosphorus and nitrogen) and sediment from agricultural production activities are common goals of these projects.

In the Saline Valley Rural Clean Water Project, the emphasis is on reducing the amount of phosphorus entering Lake Erie from southeastern Michigan. Final evaluation of the project, including an analysis of practices to reduce phosphorus in runoff, is underway.

The Department of Agriculture is also conducting two demonstration projects in the Basin. The East River Watershed project in Wisconsin is partially located in the Green Bay Area of Concern and seeks to demonstrate crop management systems that reduce the level of nitrogen, phosphorus, and pesticides required to produce acceptable crop yields. Preventing excessive loadings to surface and ground water and enhancing farm income levels are goals of the project. The Saginaw Bay project in Michigan will not only focus on nutrients and sediment but will also seek to implement Integrated Pest Management practices to prevent groundwater contamination.

A hydrologic unit project related to Sycamore Creek (Michigan) is using fertilizer, pesticide, and crop management techniques to reduce agricultural pesticides and sediment from entering surface waters. Another "hydro" project, in the Wolf Creek watershed, is working to protect Lake Adrian from sediment, phosphorus, and pesticides.

FY 1989 Accomplishments

During FY 1989, the SCS contributed to Great Lakes RAP and LAMP development in a variety of ways. Service staff contributed to the RAP development process in Ohio (Maumee and Cuyahoga Rivers), Minnesota (St. Louis River), Wisconsin (Menominee River and Green Bay), New York (Rochester Embayment, Oswego River, St. Lawrence River, and Buffalo River), and Michigan (multiple sites). The Service assigned one staff person to EPA's Great Lakes National Program Office and another to the IJC's Regional Office in Canada to work on Great Lakes environmental issues. SCS personnel also evaluated progress under the Great Lakes Phosphorus Load Reduction Plan (see Chapter 6).

Additional FY 1989 Soil Conservation Service accomplishments included:

- Completed transect tillage surveys in the Saginaw Bay and Lake Erie watersheds
- Developed conservation plans for 250,000 acres of highly erodible lands in Wisconsin
- Designed and installed 68 animal waste management systems in Wisconsin
- Completed the first phase of a direct drainage study of Lake Ontario
- Completed inventories of Indiana wetlands within the Great Lakes basin and in 13 Michigan counties
- Completed a stream bank erosion survey for the Au Sable River, Michigan
- Contributed to a Saginaw Bay drainage project to assess the effects of crop production on surface water and groundwater
- Participated in the Lost Creek Experimental Watershed Project in Ohio with Defiance Soil and Water Conservation District and Heidelberg College, which assessed the movement of pesticides, nutrients, and sediments

- Worked with Ottawa County, Ohio, to measure effects of tillage practices on water quality.

FY 1990 Accomplishments

During FY 1990, the SCS continued to emphasize water quality benefits in all program delivery elements. All initiatives begun in FY 1989 continued into FY 1990. The Service assigned one staff person to the Michigan Department of Natural Resources NPS unit for two years to assist in the prioritization of NPS impacted watersheds. Significant accomplishments include the development of standards and specifications for nutrient and pest management, and revision of the standard and specification for waste utilization.

Additional FY 1990 Soil Conservation Service accomplishments included:

- Completed wetland inventories in five Michigan counties
- Initiated a new River Basin Study for the Menominee River Basin in the Western Upper Peninsula of Michigan and Northeastern Wisconsin
- Initiated a streambank erosion inventory on the Rifle River in north-central Michigan
- Initiated implementation of the South Branch Kawkawlin River Watershed Work Plan
- Prepared a watershed work plan for Mud Creek in Barry County, a highly intensified agricultural area with identified sediment and nutrient loadings
- Participated in the preparation and implementation of four nonpoint source watershed demonstration projects.

Chapter 7

Ecosystem Surveillance

This chapter discusses U.S. surveillance of the Great Lakes system, including three EPA initiatives on persistent toxic substances:

- Establishment of a binational Integrated Air Deposition Network (IADN) that will monitor airborne deposition of trace organics on a routine basis
- A multi-agency study of the sources and fates of several persistent toxic substances in Green Bay
- Conversion and outfitting of a new ship to establish a capability to monitor trace organics in open lake waters on a routine basis.

The chapter also discusses accomplishments and plans relating to system-wide surveillance programs, including chemical and biological open lake limnology, fish monitoring programs, and the Great Lakes Atmospheric Deposition (GLAD) network.

Surveillance

Overview

Pursuant to Section 118(c)(1)(b) of the Clean Water Act, the United States is jointly implementing with Canada a network to monitor the water quality of the Great Lakes. Many surveillance activities are based on the Great Lakes International Surveillance Plan (GLISP) that the United States and Canada developed together and which helps to coordinate their surveillance activities. GLISP was last revised in 1986, drawing upon academic and agency expertise in both nations. GLISP provides recommended parameters, methods, locations, and frequencies—in effect, "best scientific grounds"—for coordinated binational surveillance of the Great Lakes system. It focuses on five general areas: eutrophication, toxic contaminants, microbiology, radionuclides, and biological community and habitat status.

The goals of surveillance activities are to evaluate the efficacy of existing control requirements, to evaluate water quality trends and identify emerging problems, and to support Remedial Action and Lakewide Management Plans. Attainment of these goals requires measurement of loadings to the lakes, evaluation of schedules for load reductions contained within remedial plans, evaluation of human exposure to contaminants, and the development of ecosystem health indicators.

At present, GLISP is primarily concerned with open lake, chemical and biological limnology. It does not address surveillance of Lake Superior or the upper connecting channels (i.e., St. Marys, St. Clair, and Detroit Rivers), nor does it address field methods in a comprehensive, detailed manner. The United States and Canada surveyed Lake Superior intensively in 1983. Between 1984 and 1987, they also conducted a major joint study of the upper connecting channels that was released in March 1989. Canada conducted a survey of Lake Superior in spring 1989 for nutrients, chlorophyll, and major ions and is also planning spring and summer cruises for 1990 and 1991.

EPA's surveillance activities, coupled with those of States, address most elements contained in GLISP. The programs do not address every parameter in all media and at the same sampling frequency sought in GLISP. Both nations fulfill GLISP under fiscal and technological constraints, giving priority to parameters of most concern.

There are three primary elements to EPA Great Lakes National Program Office's surveillance efforts: open lake surveys of ambient water quality; monitoring of toxicant levels in fish tissues; and monitoring of atmospheric deposition. The Program Office has conducted open lake spring and summer surveys of ambient water quality in Lakes Michigan, Huron, and Erie since 1983, and in Lake Ontario since 1986. Prior to these routine surveys, each of the lakes was surveyed intensively in turn. EPA does not survey Superior because it does not exhibit eutrophic conditions. The current program includes nutrients (phosphorus, nitrogen, silica), conservative ions, alkalinity (alkali and alkaline earth metals), biological structure (phytoplankton and zooplankton), chlorophyll a, and physical parameters. Surveys measure conditions and trends in the open waters of the lakes (generally defined as those greater than 30 feet deep). These waters best indicate long-term trends, because they are less influenced by local discharges of pollutants than shallower, nearshore waters. The productivity measures obtained under the open lake program enable EPA to assess the response of the lakes to nutrient control measures and trends in algal and plankton populations.

Since 1977, the Great Lakes National Program Office, State, and other Federal agencies have monitored toxic organics in the Great Lakes through analyses of chemical residues in fish tissues. Fish are excellent indicators of water quality and ecosystem health because they tend to accumulate many persistent toxic substances, whereas open water concentrations of toxic organics are generally so low that it is difficult to monitor them directly on a routine basis.

With lake-to-lake variations in number of collection sites and periodicity, States collect adult resident fish and spot-tail shiners from harbors and tributaries on a 5-to-10-year cycle and open lake salmon as part of a game fish-monitoring program. The Fish and Wildlife Service also collects open lake whole-fish samples of lake trout (walleye on Lake Erie) and smelt on a biennial basis. States conduct additional fish-monitoring programs that are directed towards protecting human health by issuance of fish consumption health advisories.

The third primary element of the Great Lakes National Program Office's surveillance activities, also a joint Federal/State endeavor, is the monitoring of atmospheric deposition. The United States operates 20 stations across the Great Lakes basin as its share of the binational GLAD network. Some States also operate air deposition monitoring programs over and above the GLAD network. GLAD presently addresses nutrients and metals, including lead, cadmium, nitrate/nitrite, and phosphorus, among about 35 parameters.

In addition, States and the U.S. Geological Survey monitor Great Lakes tributaries for pollutants on an ongoing basis, since tributaries are major conveyors of pollutants from both nonpoint and point sources.

Integrated Atmospheric Deposition Network

Since the late 1970s, the Great Lakes scientific community has been aware of the potential significance of the atmosphere as a pollution pathway. Studies of Isle Royale, a relatively isolated island in Lake Superior, revealed levels of PCBs, toxaphene, and other persistent toxic substances in its lakes. Researchers theorized that such pollutants could only have been the result of deposition from the air.

Since the Isle Royale findings, EPA's Great Lakes National Program Office has promoted ways of assessing the absolute and relative magnitude of atmospheric loadings of toxic substances. The Program Office supported conferences in 1980, 1986, and 1987 to assess the state of knowledge of the airborne deposition problem, and developed a strategy in 1987 to monitor these substances. In recognition of the potential importance of air deposition to the Great Lakes, the United States and Canada agreed in 1987 to establish an Integrated Atmospheric Deposition Network (IADN) to monitor both wet and dry atmospheric loadings of toxic substances to the Great Lakes.

It should be noted that the concentrations of toxic organics in precipitation are very minute and, therefore, difficult to collect and analyze. Scientists are developing methods to do this routinely and it is likely that the feasibility of monitoring atmospheric deposition will differ from parameter to parameter. The United States and Canada are pioneers in this area, since routine monitoring of atmospheric deposition of trace organics is not conducted anywhere else. The Program Office implemented its first master station and two satellite stations for monitoring airborne PCBs and dieldrin in fall 1988. These are located in the vicinity of Green Bay, Wisconsin. The two nations plan to build on the experience gained from the Green Bay station and an initial Canadian site on Lake Ontario in order to design a basin-wide network.

During FY 1989, the United States and Canada coordinated various management, parameter, siting, and methods issues pertaining to establishment of a network to monitor airborne deposition of persistent toxic substances. During FY 1990, the two nations plan to continue establishing one IADN master station on each of the Great Lakes. The United States will establish a master station on Lake Superior to augment the one already functioning on Lake Michigan, while Canada will establish one on Lake Huron to complement the station already on Lake Ontario. Because the Lake Superior site has the lowest background levels of toxicants, it will be used to resolve detection methods. Data will be freely shared by each nation, and the United States will be able to co-locate equipment at the Ontario site. The two nations will develop siting criteria regarding the master stations. Once binational siting criteria are developed, the Great Lakes National Program Office will also look to co-locate existing GLAD sites with IADN satellite stations to consolidate their administration.

In FY 1991, the Great Lakes National Program Office plans to establish a station on Lake Erie and, in FY 1992, will relocate the present station on Lake Michigan. Also in FY 1992, the Program Office will begin to establish six satellite stations, one on each international lake and two on Lake Michigan, while Canada will begin to establish five satellite stations. In FY 1994, based on data obtained to that point, the two nations will consider the need for establishing up to 11 additional satellite stations.

Green Bay Mass Balance Study

This special study, begun in FY 1987 and to continue through FY 1991, will help EPA develop an understanding of the sources, pathways, and fates of certain pollutants (i.e., cadmium, lead, PCBs, and the pesticide dieldrin) within a large waterbody (see Figure 7-1). By determining loadings and fates of pollutants, a mass balance study can provide the basis for more stringent regulation of water dischargers under Clean Water Act provisions for water quality-based regulation.

Another objective of the Green Bay study is to determine the feasibility of a "mass balance" analysis on one of the Great Lakes. Therefore, the Green Bay study is an important precursor to the surveillance aspects of Lakewide Management Plans. The Wisconsin Department of Natural Resources and EPA's Great Lakes National Program Office are the major sponsors of the study, with aspects supported by EPA's Environmental Research Laboratory-Duluth, Minnesota, and its Large Lakes Research Station at Grosse Ile, Michigan; the Great Lakes Environmental Research Laboratory and Wisconsin Sea Grant of the National Oceanic and Atmospheric Administration; the U.S. Geological Survey; the Michigan Department of Natural Resources; the U.S. Coast Guard; the Illinois State Water Survey; and a number of universities.

Numerous Green Bay Study activities were undertaken during FY 1989. The EPA Great Lakes National Program Office's research vessel, the *Roger Simons*, conducted a field sampling shakedown cruise on Green Bay in October 1988, and thereafter, conducted five sampling cruises in May, June, July, September, and October 1989. A winter survey was conducted

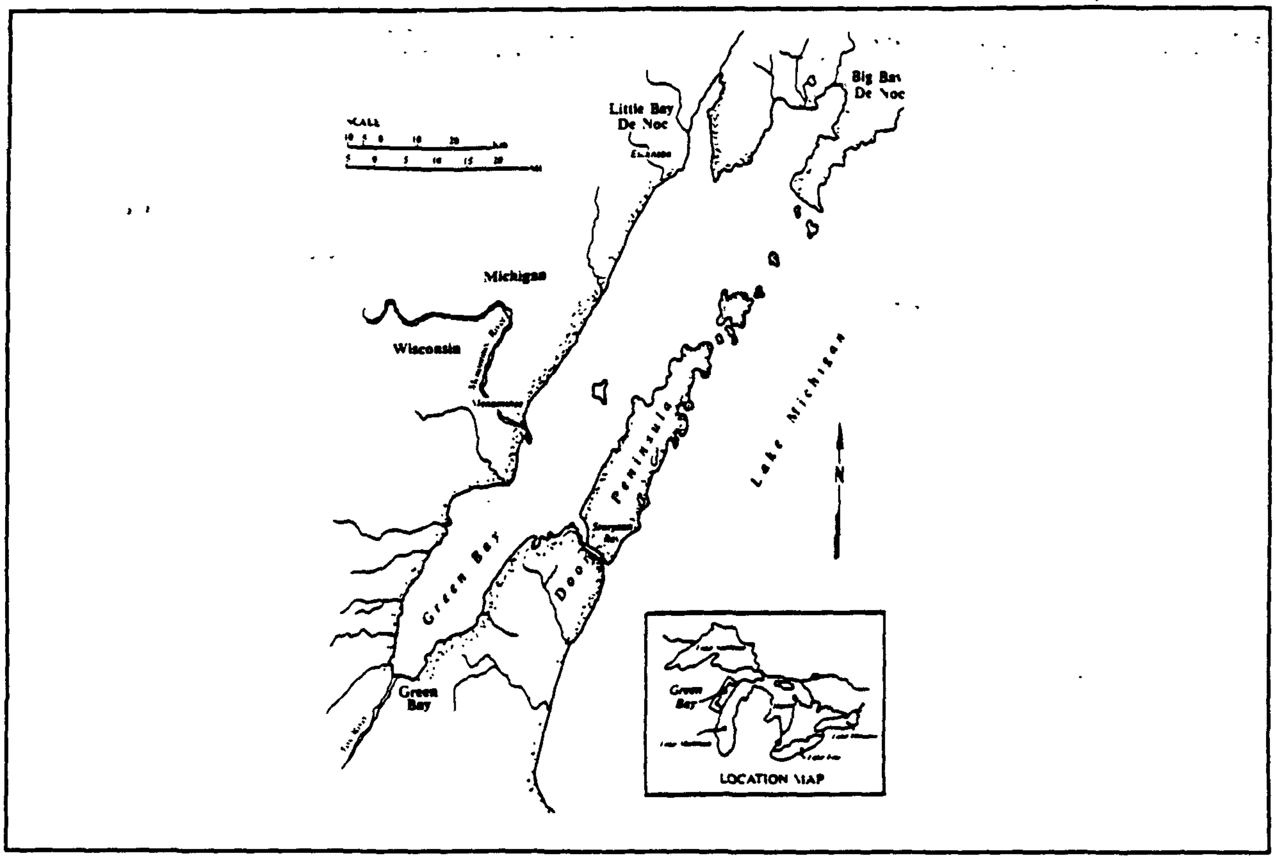

Figure 7-1. Green Bay/Fox River Study Area.

from a U.S. Coast Guard helicopter in February 1989. Another winter survey and spring survey are planned in FY 1990. In cooperation with the Wisconsin Department of Natural Resources and the U.S. Geological Survey, tributary monitoring was performed on all important tributaries to Green Bay. Wisconsin also collected fish samples. A master and two routine monitoring stations collected air deposition samples. Other studies underway include water/land/air vapor flux of contaminants, groundwater loadings, and sediment contamination.

The study has refined laboratory methods for handling a large number of samples that must be analyzed for trace organics (i.e., PCB and dieldrin). Detection of these trace contaminants in the water column requires the sampling of large volumes of water. Previously, such analyses were, in essence, small-scale research activities. However, the Green Bay study has developed methods that can be employed on a more routine basis.

The study team is beginning to obtain the results of laboratory analyses on initial samples. Preliminary PCB data from the 1988 cruise indicate, as expected, a gradient in total PCBs, with higher concentrations in the Fox River and southern Green Bay sampling stations. Preliminary results for PCBs in plankton samples show a similar trend, with higher concentrations in the Fox River and southern Green Bay, and a two- to three-fold decrease in northern Green Bay. These data will be used in developing models of contaminant transport and levels in fish. Dieldrin results do not follow the PCB trend. The highest dieldrin concentrations in plankton occur near the Door Peninsula and may reflect the historic use of dieldrin in the agricultural practices of that region; concentrations there are higher than those in both the northern and southern portions of the Bay.

In FY 1990, field sampling will conclude with a spring cruise. Thereafter, the study team will complete the analysis of samples, compile data, and calibrate existing models. A study report will be prepared in FY 1991.

New EPA Research Vessel

Early in FY 1989, EPA's Great Lakes National Program Office concluded negotiations with the U.S. Department of Transportation Maritime Administration for purchase of a vessel that will be converted into a replacement research vessel for open lake water quality monitoring. This vessel was needed because of the age (now over 50 years old) and size of the current ship, and to expand the capability for routine monitoring of persistent toxic substances in open lake waters. The larger replacement vessel will have considerably more space for analytic facilities that will prepare samples for later analysis in land-based laboratories. The shipyard conversion of the replacement vessel is scheduled for completion in fall 1990. The onboard suite of laboratory equipment will be installed after the vessel's arrival in the Great Lakes.

System-Wide Surveillance

During FY 1989, planned spring surveys for Lakes Erie, Huron, and Ontario were prevented due to vessel breakdown. The Great Lakes National Program Office accomplished all summer open lake water quality sampling that was planned for Lakes Erie, Huron, Michigan, and Ontario. During the summer survey in Lake Erie, EPA sampled for 33 parameters at 20 sites. In Lake Huron, EPA sampled for 33 parameters at 20 locations. EPA sampled for 33 parameters at 11 Lake Michigan sites and for 33 parameters at 8 Lake Ontario sites. Both spring and summer cruises are planned during 1990.

The Program Office has sponsored studies to examine whether water from certain municipal drinking water intakes is representative of open lake waters of Lakes Michigan and Ontario and could be used in selected areas in lieu of sampling by ship. Results indicate that the composition of samples collected from intake pipes is generally similar to that of samples collected from offshore waters. Storms and other weather events can affect near-shore water quality, requiring careful analysis of data before they can be used reliably. Further evaluation of the study results is planned for FY 1990.

Through an agreement with the Fish and Wildlife Service, the Program Office supports an annual monitoring program for dissolved oxygen in Lake Erie. Dissolved oxygen is measured from June through September at 10 stations in the central basin of Lake Erie. Figure 7-2 shows the trend in the annual average fully adjusted oxygen depletion rate for the central basin of Lake Erie. The adjusted oxygen depletion rates for 1988 and 1989 were the lowest reported since 1970. In 1989, the bottom waters did not become anoxic until mid-September, an encouraging sign that phosphorus load reductions may be achieving their desired effect. In several previous years, anoxic conditions developed about mid-August. This monitoring program will continue in 1991 in order to collect data to further evaluate long-term responses of central basin water quality to reductions in nutrient enrichment.

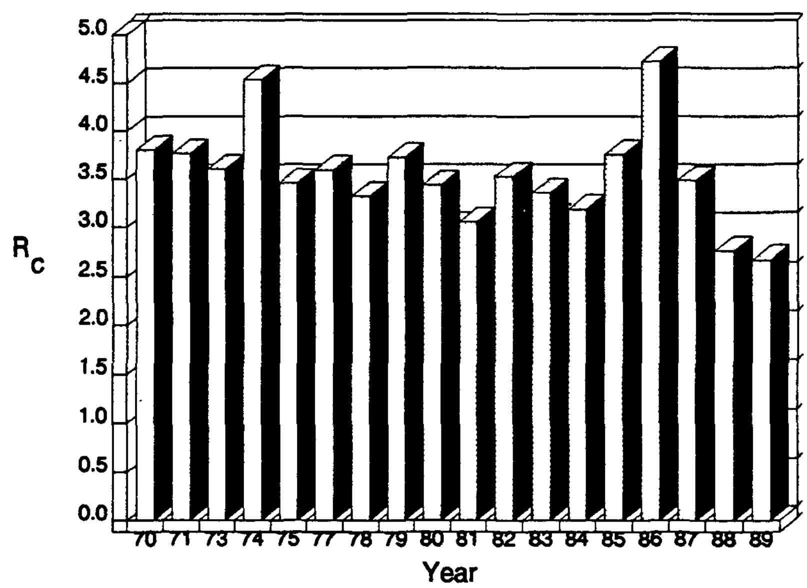

Figure 7-2. Annual Average Corrected Oxygen Depletion Rate, R_c for Central Basin of Lake Erie. (mg O_2/L/month).
Source: USEPA GLNPO, 19__.

EPA, States, and the Fish and Wildlife Service continued fish surveillance programs during FY 1989 and this activity is planned to continue during FY 1990. One Lake Michigan site was sampled for 14 organic parameters in lake trout and smelt, and the Fish and Wildlife Service sampled chinook salmon at eight sites for 21 organic parameters. On Lake Erie, the United States sampled smelt and walleye at one site for 11 parameters and rainbow trout at three sites for 21 organic parameters. On Lake Huron, the United States sampled lake trout and smelt at one site for 7 parameters and chinook salmon at two sites for 21 organic parameters. On Lake Ontario, the United States sampled lake trout and smelt at one site for 11 parameters and chinook salmon at three sites for 11 parameters. Figure 7-3 shows some of the results of this monitoring program. The figure depicts average concentrations of PCBs and DDT in Lake Michigan lake trout, chubs, coho, and smelt.

The Great Lakes States and EPA continued their joint support of a basin-wide 20-station air deposition network during FY 1989 and this activity is planned to continue during FY 1990. The sampling stations monitor nutrients, metals, and acidity in precipitation, including lead, cadmium, nitrate/nitrite, mercury, and phosphorus, among about 35 parameters. States operate the sampling stations, and provide samples to EPA on a weekly basis, provided sufficient precipitation occurred.

The States and the U.S. Geological Survey conduct tributary monitoring. The EPA Great Lakes National Program Office's activities have centered on development of sampling strategies to obtain data adequate for estimating chemical loadings to the Great Lakes, and on dissemination of these strategies to States. During FY 1989, research carried out under Program Office grants led to the development of enhanced (high-flow) strategies for seven Great Lakes

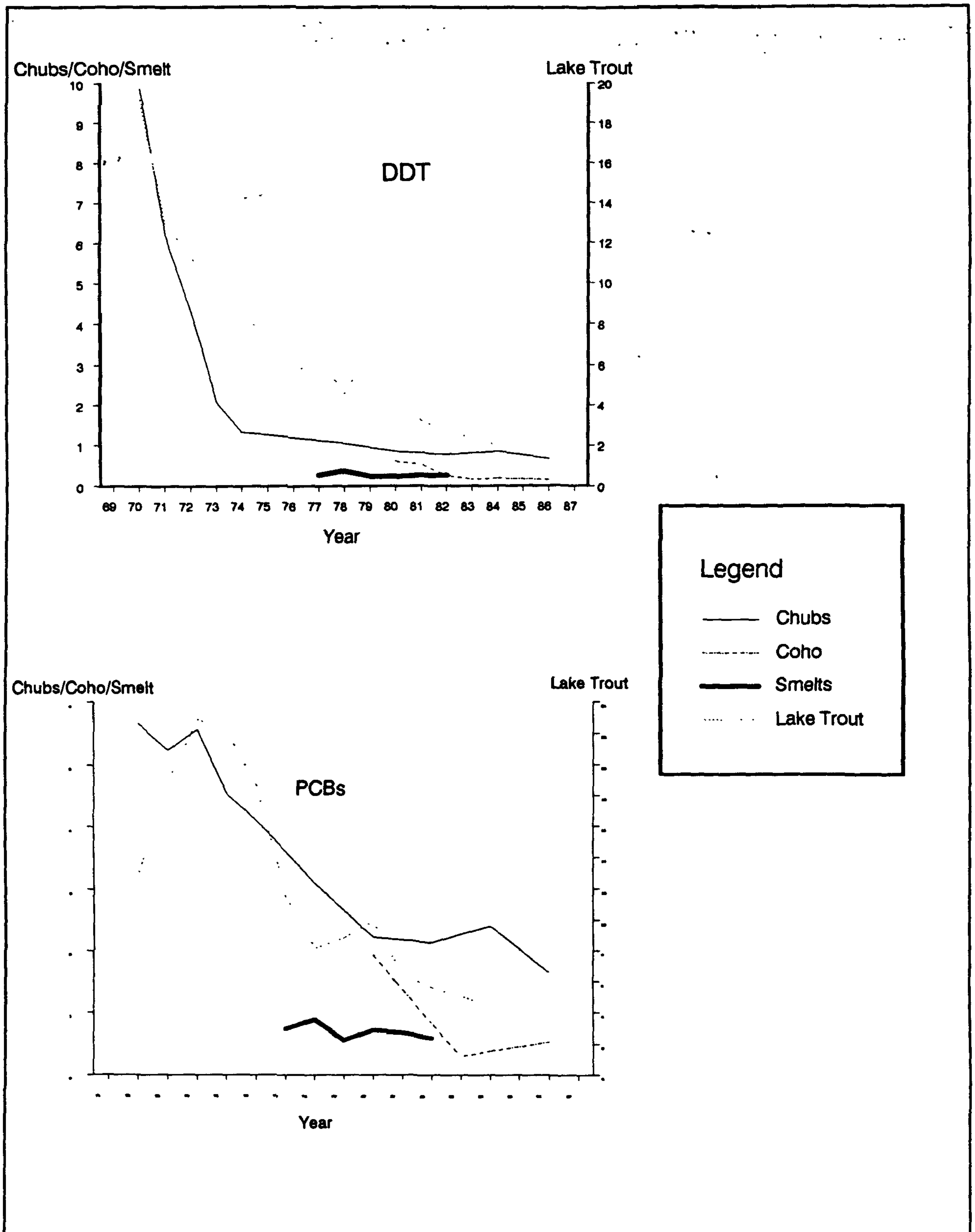

Figure 7-3. Fish Contaminants Monitoring Program Results.(Concentrations are in mg/kg)
Source: USEPA, GLNPO, 19__

tributaries in Michigan. In addition, Heidelberg College, Ohio, has developed event-responsiveness ratings for all major Great Lakes tributaries that will help EPA, States, and Canada to assess which tributaries require the most monitoring. During FY 1990, the Program Office will contribute to international workshops, sponsored by the International Joint Commission, to discuss technical strategies for implementing enhanced monitoring programs.

With a few exceptions, present tributary monitoring data are only marginally adequate for calculating loads for conventional pollutants and they are inadequate for calculating loadings of toxic contaminants. Estimates of loads for these parameters will require the development of innovative sampling technologies. One attempt at such innovation is a pilot monitoring station that the New York Department of Environmental Conservation is developing for use on the Buffalo River.

The U.S. Geological Survey maintains sampling stations on most major Great Lakes tributaries. In FY 1990, as part of the Green Bay Mass Balance Study, the Survey will conduct tributary sampling that will help to develop sampling methods for trace contaminants. This activity will also address methods and instrumentation for monitoring tributaries at or near their mouths, which is necessary for estimating tributary loadings of trace contaminants.

Chapter 8

Expenditures

During FYs 1989 and 1990, Federal expenditures on behalf of Great Lakes water quality were in excess of $150 million each year. This total represents estimates of expenditures by a number of major programs. The largest two Federal outlays are for the cleanup of abandoned hazardous waste sites by the Superfund program and for the construction of municipal wastewater treatment system improvements.

Before discussing expenditures, several general observations should be made. First, although some appropriations (e.g., EPA's Large Lakes Research Station and Great Lakes National Program Office) are specifically earmarked for the Great Lakes, many programs are broader in scope and their funding is administered on a State-wide basis. For these, it is often difficult to distinguish what portion of their expenditures were for activities within the Great Lakes basin. Second, reported expenditures are usually comprised both of actual obligations through the time at which the information was developed and of anticipated obligations during the remainder of that fiscal year. Third, expenditures of two-year appropriated funds will sometimes be incurred during the second year. The net effect of these factors is to introduce some uncertainty into the expenditures estimates.

Superfund

Figure 8-1 shows expenditures by the Superfund in the counties of the Great Lakes basin over three fiscal years (1987-1989). These counties are wholly or partly located within the Great Lakes basin. A geographic area larger than the actual watershed of

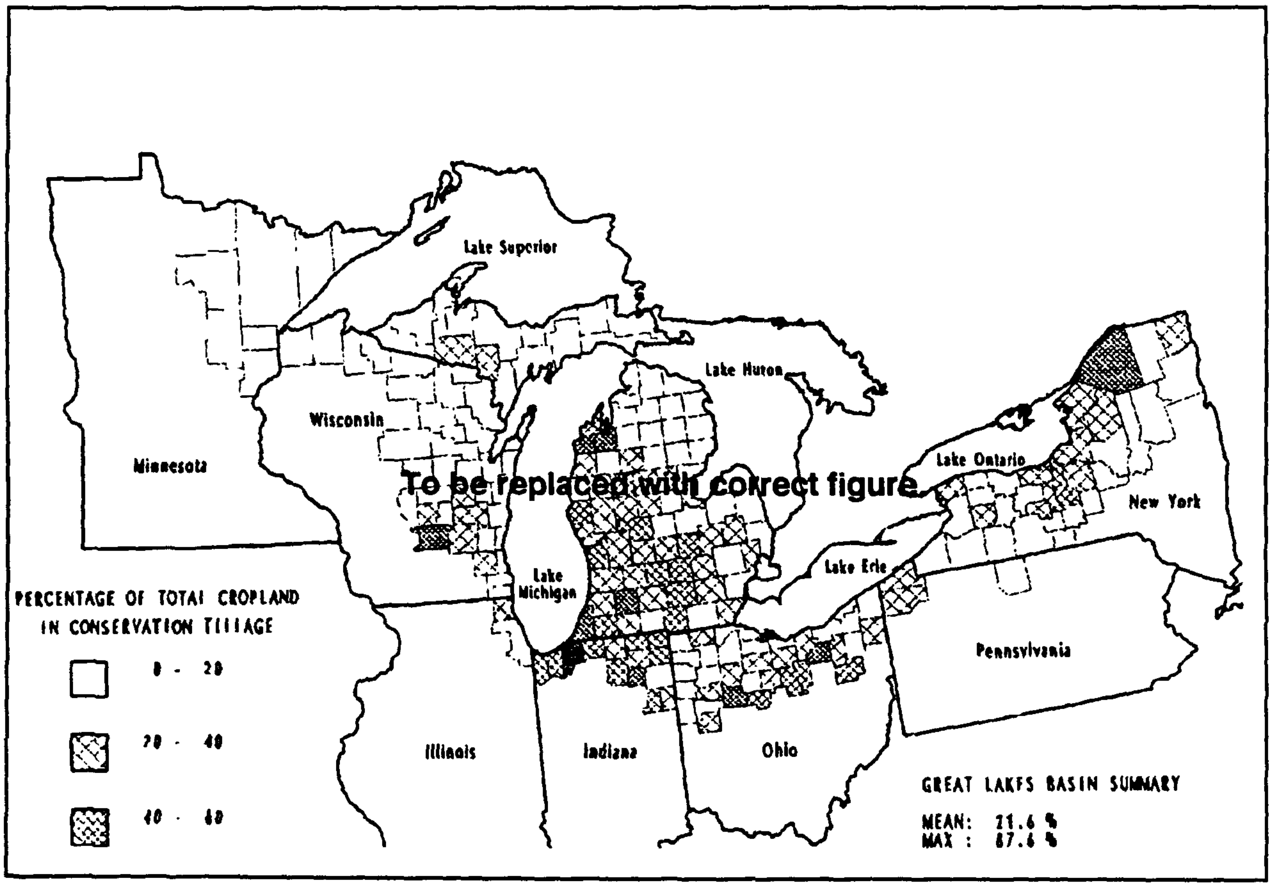

Figure 8-1. Total Superfund Expenditures in Great Lakes Counties in FYs 1987 through 1989.
Source: USEPA, 199_

the Great Lakes is used, since information from the Agency's Superfund data base can best be extracted by county.

Over this three year period, the Superfund program spent over $210 million in the counties of the Great Lakes. These costs are government outlays only and do not include costs incurred by Potentially Responsible Parties. Thus, total cleanup expenditures for Superfund sites are actually greater than the expenditures shown in Figure 8-1. It should also be noted that Agency acts to recover costs from potentially responsible parties, so that the Superfund will be reimbursed for some of these outlays.

Over this three year period, the four counties with the highest Superfund expenditures were Lapeer County, Michigan; Niagara County, New York; Ashtabula County, Ohio; and Erie County, New York. The principal sites in these counties were the Metamora Landfill in Lapeer; Love Canal in Niagara; New Lyme Landfill and Fields Brook in Ashtabula; and Wide Beach Development in Erie.

Municipal Wastewater Treatment Systems

Figure 8-2 shows Federal outlays for the construction of improved municipal wastewater treatment sys-

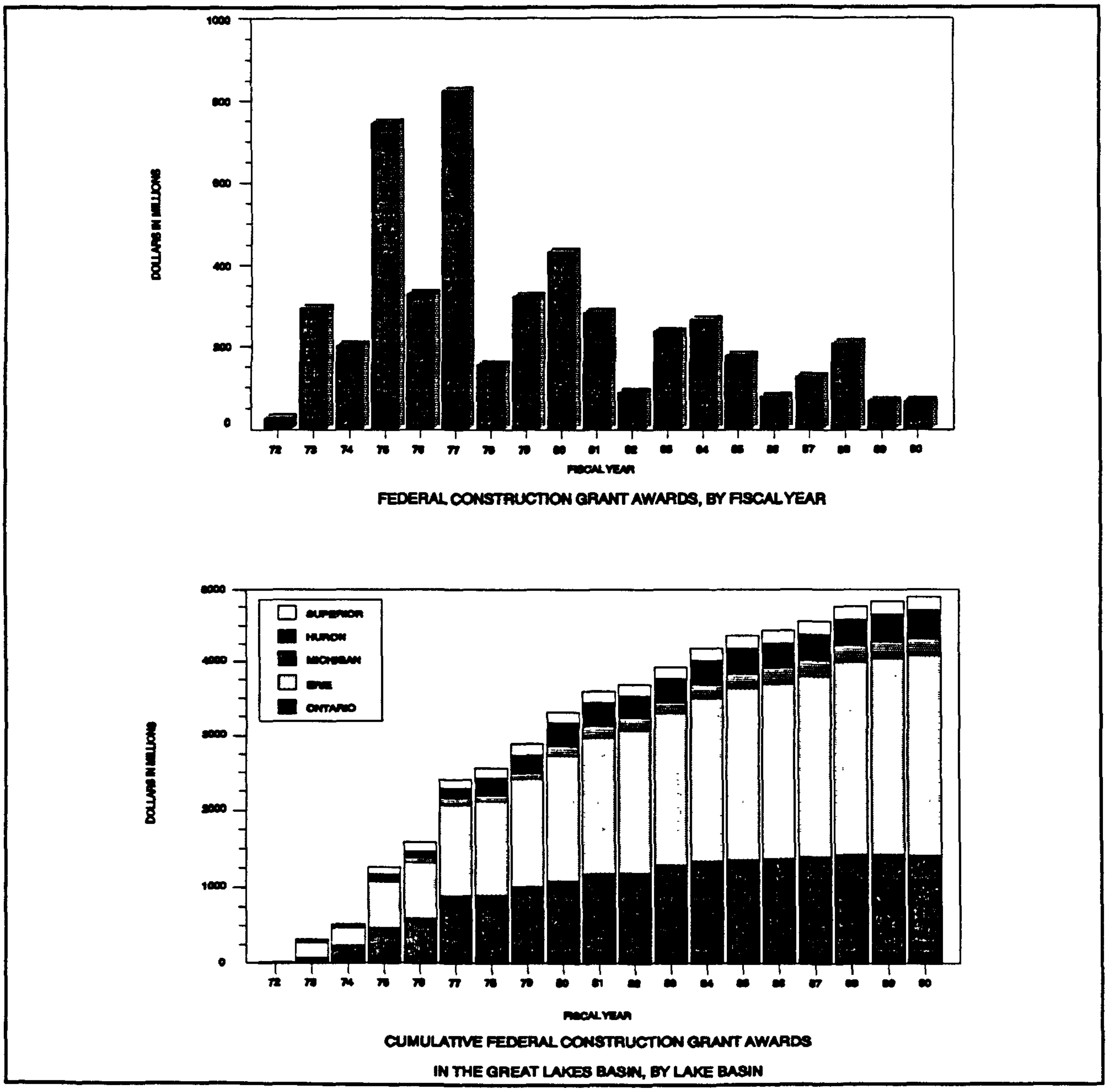

Figure 8-2. Construction Grant Awards in the Great Lakes Basin.
Source:USEPA, 199_.

Table 8-1. FY 1989 Federal Expenditures on Great Lakes Water Quality, ($ in Thousands)

Federal Agency	Judicial Enforcement	Research	Surveillance	Remedial Programs	General Administration	State Cooperative Efforts	Other	Total
EPA								
Great Lakes National Program Office			4,106	3,110	2,001	387	435	10,039
Large Lakes Research Station		1,906				1,906		
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION								
Great Lakes Environmental Research Laboratory		4,374		600		4,974		
Sea Grant (1)		3,930		469		2,689	7,088	
Coastal Zone Management (2)					5,400	5,400		
U.S. DEPARTMENT OF AGRICULTURE								
Soil Conservation Service		45	1,323	7,969	527		10	9,874
DEPARTMENT OF INTERIOR								
Fish and Wildlife Service		2,151	769	582	741		12,360	16,603
DEPARTMENT OF DEFENSE								
Army Corps of Engineers	1,387	72	3,288	16,254		60	21,061	
TOTAL	1,387	12,478	9,486	27,915	4,338	387	20,954	76,945

tems in the Great Lakes basin between 1972 and 1989. During this period, EPA provided about $4.8 billion for wastewater treatment plants around the Great Lakes. Over one half of this investment has been made for plants in Lake Erie's watershed. The second greatest Federal investment has been made in Lake Ontario's watershed.

Expenditures for the wastewater treatment system for the largest U.S. metropolitan area within the Great Lakes watershed are not included, since Chicago's treatment system discharges into the Mississippi River

Table 8-2. FY 1990 Federal Expenditures on Great Lakes Water Quality.

Federal Agency	Judicial Enforcement	Research	Surveillance	Remedial Programs	General Administration	State Cooperative Efforts	Other	Total
EPA								
Great Lakes National Program Office			5,651	3,741	2,562	490	387	12,831
Large Lakes Research Station		1,906				1,906		
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION								
Great Lakes Environmental Research Laboratory		4,400		600		5,000		
Sea Grant (1)		3,930		4,689		2,689	11,308	
Coastal Zone Management (2)					5,593	5,593		
U.S. DEPARTMENT OF AGRICULTURE								
Soil Conservation Service			1,668	7,620	548		10	9,846
DEPARTMENT OF INTERIOR								
Fish and Wildlife Service	60	1,678	1,485	615	835		9,924	14,597
DEPARTMENT OF DEFENSE								
Army Corps of Engineers	1,390	50	2,931	26,371		318	31,060	
TOTAL	1,450	11,964	11,735	38,347	9,234	490	18,921	92,141

Table 8-3. FY 1991 Estimated Federal Expenditures on Great Lakes Water Quality.

Federal Agency	Judicial Enforcement	Research	Surveillance	Remedial Programs	General Administration	State Cooperative Efforts	Other	Total
EPA								
Great Lakes National Program Office								
Large Lakes Research Station								
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION								
Great Lakes Environmental Research Laboratory								
Sea Grant (1)								
Coastal Zone Management (2)								
U.S. DEPARTMENT OF AGRICULTURE								
Soil Conservation Service								
DEPARTMENT OF INTERIOR								
Fish and Wildlife Service								
DEPARTMENT OF DEFENSE								
Army Corps of Engineers								
TOTAL								

drainage system. It should be noted that State and local governments also contributed greatly to the funding of municipal treatment systems. The total investment by Federal, State, and local governments in municipal treatment systems around the Great Lakes basin between 1972 and 1989 is about $8 billion.

Other Programs

Tables 8-1 through 8-3 show Federal expenditures on the Great Lakes by selected organizations and programs for FYs 1989 and 1990, and planned expenditures for FY 1991.

Clean Water Act Sections 118(c)(6)(A) and (D) specify that this report characterize the nature of Federal expenditures by at least four categories: judicial enforcement; research; general administration; and State cooperative efforts. To further clarify the uses of the expenditures, four additional categories have been added for this report: remedial programs; surveillance; wastewater treatment facilities; and other expenditures. For the purposes of this report, several operational definitions were made. "Judicial enforcement" expenditures are those relating to litigation to obtain compliance with environmental regulations. "General Administration" refers to staff salaries, travel, and administrative expenses. "State Cooperative Efforts" are defined as grants to State environmental agencies either expressly for development of Remedial Action Plans or more broadly for water quality programs. This is a narrow definition in that it excludes, as two examples, EPA's funding towards the Green Bay study, jointly sponsored by the Agency and by the State of Wisconsin, and ARCS sediment assessments in five Areas of Concern. Both of these studies develop information pertinent to the development of certain Remedial Action Plans and expenditures for them are included under the categories of "Surveillance" and "Remedial" activities, respectively. Water grants are on a whole-State basis, beyond the basin. Air/Waste funding is not included.

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Chapter 2

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Glossary

A

Acute Toxicity: The ability of a substance to cause poisonous effects resulting in severe biological harm or death soon after a single exposure or dose. (See: chronic toxicity, toxicity.)

Advisory: A non-regulatory document that communicates risk information.

Agricultural Pollution: The liquid and solid wastes from farming; agricultural runoff and leaching of pesticides and fertilizers; erosion and dust from plowing; animal manure and carcasses; crop residues, and debris.

Airborne Particulates: Total suspended particulate matter found in the atmosphere as solid particles or liquid droplets. Chemical composition of particulates varies widely, depending on location and time of year. Airborne particulates include: windblown dust, emissions from industrial processes, smoke from the burning of wood and coal, and the exhaust of motor vehicles.

Air Contaminant: Any particulate matter, gas, or combination thereof, other than water vapor or natural air. (See: air pollutant.)

Air Pollutant: Any substance in air which could, if in high enough concentration, harm man, other animals, vegetation, or material. Pollutants include almost any natural or artificial composition of matter capable of being airborne. They may be in the form of solid particles, liquid droplets, or in combinations of these forms. Generally, they fall into two main categories: (1) those emitted directly from identifiable sources and (2) those produced in the air by interaction between two or more primary pollutants, or by reaction with normal atmospheric constituents, with or without photoactivation. Exclusive of pollen, fog, and dust, which are of natural origin, about 100 contaminants have been identified and fall into the following categories: solids, sulfur compounds, volatile organic chemicals, nitrogen compounds, oxygen compounds, halogen compounds, radioactive compounds, and odors.

Algae: Simple rootless plants that grow in sunlit waters in relative proportion to the amounts of nutrients available. They can affect water quality adversely by lowering the dissolved oxygen in the water. They are food for fish and small aquatic animals.

Anadromous fish: Fish that spend their adulthood in the sea, but swim up rivers to spawn.

Anoxia: The absence of oxygen necessary for sustaining most life. In aquatic ecosystems this refers to the absence of dissolved oxygen in water.

Anti-Degradation Clause: Part of federal air quality and water quality requirements prohibiting deterioration where pollution levels are above the legal limit.

Aquifer: An underground geological formation, or group of formations, containing usable amounts of groundwater that can supply wells and springs.

Areas of Concern: A geographic area that fails to meet the General or Specific Objectives of the Great Lakes Water Quality Agreement where such failure has caused or is likely to cause impairment of beneficial use or of the area's ability to support aquatic life.

Atmosphere: [an] (the) The whole mass of air surrounding the earth, composed largely of oxygen and nitrogen.

Atmospheric Deposition: Pollution from the atmosphere associated with dry deposition in the form of dust, wet deposition in the form of rain and snow, or as a result of vapor exchanges.

B

Bacteria: (Singular: bacterium) Microscopic living organisms which can aid in pollution control by consuming or breaking down organic matter in sewage, or by similarly acting on oil spills or other water pollutants. Bacteria in soil, water or air can also cause human, animal and plant health problems.

Benthic Organism (Benthos): A form of aquatic plant or animal life that is found on or near the bottom of a stream, lake or ocean.

Bioaccumulative: Substances that increase in concentration in living organisms (that are very slowly metabolized or excreted) as they breathe contaminated air, drink contaminated water, or eat contaminated food. (See: biological magnification.)

Bioassay: Using living organisms to measure the effect of a substance, factor, or condition by comparing before-and-after data. Term is often used to mean cancer bioassays.

Biochemical Oxygen Demand (BOD): The amount of dissolved oxygen required for the bacterial decomposition of organic waste in water.

Biodegradable: The ability to break down or decompose rapidly under natural conditions and processes.

Biological Magnification: Refers to the process whereby certain substances become ever more concentrated in tissues or internal organs as they move up the food chain. (See: bioaccumulative.)

Biomass: All of the living material in a given area; often refers to vegetation. Also called "biota".

Biomonitoring: The use of organisms to test the acute toxicity of substances in effluent discharges as well as the chronic toxicity of low-level pollutants in the ambient aquatic environment.

Biota: (See: biomass.)

Bog: A type of wetland that accumulates appreciable peat deposits. Bogs depend primarily on precipitation for their water source, are usually acidic and rich in plant residue with a conspicuous mat of living green moss.

Buffer Strips: Strips of grass or other erosion-resisting vegetation between or below cultivated strips or fields.

By-product: Material, other than the principal product, that is generated as a consequence of an industrial process.

C

Cadmium (Cd): A heavy metal element that accumulates in the environment.

Cap: A layer of clay, or other highly impermeable material installed over the top of a closed landfill to prevent entry of rainwater and minimize production of leachate.

Carcinogen: Cancer-causing chemicals, substances, or radiation.

Carcinogenic: Cancer-producing.

Chlorinated Hydrocarbons: These include a class of persistent, broad-spectrum insecticides, that linger in the environment and accumulate in the food chain. Among them are DDT, aldrin, dieldrin, heptachor, chlordane, lindane, endrin, mirex, hexachloride, and toxaphene. Other examples include TCE, used as an industrial solvent.

Chronic Toxicity: The capacity of a substance to cause poisonous effects in an organism after long-term exposure. (See: acute toxicity.)

Cleanup: Actions taken to deal with a release or threat of release of a hazardous substance that could affect humans and/or the environment.

Coastal Zone: Lands and waters adjacent to the coast that exert an influence on the uses of the sea and its ecology, or inversely, whose uses and ecology are affected by the sea.

Combined Sewers: A sewer system that carries both sewage and storm-water runoff. Normally, its entire flow goes to a waste treatment plant, but during a heavy storm, the storm water volume may be so great as to cause overflows. When this happens untreated mixtures of storm water and sewage may flow into receiving waters. Storm-water runoff may also carry toxic chemicals from industrial areas or streets into the sewer system.

Combustion: Burning, or rapid oxidation, accompanied by release of energy in the form of heat and light. A basic cause of air pollution.

Contaminant: Any physical, chemical, biological, or radiological substance or matter that has an adverse effect on air, water, or soil.

Conventional Pollutants: Statutorily listed pollutants which are understood well by scientists. These may be in the form of organic waste, sediment, acid, bacteria and viruses, nutrients, oil and grease, or heat.

Criteria: Descriptive factors taken into account by EPA in setting standards for various pollutants. These factors are used to determine limits of concentration levels in permits. When issued by EPA, the criteria provide guidance to States on how to develop their standards.

D

DDT: The first chlorinated hydrocarbon insecticide (chemical name-Dichloro-Diphsdyl-Trichloromethane). It has a half-life of 15 years and can collect in fatty tissues of certain animals. EPA banned registration and interstate sale for virtually all but emergency uses in the United States in 1972 because of its persistence in the environment and accumulation in the food chain. DDT and its metabolites, DDD and DDE, have been found to be carcinogenic to mice. DDT, DDD, DDE, and the other persistent organochlorine pesticides are primarily responsible for the great decrease in the reproductive capabilities and consequently in the population of fish-eating birds, such as the bald eagle, brown pelican, and osprey. DDT has also been shown to decrease the populations of numerous other species of water birds, raptors, and passerines significantly.

Designated Uses: Those water uses identified in state water quality standards which must be achieved and maintained as required under the Clean Water Act. Uses can include cold water fisheries, public water supply, agriculture, etc.

Dieldrin: The pesticide aldrin degrades to dieldrin, which is very persistent in the environment. Both pesticides are carcinogens, are acutely toxic to aquatic organisms, and are bioconcentrated by aquatic organisms. Dieldrin is one of the most persistent of the chlorinated hydro carbons. Both pesticides, and especially dieldrin, have been associated with large-scale bird and mammal kills in treated areas.

Dioxin: Any of a family of compounds known chemically as dibenzo-p-dioxins. Dioxin (TCDD) is a particularly hazardous group of 75 chemicals of the chlorinated dioxin family. 2,3,7,8-TCDD or 2,3,7,8-tetrachlorodibenzo-para-dioxin is a particularly dangerous member of this group. Tests on laboratory animals indicate that it is one of the more toxic man-made chemicals known.

Direct Discharger: A municipal or industrial facility which introduces pollution through a defined conveyance or system; a point source.

Dissolved Oxygen (DO): The oxygen freely available in water. Dissolved oxygen is vital to fish and other aquatic life and for the prevention of odors. Traditionally, the level of dissolved oxygen has been accepted as the single most important indicator of a water body's ability to support desirable aquatic life. Secondary and advanced waste treatment are generally designed to protect DO in waste-receiving waters.

Drainage Basin: A water body and the land area drained by it.

Dredging: Removal of mud from the bottom of water bodies using a scooping machine. This disturbs the ecosystem and causes silting that can kill aquatic life. Dredging of contaminated muds can expose aquatic life to heavy metals and other toxics. Dredging activities may be subject to regulation under Section 404 of the Clean Water Act.

E

Ecosystem: The interacting system of a biological community and its non-living environmental surroundings.

Ecosystem Objectives: Environmental objectives that specify the nature of the Great Lakes in their desired state in terms of living organisms, their population characteristics, and condition of individual organisms.

Effluent: Wastewater—treated or untreated—that flows out of a treatment plant, sewer, or industrial outfall. Generally refers to wastes discharged into surface waters.

Effluent Limitations: Restrictions established by a State or EPA on quantities, rates, and concentrations in wastewater discharges.

Emission: Pollution discharged into the atmosphere from smokestacks, other vents, and surface areas of commercial or industrial facilities; from residential chimneys; and from motor vehicle, locomotive, or aircraft exhausts.

Emission Inventory: A listing, by source, of the amount of air pollutants discharged into the atmosphere of a community. It is used to establish emission standards.

Enrichment: The addition of nutrients (e.g., nitrogen, phosphorus, carbon compounds) from sewage effluent or agricultural runoff to surface water. This process greatly increases the growth potential for algae and aquatic plants.

Epilimnion: The warm, upper layer of water in a lake that occurs with summer stratification.

Erosion: The wearing away of land surface by wind or water. Erosion occurs naturally from weather or runoff but can be intensified by land use practices related to farming, residential or industrial development, mining, or timber-cutting.

Estuary: Regions of interaction between rivers and near shore oceans where tidal action and river flow create a mixing of fresh and saltwater. Such areas may include bays, mouths of rivers, salt marshes, and lagoons. These brackish water ecosystems shelter and feed marine life, birds, and wildlife. (See: wetlands.)

Eutrophication: The process of fertilization that causes high productivity and biomass in an aquatic ecosystem. Eutrophication can be a natural process or it can be a cultural process accelerated by an increase of nutrient loading to a lake by human activity.

Exotic Species: Species that are not native to the Great Lakes and have been intentionally introduced or have inadvertently infiltrated the system. Exotics may prey upon native species compete with them for food or habitat.

F

Fen: A type of wetland that accumulates peat deposits. Fens are less acidic than bogs, deriving most of their water from groundwater rich in calcium and magnesium. (See: wetlands.)

Fertilizer: Materials such as nitrogen and phosphorus that provide nutrients for plants. Commercially sold fertilizers may contain other chemicals or may be in the form of processed sewage sludge.

Food Chain: A sequence of organisms, each of which uses the next, lower member of the sequence as a food source.

G

Game Fish: Fish species caught for sport, such as trout, salmon, or bass.

Ground Water: The supply of fresh water found beneath the Earth's surface, usually in aquifers, which is often used for supplying wells and springs. Because ground water is a major source of drinking water there is growing concern over areas where leaching agricultural or industrial pollutants or substances from leaking underground storage tanks are contaminating ground water.

H

Habitat: The place where a population (e.g., human, animal, plant, micro-organism) lives and its surroundings, both living and non-living.

Hazardous Air Pollutants: Air pollutants which are not covered by ambient air quality standards but which, as defined in the Clean Air Act, may reasonably be expected to cause or contribute to irreversible illness or death. Such pollutants include asbestos, beryllium, mercury, benzene, coke oven emissions, radionuclides, and vinyl chloride.

Hazard Ranking System: The principle screening tool used by EPA to evaluate risks to public health and the environment associated with abandoned or uncontrolled hazardous waste sites. The HRS calculates a score based on the potential of hazardous substances spreading from the site through the air, surface water, or ground water and on other factors such as nearby population. This score is the primary factor in deciding if the site should be on the National Priorities List and, if so, what ranking it should have compared to other sites on the list.

Hazardous Waste: By-products of society that can pose a substantial or potential hazard to human health and/or the environment when improperly managed. Possesses at least one of four characteristics (ignitability, corrosivity, reactivity, or toxicity), or appears on special EPA lists.

Heavy Metals: Metallic elements with high atomic weights, e.g., mercury, chromium, cadmium, arsenic, and lead. They can damage living things at low concentrations and tend to accumulate in the food chain.

Heptachlor: Heptachlor and its active metabolite, heptachlor epoxide, are very persistent in the environment, resisting chemical and biological breakdown into harmless substances. These pollutants are liver carcinogens when administered orally to rats. Heptachlor is toxic at low concentrations in some aquatic invertebrate and fish species, and shows a strong tendency to bioaccumulate. It can concentrate at levels thousands of times greater than those in the surrounding water in a variety of aquatic organisms.

Hexachlorobenzene (HCB): A very persistent environmental pollutant that bioaccumulates. HCB is readily sorbed onto sediment particles, although desorption does occur, producing continuous, low-level concentrations of HCB in the surrounding environment. Hexachlorobenzene is carcinogenic in mice, rats, and hamsters, and produces adverse effects in humans upon exposure.

Hypolimnion: The cold, dense, lower layer of water in a lake that occurs with summer stratification.

I

Indicator: In biology, an organism, species, or community whose characteristics show the presence of specific environmental conditions.

Injection Well: A well into which fluids are injected for purposes such as waste disposal, improving the recovery of crude oil, or solution mining.

International Joint Commission (IJC): Established by the 1909 Boundary Waters Treaty. A binational Commission with responsibility for decisions regarding obstruction or diversion of United States/Canadian boundary waters and to which other questions or matters of difference can be referred for examination and report. The Commission also has powers to resolve differences arising over the common frontier. In 1972 the Commission was given responsibility for assisting and monitoring the two governments' implementation of the Great Lakes Water Quality Agreement.

Irrigation: Technique for applying waste or wastewater to land areas to supply the water and nutrient needs of plants.

L

Loading: The quantity of a substance entering a water body.

Landfills: 1. Sanitary landfills are land disposal sites for non-hazardous solid wastes at which the waste is spread in layers, compacted to the smallest practical volume, and cover material applied at the end of each operating day. 2. Secure chemical landfills are disposal sites for hazardous waste. They are selected and designed to minimize the chance of release of hazardous substances into the environment.

Leachate: A liquid that results from water collecting contaminants as it trickles through wastes, agricultural pesticides or fertilizers. Leaching may occur in farming areas, feedlots, and landfills, and may result in hazardous substances entering surface water, groundwater, or soil.

Lead (Pb): A heavy metal that is hazardous to health if breathed or swallowed. Its use in gasoline, paints, and plumbing compounds has been sharply restricted or eliminated by Federal laws and regulations. (See: heavy metals.)

Leaded Gasoline: Gasoline to which lead has been added to raise the octane level.

Limnology: The study of the physical, chemical, meteorological, and biological aspects of fresh water.

M

Marsh: A type of wetland that does not accumulate appreciable peat deposits and is dominated by herbaceous vegetation. Marshes may be either fresh or saltwater and tidal or non-tidal. (See: wetlands.)

Mass Balance Approach: An approach to evaluating the sources, transport, and fate of contaminants entering a water system as well as their effects on water quality. In a mass balance budget, the amounts of a contaminant entering the system less the quantities stored, transformed, or degraded must equal the amount leaving the system. If inputs exceed outputs, pollutants are accumulating and contaminant levels are rising. Once a mass balance budget has been established for a pollutant of concern, the long-term effects on water quality can be simulated by mathematical modeling.

Mesotrophic: See Trophic Status.

Metabolite: Any substance produced in or by biological processes and derived from a pesticide.

Mercury: A heavy metal that can accumulate in the fatty tissue of animals and fish. It can be highly toxic and cause poisoning in humans.

Mirex: Mirex, a fire retardant and pest control agent, was at one time produced in the Lake Ontario basin. Mirex bioaccumulates in a variety of organisms, but its effects are poorly known. There is evidence that mirex is very persistent in bird tissue.

Modeling: A theory or a mathematical or physical representation of a system that accounts for all or some of its known properties. Models are often used to test the effect of changes of system components on the overall performance of the system.

Monitoring: A scientifically designed system of continuing standardized measurements and observations and the evaluation thereof.

Mulch: A layer of material (wood chips, straw, leaves, etc.) placed around plants to hold moisture, prevent weed growth, protect the plants and hold the soil.

N

National Pollutant Discharge Elimination System (NPDES): The national program for controlling direct discharges from point sources of pollutants (e.g., municipal sewage treatment plants, industrial facilities) into waters of the United States.

National Priorities List (NPL): EPA's list of the most serious uncontrolled or abandoned hazardous waste sites identified for possible long-term remedial action under Superfund. A site must be on the NPL to receive money from the Trust Fund for remedial action. The list is based primarily on the score a site receives from the Hazard Ranking System. EPA is required to update the NPL at least once a year.

Nitrate: A compound containing nitrogen which can exist in the atmosphere or as a dissolved gas in water and which can have harmful effects on humans and animals.

Nitrite: 1. An intermediate in the process of nitrification. 2. Nitrous oxide salts used in food preservation.

Non-Point Source: Pollution sources which are diffuse and do not have a single point of origin or are not introduced into a receiving stream from a specific outlet. The pollutants are generally carried off land by storm water runoff. The commonly used categories for non-point sources are: agriculture, forestry, urban, mining, construction, dams and channels, land disposal, and saltwater intrusion.

Nutrient: Any substance assimilated by living things that promotes growth. The term is generally applied to nitrogen and phosphorous in wastewater, but is also applied to other essential trace elements.

O

Oligotrophic Lakes: Clear lakes with low nutrient supplies. They contain little organic matter and have a high dissolved-oxygen level.

Open Lake: Those waters in a lake unaffected by physical and chemical processes originating or resultihg from the adjacent land mass. Physical, chemical, and biological phenomena resemble oceanographic conditions in open lake waters.

Organic Chemicals/Compounds: Animal or plant-produced substances containing mainly carbon, hydrogen, and oxygen.

Organic Matter: Carbonaceous waste contained in plant or animal matter and originating from domestic or industrial sources.

Organism: Any living thing.

P

Pathogen: A disease-causing agent such as bacteria, viruses, and parasites.

PCBs: A group of toxic, persistent chemicals (polychlorinated biphenyls) used in such applications as in electrical transformers and capacitors (for insulating) and in gas pipeline systems (as a lubricant). Further sale of new use was banned by law in 1979.

Permit: An authorization, license, or equivalent control document issued by EPA or a state agency to implement the requirements of an environmental regulation; e.g., a permit to operate a wastewater treatment plant or to operate a facility that may generate harmful emissions.

Persistence: Refers to the length of a time a compound, once introduced into the environment, stays there. A compound may persist for less than a second or indefinitely.

Persistent Pesticides: Pesticides that do not break down chemically or break down very slowly and that remain in the environment after a growing season.

Pesticide: Substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest. Also, any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant. Pesticides can accumulate in the food chain and/or contaminate the environment if misused.

Phosphorus: An essential chemical food element that can contribute to the eutrophication of lakes and other water bodies.

Photosynthesis: A process occurring in the cells of green plants and some microorganisms in which solar energy is transformed into stored chemical energy.

Phytoplankton: That portion of the plankton community comprised of tiny plants, e.g., algae, diatoms.

Plankton: Tiny plants and animals that live in water.

Point Source: A stationary location or fixed facility from which pollutants are discharged or emitted. Also, any single identifiable source of pollution, e.g., a pipe, ditch, ship, ore pit, factory smokestack.

Pollutant: Generally, any substance introduced into the environment that adversely affects the usefulness of a resource.

Potentially Responsible Party (PRP): Any individual or company—including owners, operators, transporters, or generators—potentially responsible for, or contributing to, the contamination problems at a Superfund site. Whenever possible, EPA requires PRPs, through administrative and legal actions, to clean up hazardous waste sites they have contaminated.

Prevention: Measures taken to minimize the release of wastes to the environment.

Primary Waste Treatment: First steps in wastewater treatment; screens and sedimentation tanks are used to remove most materials that float or will settle. Primary treatment results in the removal of about 30 percent of carbonaceous biochemical oxygen demand from domestic sewage.

R

Remedial Action Plans (RAPs): Environmental plans aimed at restoring all beneficial uses to Great Lakes Areas of Concern.

Research: Development, interpretation, and demonstration of advanced scientific knowledge for the resolution of issues. It does not include monitoring and surveillance of water or air quality.

Resuspension (of Sediment): The remixing of sediment particles and pollutants back into the water by storms, currents, organisms, and human activities such as dredging.

Risk Assessment: The qualitative and quantitative evaluation performed in an effort to define the risk posed to human health and/or the environment by the presence or potential presence and/or use of specific pollutants.

Retention Time: The time it takes for the volume of water in a lake to exit through its outlet, i.e., Total volume/outlet flow = Retention time, used to estimate how long a contaminant would persist in a waterbody once introduced.

Risk Management: The process of evaluating alternative regulatory and non-regulatory responses to risk and selecting among them. The selection process necessarily requires the consideration of legal, economic, and social factors.

Run-Off: That part of precipitation, snow melt, or irrigation water that runs off the land into streams or other surface-water. It can carry pollutants from the air and land into the receiving waters.

S

Secondary Waste Treatment: The second step in most waste treatment systems in which bacteria consume the organic parts of the waste. It is accomplished by bringing together waste, bacteria, and oxygen in trickling filters or in the activated sludge process. This treatment removes floating and settleable solids and about 90 percent of the oxygen-demanding substances and suspended solids. Disinfection is the final stage of secondary treatment. (See: primary, tertiary treatment.)

Sediments: Soil, sand, and minerals washed from land into water usually after rain. Excess sediments pile up in reservoirs, rivers, and harbors, destroying fish-nesting areas and holes of water animals, and clouding the water so that sunlight does not reach aquatic plants. Careless farming, mining, and building activities will expose sediment materials, allowing them to be washed off the land after rainfalls.

Sewer: A channel or conduit that carries wastewater and stormwater runoff from the source to a treatment plant or receiving stream. Sanitary sewers carry household, industrial, and commercial waste. Storm sewers carry runoff from rain or snow. Combined sewers are used for both purposes.

Site Inspection: The collection of information from a Superfund site to determine the extent and severity of hazards posed by the site. It follows and is more extensive than a preliminary assessment. The purpose is to gather information necessary to score the site, using the Hazard Ranking System, and to determine if the site presents an immediate threat that requires prompt removal action.

Stagnation: Lack of motion in a mass of air or water, tending to trap pollutants.

Standards: Prescriptive norms which govern action and actual limits on the amount of pollutants or emissions produced. EPA, under most of its responsibilities, establishes minimum standards. States are allowed to be stricter.

Stratification (or Layering): The tendency in deep lakes for distinct layers of water to form as a result of vertical change in temperature and therefore in the density of water.

Superfund: The program operated under the legislative authority of CERCLA and SARA that carries out the EPA solid waste emergency and long-term removal remedial activities. These activities include establishing a National Priorities List, investigating sites for inclusion on the list, determining their priority level on the list, and conducting and/or supervising cleanup and other remedial actions.

Surveillance: Specific observations and measurements relative to control or management.

Suspended Solids: Small particles of solid pollutants that float on the surface of, or are suspended in sewage or other liquids.

Swamp: A type of wetland that is dominated by woody vegetation and that does not accumulate appreciable peat deposits. Swamps may be fresh or saltwater and tidal or non-tidal. (See: Wetlands.)

Synergism: The cooperative interaction of two or more chemicals or phenomena producing a greater total effect than the sum of their individual effects.

T

Technology-Based Standards: Effluent limitations applicable to direct and indirect sources which are developed on a category-by-category basis using statutory factors, not including water-quality effects.

Terracing: Diking, built along the contour of sloping agricultural land, that holds runoff and sediment to reduce erosion.

Tertiary Waste Treatment: Advanced cleaning of wastewater that goes beyond the secondary or biological stage. It removes nutrients such as phosphorous and nitrogen and most biological oxygen demand and suspended solids.

Toxaphene: A chlorinated organic pesticide that is persistent in the natural environment. Toxaphene has induced liver cancer in mice and thyroid tumors in rats. Transport through the soil, water, and air can occur relatively easily. It has a relatively high degree of toxicity in aquatic organisms and has resulted in fish kills and adverse effects on fish development and reproduction. Bird kills due to toxaphene have been reported.

Toxic: Poisonous to living organisms.

Toxic Substance: A substance which can cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological or reproductive malfunctions, or physical deformities in any organism or its offspring, or which can become poisonous after concentration in the food chain or in combinations with other substances.

Toxicant: A poisonous agent that kills or injures animal or plant life.

Toxicity: The degree of danger posed by a substance to animal or plant life. (See: acute, chronic toxicity.)

Trophic Status: A measure of the biological productivity in a body of water. Aquatic ecosystems are characterized as oligotrophic (low productivity), mesotrophic (medium productivity) or eutrophic (high productivity).

U

Underground Injection Control (UIC): The program under the Safe Drinking Water Act that regulates the use of wells to pump fluids into the ground.

Underground Storage Tank: A tank located all or partially underground that is designed to hold gasoline or other petroleum products or chemical solutions.

V

Volatile: Description of any substance that evaporates readily.

W

Waste Load Allocation: The maximum load of pollutants each discharger of waste is allowed to release into a particular waterway. Discharge limits are usually required for each specific water quality criterion being, or expected to be, violated.

Waste Treatment Plant: A facility containing a series of tanks, screens, filters, and other processes by which pollutants are removed from water.

Water Quality Criteria: Maximum allowable concentrations of pollutants to protect uses of a water body (e.g., drinking, swimming, farming, fish production, or industrial processes).

Water Quality Standards: State-adopted and EPA-approved ambient standards for water bodies. The standards are developed considering the use of the water body and the water quality criteria which must be met to protect the designated use or uses.

Wetlands: An area that is regularly saturated by surface or groundwater and subsequently is characterized by a prevalence of vegetation that is adapted for life in saturated soil conditions. Examples include: swamps, bogs, fens, marshes, and estuaries.

X, Y, Z

Zooplankton: Minute aquatic animals eaten by fish.

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