United States
Environmental Protection
Agency

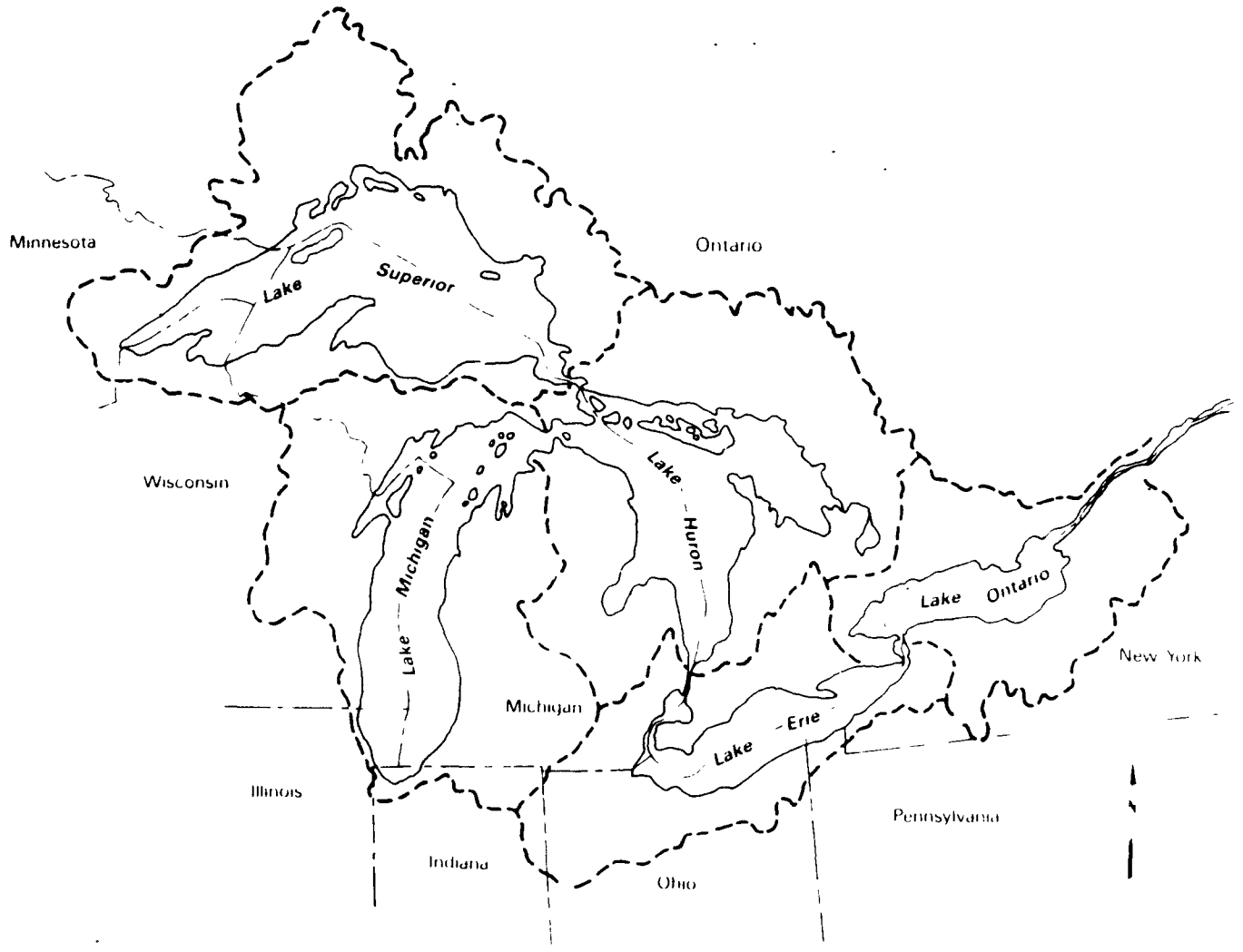
Great Lakes National
Program Office
230 South Dearborn Street
Chicago, Illinois 60604

EPA 905/9-89/005
GLNPO 04-89

EPA

U.S. Progress in Implementing The Great Lakes Water Quality Agreement

Annual Report to Congress 1988



U.S. PROGRESS IN IMPLEMENTING THE GREAT LAKES WATER QUALITY AGREEMENT

ANNUAL REPORT TO CONGRESS

DRAFT

July 1989

TABLE OF CONTENTS

EXECUTIVE SUMMARY i

1. INTRODUCTION 1-1

1.1 HISTORICAL OVERVIEW OF GREAT LAKES WATER QUALITY PROBLEMS 1-2
1.2 THE GREAT LAKES WATER QUALITY AGREEMENT 1-4
1.3 INSTITUTIONAL FRAMEWORK FOR IMPLEMENTING THE AGREEMENT 1-5

1.3.1 Role of the International Joint Commission 1-5
1.3.2 Role of the Great Lakes National Program Office 1-7
1.3.3 Role of Other USEPA Offices 1-9
1.3.4 Role of Other Federal Agencies 1-10
1.3.5 Role of the States 1-12

2. ENVIRONMENTAL QUALITY OBJECTIVES UNDER THE AGREEMENT 2-1

2.1 GENERAL OBJECTIVES 2-2
2.2 SPECIFIC WATER QUALITY OBJECTIVES 2-2
2.3 ECOSYSTEM OBJECTIVES 2-4
2.4 PROCESS FOR PERIODIC REVISION OF OBJECTIVES 2-4

3. STATE OF THE GREAT LAKES 3-1

3.1 LAKE SUPERIOR 3-2
3.2 LAKE MICHIGAN 3-2
3.3 LAKE HURON 3-6
3.4 LAKE ERIE 3-7
3.5 LAKE ONTARIO 3-11
3.6 THE CONNECTING CHANNELS 3-13

4. MANAGEMENT PLANS 4-1

4.1 PRINCIPLES FOR REMEDIAL ACTION AND LAKEWIDE MANAGEMENT PLANS 4-2
4.2 LAKEWIDE MANAGEMENT PLANS 4-3

4.2.1 Nutrient Management Plans 4-3
4.2.2 Lake Ontario Toxics Management Plan 4-4
4.2.3 Lake Michigan Toxic Pollutant Control/Reduction Strategy 4-6

4.3 REMEDIAL ACTION PLANS 4-6
4.4 POINT SOURCE IMPACT ZONES 4-8
4.5 FEDERAL/STATE INTERACTIONS 4-8

5. REMEDIAL PROGRAMS 5-1

5.1 OVERVIEW OF REMEDIAL PROGRAMS 5-1
5.2 REGULATORY PROGRAMS 5-6

5.2.1 Point Sources 5-6
5.2.2 Nonpoint Sources 5-12
5.2.3 Contaminated Sediment 5-14
5.2.4 Airborne Contaminants 5-14
5.2.5 Contaminated Ground Water 5-15
5.2.6 Discharges from Vessels 5-16

5.3 NONREGULATORY PROGRAMS 5-17

6. DEMONSTRATION PROGRAMS 6-1

6.1 CONTAMINATED SEDIMENTS 6-2
6.2 POINT SOURCES 6-2
6.3 NONPOINT SOURCES 6-3

7. ENVIRONMENTAL SURVEILLANCE, MONITORING, AND RESEARCH 7-1

7.1 BACKGROUND 7-1
7.2 OPEN LAKE SURVEILLANCE AND MONITORING 7-7

7.2.1 Limnology 7-7
7.2.2 Water Column Contaminants 7-7
7.2.3 Sediment Contaminants 7-8
7.2.4 Fish Contaminants 7-8

7.3 NEARSHORE AND HARBOR SURVEILLANCE 7-8
7.4 POLLUTANT LOADINGS 7-9

7.4.1 Atmospheric Deposition Monitoring 7-9
7.4.2 Tributary Monitoring 7-11
7.4.3 Contaminated Sediment 7-11

7.5 SOURCES OF POLLUTANTS 7-11

7.5.1 Point Sources 7-12
7.5.2 Nonpoint Sources 7-13
7.5.3 Contaminated Ground Water 7-13

7.6 MASS BALANCE STUDIES 7-13
7.7 RESEARCH 7-15

8. INTERNATIONAL/INTERAGENCY PROGRESS 8-1

8.1 INTERNATIONAL COORDINATION 8-1
8.2 INTER- AND INTRA-AGENCY COORDINATION 8-2

9. GREAT LAKES OUTLOOK 9-1

9.1 CURRENT CHALLENGES 9-1

9.1.1 Further Reductions of Pollutant Loadings 9-1
9.1.2 Eliminating Localized Contamination Problems 9-2
9.1.3 Developing an Ecosystem Approach to Management 9-2

9.2 GENERAL STRATEGY FOR MEETING CURRENT CHALLENGES 9-3

9.2.1 Eutrophication 9-3
9.2.2 Toxic Pollutants 9-4
9.2.3 Surveillance and Monitoring 9-4
9.2.4 Environmental Management Plans 9-4
9.2.5 Remedial Activities 9-4
9.2.6 Research 9-4
9.2.7 Technology Development and Transfer 9-4
9.2.8 International/Interagency/Intra-agency Coordination 9-5
9.2.9 Public Education and Involvement 9-5

9.3 LONG-TERM PROSPECTS FOR GREAT LAKES RECOVERY 9-5

9.3.1 Toxic Substances 9-5
9.3.2 Increased Water Withdrawals 9-6
9.3.3 Global Warming 9-6
9.3.4 Ecosystem Manipulation and Biotechnology 9-6
9.3.5 Waste Management 9-7

10. FUNDING FOR GREAT LAKES PROGRAMS 10-1

10.1 FEDERAL RESEARCH AND MANAGEMENT PROGRAMS 10-1

10.1.1 The 1988 Budget 10-2
10.1.2 The 1989 Budget 10-2
10.1.3 Funding History and Trends 10-4

10.2 FEDERAL POLLUTION ABATEMENT AND CONTROL PROGRAMS 10-4
10.3 FEDERAL CONSTRUCTION GRANTS FOR WASTEWATER TREATMENT WORKS 10-8

11. GLOSSARY OF TERMS 11-1

LIST OF TABLES

2-1 Specific Water Quality Objectives under the Great Lakes Water Quality Agreement of 1987 2-3

3-1 Water Quality Conditions in Lake Superior Compared to Great Lakes Water Quality Agreement Objectives 3-3

3-2 Water Quality Conditions in Lake Michigan Compared to Great Lakes Water Quality Agreement Objectives 3-5

3-3 Water Quality Conditions in Lake Huron Compared to Great Lakes Water Quality Agreement Objectives 3-8

3-4 Water Quality Conditions in Lake Erie Compared to Great Lakes Water Quality Agreement Objectives 3-10

3-5 Water Quality Conditions in Lake Ontario Compared to Great Lakes Water Quality Agreement Objectives 3-12

4-1 Summary of the 1990 Phosphorus Load Reduction Goals for Lake Erie, Lake Ontario, and Saginaw Bay 4-5

4-2 Status of U.S. Remedial Action Plans 4-9

5-1 Major Federal Programs Contributing to Great Lakes Water Quality Improvement 5-2

7-1 U.S. Environmental Surveillance and Monitoring Programs in the Great Lakes Region 7-3

7-2 U.S. Great Lakes Research Programs 7-17

10-1 Federal Funding for Selected Great Lakes Research and Management Programs 10-3

10-2 Federal Funding for Pollution Abatement and Control Programs in Selected U.S. Environmental Protection Agency Regions 10-7

10-3 Federal Construction Grants for Wastewater Treatment Works in Selected U.S. Environmental Protection Agency Regions 10-9

LIST OF FIGURES

1-1	The Great Lakes Basin	1-3
1-2	International Joint Commission and Its Advisory Groups for the Great Lakes Water Quality Agreement	1-6
1-3	Coordination Responsibilities of the Great Lakes National Program Office	1-8
3-1	Areas of Concern within Lake Superior	3-3
3-2	Areas of Concern within Lake Michigan	3-5
3-3	Areas of Concern within Lake Huron	3-8
3-4	Areas of Concern within Lake Erie	3-10
3-5	Areas of Concern within Lake Ontario	3-12
5-1	Direct Linkages Between USEPA's Statutory Programs and Great Lakes Concerns	5-7
5-2	Indirect Linkages Between USEPA's Statutory Programs and Great Lakes Concerns	5-8
5-3	Progress in Meeting NMP Goal	5-11
5-4	Enforcement Action Trends - Region V Great Lakes Major Permittees	5-11
7-1	Federal Agency Participation in Great Lakes Research	7-20
10-1	Trends in Federal Funding for Selected Great Lakes Research and Management Programs	10-5

FOREWORD

The Great Lakes system is a precious natural resource that provides a wide range of benefits to millions of U.S. and Canadian citizens. It is the largest reservoir of fresh surface water on earth, containing about 20 percent of the world's total supply. It supports a vital and unique biological community, provides drinking water to some 42 million people, and serves as the basic foundation for industrial and agricultural development in the American midwest.

Despite its immense size and immeasurable value, the Great Lakes ecosystem is fragile and has been extensively damaged by pollution. The environmental problems of the Great Lakes are intensified because of the low exchange rate of the system, with less than 1 percent of its water flowing out via the St. Lawrence River to the Atlantic Ocean each year. Therefore, when pollutants reach the Great Lakes, they tend to remain there for a long period. Pollutants settle into sediments and enter the food chain, passing from one organism to another, accumulating in top predators, such as lake trout, birds of prey, and people.

When the Congress amended the Clean Water Act (CWA) in 1987, it called for a strengthening of our national commitment to restore and maintain the environmental quality of the Great Lakes. The U.S. Environmental Protection Agency (USEPA) was designated as the lead agency among the several agencies working to meet these goals, which are embodied in the Great Lakes Water Quality Agreement (GLWQA) between the United States and Canada.

Section 118(c)(6) of the CWA as amended directs the Administrator of the USEPA to submit to Congress a comprehensive annual report on progress in implementing the GLWQA, program plans for the subsequent year, and long-term prospects for Great Lakes recovery.

This is the first Annual Report to Congress on Progress in Implementing the GLWQA. It provides an overview of GLWQA objectives, the state of the Great Lakes, and accomplishments relating to resource management plans, remedial programs, and demonstration projects for eliminating pollution in the Great Lakes Basin. It also addresses environmental surveillance and research programs and efforts to increase interagency cooperation.

Overall, much progress has been made in responding to the new Congressional directives. Institutional relationships have been strengthened, environmental research and information programs have been improved, and foundations have been developed for remediating specific pollution problems. The restoration of the Great Lakes is certain to be a long-term process, however, with the most difficult challenges remaining.

EXECUTIVE SUMMARY

INTRODUCTION

The Great Lakes System includes the five Great Lakes and four major connecting channels. The Lakes are shared by the United States and Canada, except for Lake Michigan which is located wholly within the United States. Eight States (Minnesota, Wisconsin, Michigan, Illinois, Indiana, Ohio, Pennsylvania, and New York) and the Canadian Province of Ontario border the Lakes.

The land area of the Great Lakes Basin is heavily developed with major urban centers and extensive agricultural areas. The Basin supports about 50 percent of Canadian and 20 percent of U.S. industrial production. Overall, the activities of more than 37 million people residing in the Basin and millions more residing outside of it have profoundly affected the Great Lakes ecosystem.

Concerns about water quality in the Great Lakes have progressed through a number of stages. In the 1880s, the contamination of drinking water intakes by human sewage led local governments to begin primary treatment and disinfection of sewage. Primary sewage treatment and treatment of drinking water reduced the incidence of waterborne disease in the region through the first half of the 20th century. Still, oxygen depletion associated with organic wastes and enrichment by excess nutrients caused biological changes in many areas of the Lakes through the first half of this century. Beaches were closed or avoided. Algal growth increased, causing oxygen depletion, fish kills, and loss of other organisms in some nearshore areas, as regional development continued.

The problem of eutrophication became critical in the 1960s, especially in Lake Erie. Cycles of algal blooms, decay, and oxygen depletion were becoming annual events. As a result, the public demanded action. The Federal government responded by requiring and helping to support secondary treatment of sewage and tightening controls on industrial discharges.

Once scientific consensus was reached that high levels of phosphorus were the primary cause of lake eutrophication, further efforts were focused on progressively reducing loadings of this nutrient. By 1980, decreased algal growth and increased dissolved oxygen levels in nearshore waters signified a major improvement in the water quality of most of the Great Lakes. In addition, government programs have been successful in reducing the concentration of many pollutants in the System, including metals and pesticides.

Despite progress, the cool-water aquatic communities, which characterized the Great Lakes at the time of European colonization, have not been fully re-established, and the dynamics of the ecosystem remain impaired by pollution. Phosphorus levels are still too high in some areas. Of increasing concern is the presence of a number of persistent toxic pollutants in the Great Lakes system, including polychlorinated biphenyls (PCBs), mercury, and some pesticides. Such pollutants have been linked to adverse effects on human health, leading to public fish consumption advisories throughout the region. They have also been associated with adverse effects on wildlife, including reproductive impairments and congenital abnormalities in fish and birds.

THE GREAT LAKES WATER QUALITY AGREEMENT

The United States and Canada established the Great Lakes Water Quality Agreement (GLWQA) as the overarching framework for cooperative efforts to restore and maintain the Great Lakes System. Initially signed in 1972, the Agreement was renegotiated in 1978 and amended in 1983 and 1987 to reflect our increasing understanding of the Great Lakes ecosystem and changing environmental quality objectives.

Water Quality Objectives

The first objectives of the GLWQA were general, primarily addressing conventional pollutants. More specific and quantitative objectives were added in 1978 for 41 chemical, physical, microbiological, and radiological parameters:

- Chemical objectives were established to include limits on 19 organic compound categories, such as aldrin/dieldrin and PCBs, and limits on 18 inorganic chemistry parameters, such as arsenic and mercury.
- Physical objectives were set for asbestos (lowest possible level) and for temperature (no change that would adversely affect the general use of waters).
- Microbiological objectives were set for water and fish, requiring the substantial absence of bacteria, fungi, or viruses that adversely affect human health.
- Objectives were set to limit the total human dose of radiation from drinking lake water to 1 millirem.

The 1978 GLWQA also added a focus on phosphorus load reduction. Phosphorus load reduction targets were made more stringent in 1983. Further reductions of 2,000 metric tons per year were required in the Lake Erie Basin, and 430 metric tons per year were required in the Lake Ontario Basin.

One of the most important elements of the 1987 GLWQA Amendments was the inclusion of ecosystem objectives. These objectives (e.g., maintaining Lake Superior as a balanced and stable oligotrophic ecosystem with lake trout as the top aquatic predator and the Pontoporeia hoyi as a key food chain organism) are intended to represent the cumulative goals of limits on various individual physical, chemical, and biological parameters.

Implementing the Agreement

In the United States, responsibility for water quality management is shared by Federal, State and local government, with the States having the primary or lead role. Since the Great Lakes are an international resource, the institutional framework for water quality management is particularly complex, requiring close cooperation and coordination among many Canadian and U.S. agencies at all levels of government.

International organizations, such as the International Joint Commission (IJC) and its Water Quality Board, monitor and advise the United States and Canada on progress in achieving GLWQA goals and objectives.

Under the Clean Water Act (CWA) and other Federal statutes, the U.S. Environmental Protection Agency (USEPA) controls certain types of activities that an affect water quality. The USEPA and other Federal agencies provide financial support and policy and technical guidance for many State environmental programs and provide leadership in research and development of new approaches to solving pollution problems.

The States have primary responsibility for developing and implementing water quality management plans and for regulating sources of pollutants. Local agencies also have important roles in water quality improvement through their activities related to land use planning, zoning, and local development requirements.

STATE OF THE GREAT LAKES

Recent surveillance and monitoring data indicate that Lake waters generally meet most of the water quality objectives set under the GLWQA. At the close of FY 1988, levels of phosphorus in the Great Lakes are meeting or approaching the 10 microgram per liter target for open waters of the Lakes. However, for Lakes Erie and Ontario, and for Saginaw Bay in Lake Huron, further reductions are needed to meet the objectives and target loadings.

Although the levels of many toxic pollutants declined significantly through the late 1970s, the concentration of some substances appears to have stabilized at levels above GLWQA objectives. Overall, the Water Quality Board has identified a total of 362 chemicals of concern within the Great Lakes ecosystem, some of which are particularly persistent. Pollutants of priority concern include total PCBs, DDT and its metabolites, dieldrin, toxaphene, forms of dioxin and benzofuran, mirex, mercury, alkylated lead, benzo(a)pyrene, and hexachlorobenzene. All of these compounds are capable of producing adverse and sometimes irreversible effects in a wide range of mammalian and aquatic species. Because they can accumulate in organisms and increase in concentration through the food chain, their recognized threat to human health and ecosystem integrity is significantly enhanced.

In total, about 30,000 chemical compounds are used within the Great Lakes Basin and may be present within the system. In addition, about 1,000 new chemicals are developed each year within the United States, suggesting that the potential list of toxic contaminants in the Lakes may be increasing over time.

Public health fish consumption advisories continue to be in effect for all five lakes. Restrictions apply mainly to certain game fish, such as trout and salmon, particularly larger fish, since they tend to carry higher body burdens of toxic substances. Nursing mothers, pregnant women, and children are advised to completely avoid eating fish species of concern.

Currently, 42 specific areas of serious localized contamination have been identified within the Great Lakes (30 of which are located partially or completely in the United States) by the Water Quality Board. Referred to as Areas of Concern (AOCs), all but one of these areas suffer from toxic substances contamination. Most have problems relating to contaminated bottom sediments.

Lake Superior

Lake Superior is the largest and deepest of the Great Lakes and has remained the most pristine. Water quality is generally good throughout the Lake and excellent in open lake waters. Phosphorus concentrations in Lake Superior are the lowest of all the Great Lakes and have not changed significantly since 1965. Concentrations of PCBs in certain fish are of concern, however. Public health fish consumption advisories have been issued for lake trout taken from Lake Superior waters, recommending restricted consumption of fish up to 30 inches and no consumption of fish greater than 30 inches. High concentrations of mercury in fish from the St. Louis Bay have also resulted in fish consumption advisories. Serious localized contamination affects three AOCs within U.S. waters: St. Louis River/Bay, Torch Lake, and Deer Lake/Carp Creek/Carp River.

Lake Michigan

Lake Michigan is the second largest Lake in terms of volume and depth. Nutrient concentrations are generally higher than those in Lake Superior. Phosphorus loadings to the Lake are estimated to have remained below the target level of 5,670 metric tons per year since 1981. PCB and dieldrin concentrations in fish are declining but still remain above the Agreement objectives. Public health fish consumption advisories have been issued for lake trout, salmon, and brown trout taken from Lake Michigan waters, recommending restricted consumption of fish beyond specified sizes. In addition, the public has been advised not to eat any carp or catfish, or very large lake trout, chinook salmon, or brown trout. Ten AOCs have been designated within Lake Michigan: Manistique River, Menominee River, Fox River and Southern Green Bay, Sheboygan, Milwaukee Harbor, Waukeegan Harbor, Grand Calumet and Indiana Harbor Canal, Kalamazoo River, Muskegon Lake, and White Lake.

Lake Huron

Lake Huron is the second largest Great Lake in terms of surface area (59,700 km^2). Like Lake Superior, Lake Huron has a drainage basin that supports lower population densities and more forested lands than the other Great Lakes. Consequently, the quality of the open waters of Lake Huron is generally high, with levels of nutrients and major ions within GLWQA objectives. Water quality is generally good; on a relative basis, water quality is between Lake Superior and Lake Michigan. No significant change in phosphorus levels has been measured in the Lake since 1980, but Saginaw Bay has improved. Since 1976, the estimated annual phosphorus loadings have approached the target value of 4,360 metric tons. Phosphorus levels are highest in Saginaw Bay in the U.S. and lowest in Georgian Bay in Canada. Dieldrin and DDT levels in fish are below the objectives established by the Agreement. PCB levels remain above the current objective and no decreasing trend is discernible. Public health fish advisories have been issued suggesting that the consumption of lake trout, rainbow trout, and brown trout caught in Lake Huron waters be restricted. Of four AOCs located in Lake Huron, only one, Saginaw River/Saginaw Bay is located within U.S. boundaries.

Lake Erie

Lake Erie is the fourth largest Great Lake in terms of surface area (25,700 km^2)and is.the most shallow lake, with a mean depth of only 19 meters. It consists of three distinct basins, which differ in water quality characteristics. Erie's shores are highly urbanized and its major tributaries drain intensively farmed soils. Water quality conditions vary among the three basins, although there has been an overall decreasing trend in nutrient levels in the Lake. Available data show that phosphorus lake concentrations generally have declined since 1968. DDT and dieldrin concentrations in fish tissue are below established objectives. PCB concentrations remain above the Agreement objective. Both carp and catfish are the subject of public health fish consumption advisories, with restricted consumption being recommended in New York and no consumption being recommended in other States bordering the Lake. Seven areas of localized contamination have been designated within U.S. waters of Lake Erie: Clinton River, Rouge River, River Raisin, Maumee River, Black River, Cuyahoga River, and Ashtabula River.

Lake Ontario

Lake Ontario is the smallest of the Great Lakes (19,520 km^2),but with a mean depth of 86 meters, is deeper than Lake Erie. Located at the end of the Great Lakes chain, Lake Ontario receives nutrients and toxic contaminants contained in the outflow of upstream systems. Because of this source and those within the basin, Lake Ontario has relatively high open water pollutant concentrations. Monitoring data show that phosphorus concentrations

have declined markedly since 1973, and loadings are estimated to approach the target value of 7,000 metric tons per year. PCB concentrations in lake trout greatly exceed the Agreement objective, but are declining. DDT concentrations approximate the objective level and are not declining. Dieldrin concentrations are below the established objective and are declining. The public has been advised not to consume more than one meal per month of white perch, coho salmon (under 21 inches), or rainbow trout (under 18 inches) from Lake Ontario. The public was also advised not to consume any of the following fish from Lake Ontario waters: American eel, channel catfish, lake trout, chinook salmon, coho salmon (over 21 inches), rainbow trout (over 18 inches), and brown trout (over 18 inches). Four AOCs are located within the U.S. boundaries of Lake Ontario: Buffalo River, Eighteenmile Creek, Rochester Embayment, and Oswego River.

The Connecting Channels

The Connecting Channels (i.e., St. Marys River, St. Clair River, Lake St. Clair, Detroit River, and Niagara River) are the major links between each of the Great Lakes. The St. Lawrence River is the major outflow of the Great Lakes System to the Gulf of St. Lawrence and ultimately the Atlantic Ocean. These channels, with the exception of Lake St. Clair, have been designated as areas for priority cleanup (i.e., AOC) because Agreement objectives have been exceeded and/or beneficial uses have been impaired.

WATER QUALITY MANAGEMENT PLANS

The 1987 changes to the GLWQA and the CWA introduced several new requirements relating to water quality management planning. These new requirements focus on managing nutrient loadings and reducing levels of designated toxic pollutants. The new planning requirements are intended to build on our current foundation of water quality management planning activities to achieve GLWQA objectives.

Under Section 303 of the CWA, the States have primary responsibility for undertaking a continuous planning process for restoring and maintaining water quality. Reports are also required under Section 305(b) describing the overall water quality of all navigable waters in the State. The USEPA Regional Water Divisions assist the States in their water quality planning efforts by providing annual guidance for overall Agency objectives, and by reviewing and evaluating annual plans for State programs.

The 1987 Amendments to the CWA added provisions under Section 304(l) for State Toxic Substances Control Strategies and under Section 319 for State Nonpoint Source Program Plans. The Great Lakes States began taking action to meet these requirements during FY 1988, with assistance from USEPA Headquarters and Regional Water Divisions. As required by Section 304(l), all of the Great Lakes States developed and submitted listings of water bodies that fail to meet water quality objectives due to point source discharges of toxic substances, and proposed strategies for reducing toxics to appropriate levels, as required under Section 304(l) of the Act. The USEPA is currently reviewing the listings and the management strategies.

Under Section 319, each State is required to submit a report that identifies those navigable waters, which without additional nonpoint source controls, are not expected to meet water quality standards. The implementation of additional programs for nonpoint source control will begin in FY 1989.

Section 118 of the CWA introduced new water quality management planning responsibilities that apply specifically to the Great Lakes Basin. Section 118 charges GLNPO with two management planning responsibilities: 1) in cooperation with appropriate Federal, State, tribal, and international agencies, to develop and implement specific action

plans to carry out U.S. responsibilities under the GLWQA, and 2) to develop, in consultation with the States, a 5-year plan and program for reducing the amount of nutrients introduced into the Great Lakes.

The 1987 GLWQA Amendments call for nonattainment of objectives to be addressed at three geographic scales: Lakewide Management Plans (LMPs) will address Critical Pollutants that are impairing beneficial uses in waters of the open Lakes, Remedial Action Plans (RAPs) will address use impairments within designated AOCs, and Point Source Impact Zones adjacent to discharges will be identified and minimized.

During FY 1988, RAPs were completed for seven U.S. Areas of Concern and were submitted to the IJC for review. The IJC's review of these initial RAP submissions has indicated that most require additional definition of the nature and sources of environmental problems in the respective AOCs. The States plan to submit seven additional RAPs during FY 1989.

LMPs are intended to be cooperative strategies for reducing loadings of critical pollutants to the open waters of each of the Lakes. Developing a useful framework for these plans is a major challenge, since the systematic reduction of toxic substances is a particularly complex task, both technically and institutionally. Determining the relative importance of various sources of toxic pollution will require extensive study, since toxic pollutants to the Great Lakes are variously borne by air, ground water, land runoff, tributaries, industrial and municipal dischargers, and by releases from contaminated sediment. In some cases, the detection of toxic substances from these sources will require developing or applying new technologies. In turn, a variety of new remedial measures will be necessary to address past as well as continuing loadings of persistent toxic pollutants to the Great Lakes. Because many toxic substances are long lived, eliminating them is likely to be a much longer process than that of controlling eutrophication. In FY 1989, USEPA will work with other government agencies and nongovernment organizations to develop a useful framework for LMPs. This framework will reflect experience gained in recent large lake studies and management planning efforts.

In 1986, USEPA and the States of Illinois, Indiana, and Michigan prepared a Lake Michigan Toxic Pollutant Control/Reduction Strategy. The objectives of this strategy are to restore multiple human uses of Lake Michigan and to protect human health and the Lake Michigan ecosystem by achieving a significant reduction in the loading rates of toxic pollutants.

In February 1987, USEPA, the New York State Department of Environmental Conservation, Environment Canada, and the Ontario Ministry of the Environment signed a declaration of intent to prepare a Toxics Management Plan for Lake Ontario. 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, within the ecosystem, of the most sensitive native species.

Environmental plans for the Lakes require extensive cooperation between various jurisdictions and levels of government, with all parties responsible for the health of the Great Lakes system. Within the United States, one important indication of commitment to this cooperation was seen in June 1986 when the Governors of the eight Great Lakes States signed the Great Lakes Toxic Substances Control Agreement. This Agreement pledges the States to treat the Lakes as one ecosystem without regard to political boundaries. It acknowledges that toxic pollutants are the foremost problem in the Basin and lays out goals for the States toward promoting coordinated toxic pollution reduction programs. Since signing the Agreement, the States have made considerable progress toward developing coordinated control programs. In FY 1988, the Governors further agreed to establish a permanent fund for Great Lakes studies.

REMEDIAL PROGRAMS

Considerable pollution control progress in the Great Lakes has been made under CWA mandated programs. Point source discharges to the Great Lakes are now regulated under 3,675 National Pollutant Discharge Elimination System (NPDES) permits, 2,531 of which apply to industrial facilities and 1,144 of which apply to municipal sewage treatment facilities. Several States are now incorporating toxic limits into NPDES permits to control discharge of toxic pollutants in effluents. Also in 1987, approximately $8 billion in Federal and State construction grants had been invested in Great Lakes Basin municipal sewage treatment projects.

Another provision of the CWA calls for the establishment of approved Pretreatment Programs for commercial and industrial firms using publicly owned treatment works (POTWs). In the Great Lakes States, a total of 476 POTWs are subject to these requirements. A total of 466 facilities (97.9 percent) received program approval by September 30, 1988.

The National Municipal Policy (NMP), initiated in 1984, required municipal compliance with effluent limitations by July 1, 1988. Implementation of the NMP resulted in 87 percent of POTWs providing at least secondary treatment of wastewater. Voluntary compliance and Federal and State enforcement are responsible for the successful record. The remaining 13 percent of POTWs in noncompliance are currently on enforcement timetables or in litigation.

Present emphasis for phosphorus control is on nonpoint sources, particularly contributions made by agricultural runoff since reducing agricultural sources is most cost effective. Additional management of nonpoint sources is necessary if target phosphorus load reductions are to be met. In past years, the USEPA and the U.S. Department of Agriculture (USDA) Soil Conservation Service (SCS) have worked jointly with the States to conduct demonstration projects and to promote the use of conservation tillage techniques and other Best Management Practices in farming. During FYs 1987 and 1988, USEPA and USDA, in conjunction with the Great Lakes States, reviewed progress in implementing the Great Lakes Phosphorus Load Reduction Plans and fulfilling the terms of Annex 3 of the GLWQA. They also worked to implement an improved tracking system to measure the adoption of conservation tillage techniques that will improve estimates of runoff. During FY 1989, both agencies will continue to collaborate with the States to update and implement phosphorus reduction plans. Under USDA's 1990 Water Quality Initiative, a significant increase in technical and financial assistance related to water quality activities is expected. These activities will be carried out in accordance with priorities identified in State management plans.

Considerable progress has been made under other environmental programs as well. Since Federal regulations for hazardous waste generation, transport, treatment, storage, and disposal facilities were promulgated in 1980, USEPA and delegated State programs have identified 25,958 permittees and permit applicants in the Great Lakes Basin. In FY 1988, USEPA began implementing statutory provisions for corrective action at active hazardous waste management facilities. These activities will ensure that existing contamination from such facilities that may be affecting water quality in the Lakes will be remedied in the near future. In addition, they may be used to accomplish cleanup of contaminated sediments in cases where sediment contamination in the Lakes or their tributaries can be attributed to a particular permit applicant.

Uncontrolled hazardous materials sites in the Basin have received considerable attention in recent years as well. The USEPA's National Priorities List (NPL), required

under Superfund, includes over 130 sites located in the Great Lakes Basin. Moreover, States such as Michigan, New York, Ohio, and Minnesota have created their own State Superfund programs to address sites that do not warrant listing on the NPL, but have high State priority for cleanup. Programs for active and abandoned hazardous waste sites will be an important part of future efforts to address concerns related to the potential contributions of toxic pollutants from contaminated ground water to the waters of the Great Lakes.

State air programs in the Great Lakes Basin have also made considerable progress. In particular, over the past few years, significant reductions in sulfur dioxide emissions have been achieved in the Basin. Attention has now turned to control of air toxics. All eight States are coordinating emissions inventory procedures for air toxics and jointly developing permit guidelines to ensure that appropriate controls are placed on sources of air toxics.

The 1987 Amendments to the CWA and the GLWQA call for special attention to nonpoint sources of pollution such as contaminated ground water, the atmosphere, and contaminated sediments. Information on the extent of contributions made by such sources is presently incomplete; however, sufficient data exist to conclude that they are important causes of both localized and lakewide problems and should be considered in all management plans for water quality restoration.

Advanced identification of significant wetlands in the Basin is in progress to protect them for the future. Wetlands play an important role in slowing soil erosion and surface runoff, as well as providing habitat and nursery areas for numerous species. Under Section 404 of the CWA, the U.S. Army Corps of Engineers (USCOE), in cooperation with the USEPA, issues permits for the placement of dredged or fill material in waters of the United States, including wetlands. The annual number of standard dredge permits issued by the USCOE in the Great Lakes Basin (Northcentral Division) has declined over 19 percent during FY 1988.

DEMONSTRATION PROGRAMS

Demonstration programs have played an important role in Great Lakes programs under the CWA by demonstrating the feasibility of alternative technologies and approaches. Lower cost alternatives have been shown to be effective for removal of phosphorus from point sources, for control of combined sewer overflows, and for addressing agricultural nonpoint sources of pollution. Cost savings through demonstration projects can be substantial. The potential savings of $17 million from one combined sewer demonstration in Saginaw Michigan nearly equals the total authorization for Section 108(a). In the case of agricultural sources, the cost effectiveness of alternative tillage methods is substantial, but by demonstrating new methods at a local level, acceptance was greatly accelerated.

Section 108(a) authorized $20 million to support a number of demonstration projects for nonpoint source pollution control techniques in the Great Lakes Basin. Numerous agencies participated in studies to demonstrate specific control technologies, including those for agricultural pollution; to increase public awareness of water pollution issues; to document water quality results through monitoring; and to evaluate combined sewer systems and sewage land application techniques. Overall, the projects have been highly successful.

In future years, USEPA expects that demonstration projects on contaminated sediments, ground water, and air toxics will receive high priority. Section 118 (c)(3) of the 1987 Amendments to the CWA calls for the Great Lakes National Program Office (GLNPO) to conduct a study that includes demonstration projects addressing remedial technologies for removal of toxic pollutants from the Great Lakes with special emphasis on removal of toxic pollutants from contaminated bottom sediments. GLNPO began this study in FY 1988. This study and the accompanying demonstration projects will be vital to determine the measures necessary to clean up AOCs, of which nearly all have contaminated

sediment. USEPA expects that the contaminated sediments study will prove of national relevance.

ENVIRONMENTAL SURVEILLANCE, MONITORING, AND RESEARCH

The Great Lakes Surveillance and Monitoring program is an interrelated network of activities conducted by the States, USEPA, and other Federal agencies. The core of this network is coordinated by GLNPO and implemented by the States, GLNPO itself, and colleges and universities working under grants from GLNPO. The program consists of four major components: open lake monitoring, nearshore and harbor monitoring, pollutant loadings measuring, and pollutant source identification.

Open lake surveys measure the conditions and trends in the waters of the open lakes. The open lakes reflect long-term changes since they are far more uniformly mixed than the more shallow, nearshore waters that are directly influenced by pollutant discharges and are far more variable in quality. Open lake surveys include the study of plankton and nutrients, as well as contaminants in the water column, sediment, and fish.

Nearshore surveys are conducted using a combination of large and small ships. Water, living organisms, and sediment are all sampled, but emphasis is often placed on fish and sediment as the best places to measure toxic substances.

The Great Lakes receive wastes from a substantial portion of U.S. population, industry, and agriculture. To determine total loadings to the Lakes, information must be obtained on inputs through all pathways. Great Lakes surveys focus on two principal routes: through the atmosphere and through tributary streams. Contaminated sediments are also surveyed since significant quantities of stored contaminants can be recycled back into the water and biota.

The sources of pollutants are varied. Numerous monitoring programs are in place or are in the development phase to document compliance and improvements in the system. These programs include NPDES discharge monitoring for point source discharges, surveys to identify nonpoint sources of phosphorus, and identification of existing or potential sources of contaminated ground water.

In FY 1989, GLNPO, the National Oceanic and Atmospheric Administration (NOAA), and the State of Wisconsin will continue field work for a comprehensive 4-year study of the sources and fates of toxic pollutants in Green Bay on Lake Michigan. The "Green Bay Mass Balance Study" involves development and field-calibration of a model that describes the principal sources and fates of toxic pollutants in large lakes. It is addressing contributions of toxics from point sources and from nonpoint sources, such as contaminated sediment, ground water, and air deposition. Field work for the Green Bay Mass Balance began in 1988. If this mass balance pilot proves successful, USEPA will then apply the mass balance approach to a whole lake system as an important tool for LMPs. In addition to serving as an important step in the development of a new decision-making framework for water quality management, the Green Bay Mass Balance Study will also serve as a forum for research on the relative importance of point and nonpoint sources of pollution.

By the end of 1988, a number of important objectives were achieved in surveillance and monitoring:

- Annual open lake phosphorus monitoring programs were completed for all five Lakes.

- An extensive fish monitoring program in nearshore and open Lake areas was completed involving over 20 different States and Federal agencies.

- During FY 1988, USEPA, the States, USCOE, NOAA's Great Lakes Environmental Research Laboratory, and other organizations began or continued important programs for surveillance and research related to nonpoint sources of pollution.

- Programs were initiated for studying sources of contaminated ground water that can affect water quality in the Great Lakes, for monitoring air deposition of toxics to the Lakes, for studying contaminated sediments and the rates at which contaminants may transfer from the sediment to lake water, and for monitoring contributions of toxic pollutants to the Lakes from the tributaries that empty into them.

- USEPA and Environment Canada, working in conjunction with several States and the Province of Ontario, completed a study of the Upper Great Lakes Connecting Channels that addresses contaminated sediments and other toxic pollution problems in the St. Marys River, St. Clair River, Detroit River, Niagara River, and the St. Lawrence River.

- Monitoring stations for air toxics were established in Green Bay, and sediment sampling and other surveillance were conducted.

The Great Lakes surveillance and monitoring program is one of the most comprehensive and extensive monitoring programs in the United States. Advanced methods and technologies for measuring toxic pollutants in water, air, and sediment are being used or developed. Lessons learned from this program can be applied to other regions of the United States.

Basic research on the Great Lakes is carried out to improve our fundamental understanding of the physical, chemical, and biological processes of the Lakes and their interrelationships. Many organizations participate in Great Lakes research. Within USEPA, the Office of Research and Development (ORD)-Large Lakes Research Station at Grosse Ile, Michigan, and the National Water Quality Laboratory at Duluth, Minnesota, conduct research specific to Great Lakes priorities. GLNPO also provides grant money for research directly to universities and through interagency agreements with NOAA, the United States Fish and Wildlife Service (USFWS), and USCOE. NOAA participates directly through operation of its Great Lakes Environmental Research Laboratory at Ann Arbor, Michigan, and also provides grants to universities for Great Lakes research under its Sea Grant program. The USFWS National Fisheries Research Center for the Great Lakes conducts fisheries research, and USFWS funds Cooperative Fishery Research Units at selected universities.

Great Lakes research addresses three general areas: water quality management, ecosystem dynamics, and fishery resources. Water quality management research projects in FY 1988 focused primarily on developing information needed to support mass balance modeling efforts in Green Bay and elsewhere and on the Great Lakes contaminated sediments study. Research highlights in FY 1988 include:

- A study by the NOAA Great Lakes Environmental Research Laboratory on the rate of exchange of contaminants between Green Bay and Lake Michigan

- An investigation by the University of Minnesota of PCB uptake rates by phytoplankton

- A study by GLNPO to improve tributary monitoring techniques for toxic substances and to investigate the toxic effects of contaminants unique to the Great Lakes Basin

- Studies by several universities for investigating the extent of sediment contamination in Lake Ontario and for studying sediment resuspension, deposition, and fate in the Lakes (funded by GLNPO)

- Research by the USCOE on contaminated sediments in the Great Lakes.

The emphasis on research to support the Green Bay Mass Balance Study and the contaminated sediments study is expected to continue during the next 2 years. Another area for research is the effects of toxic chemicals on Great Lakes species to support the establishment or chemical specific objectives and further development of ecosystem objectives.

INTERNATIONAL AND INTERAGENCY COOPERATION

Because the Great Lakes transcend both State and national boundaries, many programs entail cooperative efforts involving U.S. Federal and Canadian agencies, the States and Provinces, and local governments. Official actions concerning the Agreement are normally led by the U.S. Department of State. At the working level, coordination on projects related to the Agreement is generally led by USEPA with involvement of the State Department as required.

The 1987 Amendments to the CWA recognize that careful coordination of Great Lakes activities is essential. The CWA requires that USEPA, through GLNPO, coordinate its activities related to the Great Lakes and also work with other Federal and State agencies to meet U.S. obligations under the GLWQA. The USEPA has assumed three principal responsibilities related to coordination with Canada and the IJC:

- Coordinating U.S. environmental programs with those of Canada, including conducting twice-yearly meetings of the Parties (the United States and Canada) to review progress in implementing the Agreement

- Preparing reports to the IJC as called for in the Agreement

- Providing support to the IJC and its Water Quality Board in efforts to carry out its assigned responsibilities under the Agreement.

In FY 1988, USEPA participated in joint U.S./Canadian task forces to address specific requirements of the Agreement for coordinated projects on air deposition monitoring, toxic substances, and contaminated sediment. Joint U.S. and Canadian activities in these areas will continue in FY 1989 and beyond. In FY 1989, USEPA plans to make considerable progress, together with Canada, toward implementing a coordinated joint surveillance and monitoring plan that will support further development of compatible data systems.

GLNPO works closely on Great Lakes initiatives with other USEPA regional and Headquarters offices, including ORD, the Office of Water, and the Office of Policy, Planning, and Evaluation. ORD laboratories are making important contributions to the Green Bay Mass Balance Study, the contaminated sediments study, and other initiatives.

External to USEPA, GLNPO participated in many joint efforts with States during FY 1988, including projects related to developing RAPs, conducting fish monitoring programs, developing air toxics inventories, studying contaminated sediments, and studying the impacts

of combined sewer overflows. Also in FY 1988, the USEPA worked to improve its coordination with other Federal agencies regarding Great Lakes projects. Interagency agreements were established with the USCOE, USFWS, and the United States Geological Survey. Work under these agreements is continuing in FY 1989.

GREAT LAKES OUTLOOK

This first comprehensive Report to Congress on implementing the GLWQA illustrates the substantial progress made in restoring water quality in the Great Lakes. The long-term prospects for fully restoring and enhancing the Great Lakes depend in part on our success in resolving current water quality issues. The future of the Lakes, however, will also be determined by the nature of emerging or unforseen problems and our success in responding to them. Emerging and future water quality issues need to be considered within the context of the economic and cultural conditions that will evolve over the next 20 years. Economic growth and development have slowed in many areas of the Great Lakes Basin. The nature and degree of regional economic revitalization or decline will be influential on the types of pollution problems that will have to be addressed, as well as on the resource base available for responding to those problems.

Conditions outside the Great Lakes Basin will also influence the long-term prospects for restoring beneficial uses of the Lakes. Changes in national and worldwide demand and prices of commodities or natural resources will influence the regional economy and environmental conditions. Shifting markets and technological developments could change regional industrial profiles and demographic patterns.

Some issues are likely to be particularly important in shaping the future of the Great Lakes, including the problem of toxic chemicals, increased water withdrawals, global warming, ecosystem manipulation and biotechnology, and waste management. Many Federal, State, and local organizations must participate in these challenges, which will create a complex institutional climate. The 1987 changes to the CWA and the GLWQA recognize this complexity and provide a management framework for the Great Lakes jurisdictions to work together to achieve environmental results. As our knowledge regarding the extent of and the means for dealing with these issues grows, this framework will allow planning of remedial actions as successful as those taken to remedy eutrophication in the Lakes.

FUNDING FOR GREAT LAKES PROGRAMS

The Federal government expends more than $500 million annually on programs intended to improve Great Lakes water quality. More than 90 percent of this funding goes to the construction of sewage treatment facilities, under the Construction Grants program administered by the U.S. Environmental Protection Agency (USEPA). Major Federal research and management programs account for an additional $33 million, or about 7 percent of total expenditures. Pollution abatement and control programs, including State grants and support for USEPA permitting and enforcement responsibilities, account for an additional $15 million, or 3 percent of the total for major programs.

Recent trends include a gradual reduction in Construction Grants funding. The program is scheduled to be phased out by 1990, to be replaced by a new Federally supported State revolving-fund system. Funding for major Great Lakes research and management programs declined in the middle of this past decade, but has now been restored to the 1980 level. Furthermore, additional funding sources have been identified within USDA's 1990 Water Quality Initiative. Funding increases have been provided to the USEPA's Great Lakes National Program Office to support its new responsibilities under the CWA and GLWQA. Funding for some Federal pollution abatement and control programs

has been reduced, however grants for State pollution control programs have been increased.

Many other Federal programs contribute directly or indirectly to environmental improvements in the Great Lakes. For example, USDA also supports programs that contribute to the management and restoration of Great Lakes water quality (e.g., nonpoint source management). Funding for these programs is not represented within the reported totals for selected Federal programs. The costs and benefits of these types of programs are difficult to apportion. Certainly, the Superfund program and air quality control programs administered by the USEPA, and the numerous research and assessment programs undertaken by various Federal natural resource management agencies, represent major government commitments with important implications for regional environmental quality.

1. INTRODUCTION

The Great Lakes are a precious natural resource, providing millions of U.S. and Canadian citizens with valuable benefits -- among them, important commercial and sport fisheries, a major transportation system, water supply, modifier of climate, recreational resource, and means of waste disposal. Over the years, however, the impacts of tremendous population growth with accompanying urbanization and industrialization along shorelines, coupled with agricultural practices throughout the Great Lakes Basin, have seriously affected the water quality and ecosystem health of the Lakes. As a result, the ability of the Great Lakes resource to continue to provide these benefits has been severely threatened.

Although the United States and Canada have made substantial progress over the last 15 years in alleviating some of the most serious water quality problems affecting the Lakes, much remains to be done. We face the formidable challenges of decreasing further loadings of conventional pollutants, eliminating persistent toxic substances, and, ultimately, restoring the integrity of the Great Lakes ecosystem.

The Great Lakes Water Quality Agreement (GLWQA) was established by the United States and Canada as the overarching framework for cooperative binational efforts to restore and maintain the Great Lakes System. The initial Agreement, signed in 1972, focused on reducing nutrient loadings to the Lakes in order to curb the process of eutrophication. Renegotiation of the Agreement in 1978, and amendments in 1983 and 1987, have substantially broadened and heightened the objectives of the GLWQA. Over the years, the Agreement has served well in the development of measures to restore and enhance the Great Lakes System.

In 1987, the United States confirmed its commitment to attaining the goals of the GLWQA through enactment of the Water Quality Act Amendments to the Clean Water Act (CWA). In particular, Section 118 of the Amendments instructs the U.S. Environmental Protection Agency (USEPA) to take the lead role in the effort to meet these goals, working with other Federal, State, and local authorities. This Section formally establishes the Great Lakes National Program Office (GLNPO) within the USEPA as the entity with operational responsibilities for several new Great Lakes water quality initiatives, and for overall coordination of U.S. efforts under the GLWQA. The Act also requires the USEPA Administrator to submit a comprehensive annual report to Congress, summarizing achievements and progress during the previous year on the part of all agencies, prospects for Great Lakes restoration, and efforts planned for the coming year.

This document is the first Annual Report to Congress on Progress in Implementing the Great Lakes Water Quality Agreement. The report provides a broad view of progress in restoring the Great Lakes and incorporates background information on the Agreement and its provisions. Recent additions to the Agreement's provisions, as well as cooperative efforts, surveillance and monitoring activities, Federal remedial activities (including technological demonstrations), and prospects and plans for the future are highlighted.

1.1 HISTORICAL OVERVIEW OF GREAT LAKES WATER QUALITY PROBLEMS

The Great Lakes System includes the five Great Lakes (Figure 1-1) and their four major connecting channels. Generally, the system flows from Lake Superior, at 600 feet above sea level, through the other four Lakes and the connecting channels and then out through the St. Lawrence River to the Atlantic Ocean. The Lakes are shared by the United States and Canada, except for Lake Michigan, which is located wholly within the United States. Eight U.S. States (Minnesota, Wisconsin, Michigan, Illinois, Indiana, Ohio, Pennsylvania, and New York) and the Canadian Province of Ontario border the Lakes.

The activities of more than 37 million people residing in the Basin and millions more residing outside of it have had profound adverse effects on the Great Lakes ecosystem. The numerous tributaries to the system receive drainage from a range of land uses and types of soil, resulting in numerous pollution problems. The southern half of the Great Lakes Basin is particularly intensively developed, with major urban centers and extensive agricultural areas, all of which contribute to the degradation of water quality and ecosystem health in the Lakes.

Concerns about water quality in the Great Lakes have progressed through four general stages over time, focusing on disease organisms, oxygen depletion, nutrients and eutrophication, and toxic contamination as important pollution problems. Appreciation for the complexity of the causes of water quality degradation in the Great Lakes has grown with experience in monitoring responses to pollution control measures over the past 20 years.

Before intensive settlement and development of the region, the waters of the Great Lakes were clear and cool throughout the system. Algal growth was minimal and there were many species of fish, some now extinct. The average size of individual fish was much larger, and longer-lived species such as sturgeon and lake trout were abundant. Causes of the drastic changes in the Great Lakes fisheries include water quality degradation, accidental and deliberate introduction of exotic fish species, over-fishing, and habitat loss.

When cities first developed in the Basin, localized water quality degradation attributable to waste disposal was considered inconsequential, given the huge volume of water in the Great Lakes. Later, it was realized that fundamental changes in such large systems may not become obvious until they are well advanced. By the 1880s, contamination of drinking water intakes by human sewage led local governments to begin primary treatment and disinfection of sewage.

Primary sewage treatment and improved treatment of drinking water substantially reduced the incidence of waterborne disease in the region through the first half of the 20th century, except in the case of diseases contracted by swimming. Still, enrichment by organic wastes was causing subtle biological changes in many areas of the Lakes through the first half of this century. Beaches were frequently closed to swimming because of high fecal coliform counts, or else were avoided because of algae, odors, floating oil, or dead fish.

Eventually, algal growth increased, causing oxygen depletion and destruction of biota in nearshore and estuarine areas. How such changes could affect an entire Great Lake was not recognized until eutrophication became obvious in the shallow, more vulnerable Lake Erie. By 1960, changes in productivity and the annual cycle of algal bloom, decay, and oxygen depletion in Lake Erie had been linked to over-enrichment. With the public demanding further pollution control, the Federal Government responded by requiring secondary treatment of sewage and control of industrial waste discharges.

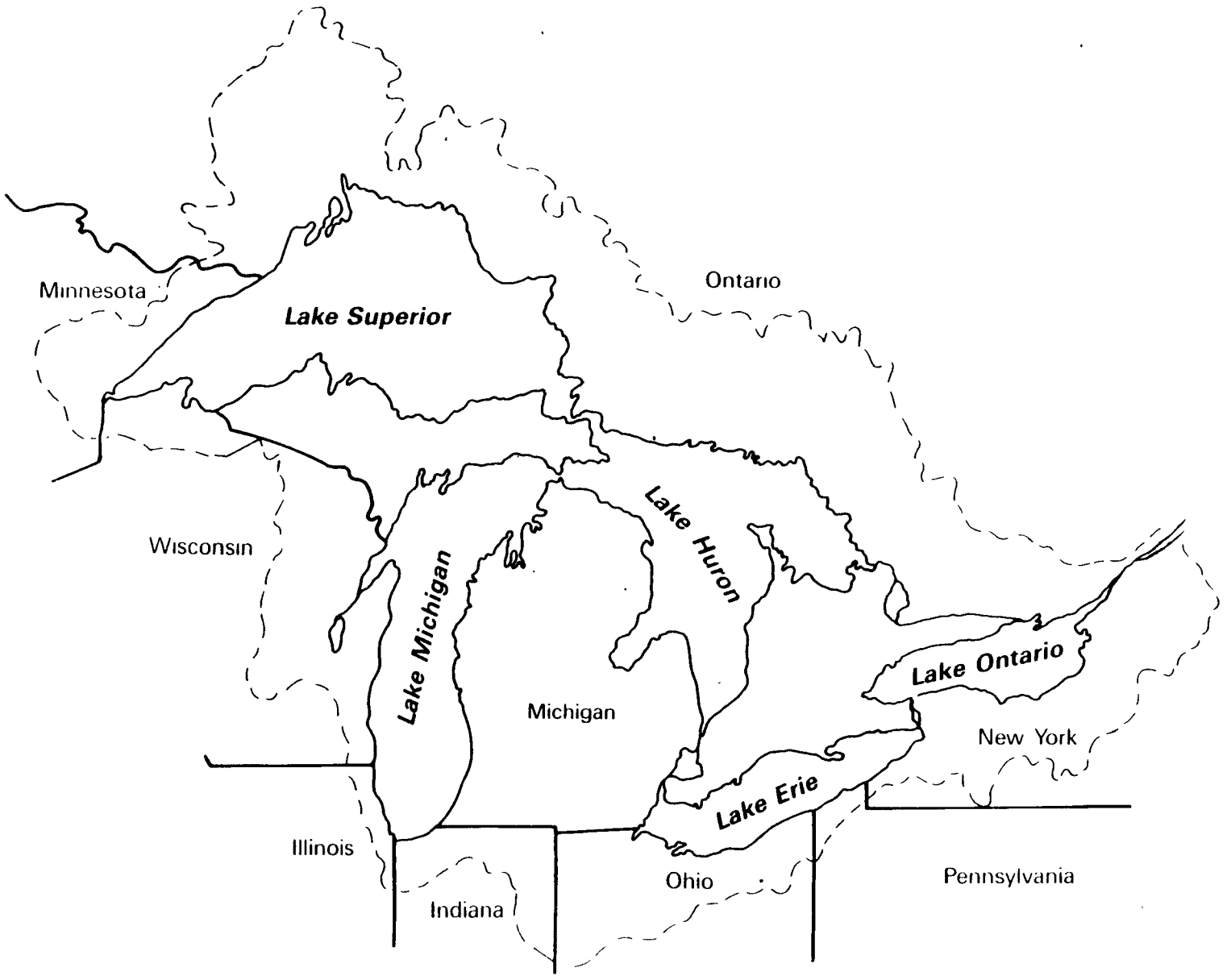


Figure 1-1. The Great Lakes Basin

Once scientific consensus was reached that the limiting nutrient for the Great Lakes is phosphorus, phosphorus reduction became the chief objective of the first GLWQA with Canada in 1972. In the same year, Congress passed the 1972 Federal Water Pollution Control Act Amendments. This legislation provides the chief vehicle for fulfilling U.S. obligations under the binational compact.

By 1980, decreased algal growth and increased dissolved oxygen levels in nearshore waters signified an improvement in water quality in most of the Great Lakes. Today, eutrophication of the open Lakes appears largely under control. However, toxic contamination is now considered a major threat to ecosystem health and human uses of the Lakes.

Some toxic substances are proving to be remarkably persistent in the Great Lakes System. This is due in part to the long retention time of the two upper Lakes, Superior and Michigan, which, on average, require 100 years or more to fully renew their water. Thus, concentrations of contaminants in the water column can remain fairly constant over a long period. Even though the lower Lakes have shorter retention times, their water is supplied by the upper Lakes. Thus, they can inherit persistent water quality problems. In addition, some contaminants can remain in the ecosystem longer by entering the food chain or attaching to sediment particles.

1.2 THE GREAT LAKES WATER QUALITY AGREEMENT

The Boundary Waters Treaty of 1909 affirmed that Canada and the United States have equal rights to the use of waterways that cross the international border and that neither country has the right to pollute its neighbor's resources. The International Joint Commission (IJC) was established as an independent body to assist the two governments under the treaty. For many years, the treaty primarily provided a process for limited regulation of water levels and flows for the purposes of navigation and power production.

The first GLWQA between the United States and Canada (the Parties), signed in 1972, called for the control of pesticides as the principal means for controlling toxic pollution. The 1978 Agreement expanded upon this policy by requiring the control of all toxic substances that could endanger the health and well-being of any living organism. The 1978 Agreement widened the geographic scope of the Parties' commitment, envisioning restoration and enhancement throughout the Great Lakes Basin, not just in the waters of the Great Lakes. The 1983 Supplement to the Agreement confirmed the phosphorus target loads and called for the preparation of phosphorus load reduction plans.

The 1987 Amendments to the GLWQA reaffirmed our national goal to "restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin ecosystem." To strengthen efforts to achieve this purpose, the Parties agreed to:

- Develop programs, practices, and technology necessary for a better understanding of the Great Lakes Basin ecosystem, and to
- Eliminate or reduce to the maximum extent practicable the discharge of pollutants into the Great Lakes system.

A major provision of the original Agreement that remains an important part of the GLWQA is the setting of specific water quality objectives. These objectives specify ambient levels of pollutants that must be attained to protect beneficial uses of the Lakes. Attainment

of these water quality objectives is the major focus for directing remedial programs in response to the GLWQA.

In addition to setting objectives, the GLWQA calls for the preparation of management plans, implementation of remedial actions to address pollution sources, and monitoring of compliance and environmental conditions. Implementation in each country depends on the integration of remedial programs into national, provincial, and State laws and policies. Responsibilities under the Agreement are shared equally by the Parties, working in cooperation with the States and Provinces.

The 1987 revisions to the GLWQA recognize the need for strengthened efforts to address the continuing contamination of the Great Lakes Basin ecosystem, particularly by persistent toxic substances. The revised Agreement acknowledges that many of these toxic substances may result in part from sources of air pollution within and beyond the Great Lakes Basin. It also recognizes that these substances may lead to polluted ground water and sediments that become potential sources of contaminant loadings to the Lakes.

The current GLWQA provides an awareness that further research and program development is imperative for effective remedial actions. Also, recognizing the need for leadership and accountability in the implementation of control measures, the roles of the two governments and the IJC are given clearer definition. For example, the Parties are called upon to provide six biennial progress reports to the IJC. The IJC is then to conduct evaluations followed by recommendations to the two countries (the Department of State, representing the United States) on the adequacy of the reported activities in satisfying the terms of the Agreement.

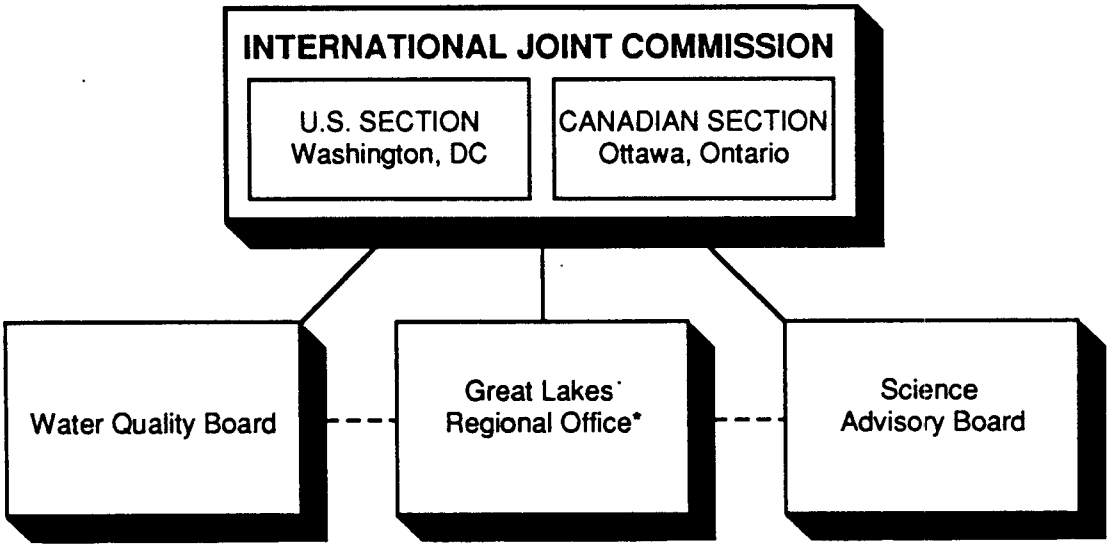
1.3 INSTITUTIONAL FRAMEWORK FOR IMPLEMENTING THE AGREEMENT

The institutional framework for implementing the GLWQA is complex, owing to the number and diversity of organizations that have important roles in the assessment, management, and protection of Great Lakes water and living resources. As described below, the IJC (or the Commission) evaluates the progress of the United States and Canada in implementing the Agreement. The IJC Water Quality Board is the Commission's principal advisor on water quality matters.

Each country has its own governmental structure to implement the Agreement. Within the United States, GLNPO leads efforts to ensure compliance with the GLWQA, working to coordinate the efforts of many Federal, State, and local institutions with operational responsibilities in the Great Lakes region. Within this framework, the eight Great Lakes States have the primary responsibility for implementing regulatory and management programs that control water quality.

1.3.1 Role of the International Joint Commission

The IJC consists of six Commissioners, three appointed by the Chief Executive of each country (Figure 1-2). The Commission addresses boundary water concerns along the international border by calling attention to problems, recommending action to the Parties, or evaluating actions of the governments under the Agreement.



Key: * Administrative and technical support

Figure 1-2. International Joint Commission and Its Advisory Groups for the Great Lakes Water Quality Agreement

The IJC has created two boards to provide advice concerning water quality within the Great Lakes Basin: the Water Quality Board and the Science Advisory Board. The purpose of the Water Quality Board is to advise the IJC about progress under the Agreement and to propose needed actions. Members serve as resource experts rather than as representatives of their agencies. U.S. members are generally drawn from State environmental management agencies, EPA, and other Federal regulatory agency staff. The USEPA's Great Lakes National Program Manager is the U.S. co-chair, serving jointly with a Canadian counterpart.

The Science Advisory Board advises both the IJC and the Water Quality Board about needed scientific research and carries out special investigations on request. Its membership is generally drawn from government and academia. Both boards are assisted by committees and task forces.

The IJC operates a binational Great Lakes Regional Office in Windsor, Ontario, that provides secretariat services to the two boards of experts called for in the Agreement. The agencies represented on the boards fund the participation of their staffs and the activities required to serve the boards. No reimbursement for services by Government agency personnel is provided by the IJC, although some travel costs are reimbursed to non-federal participants.

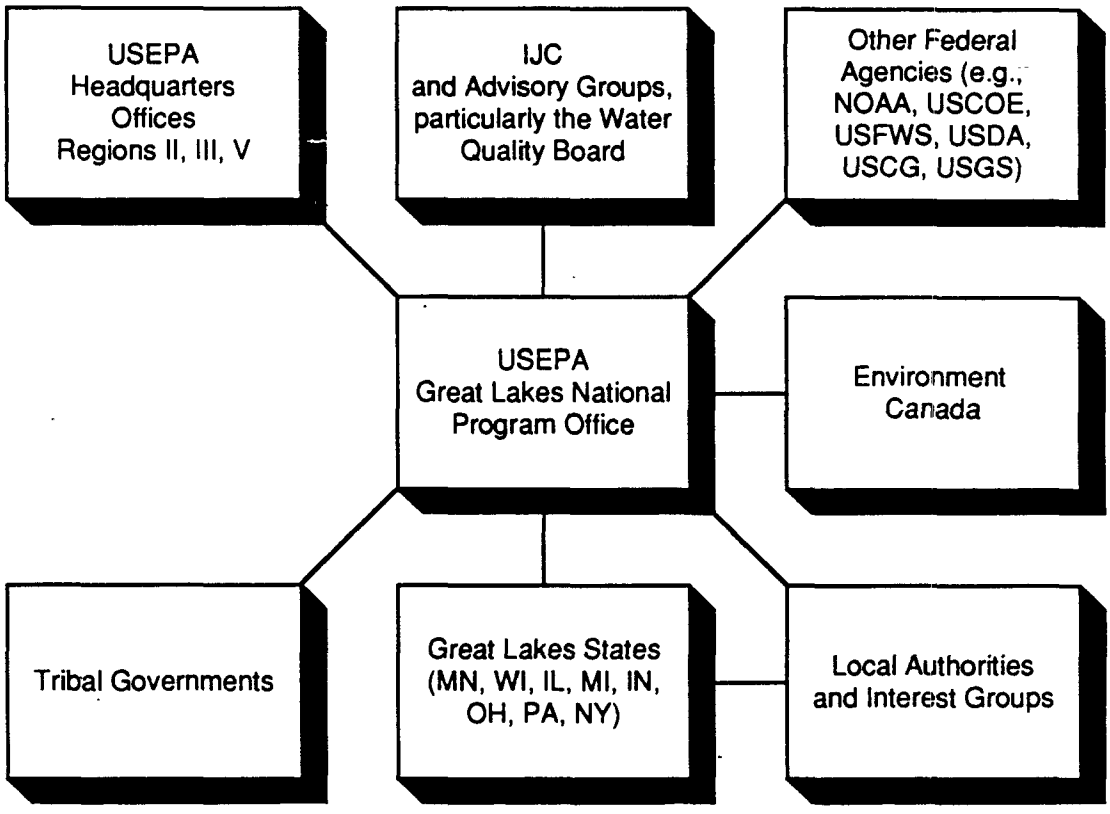
1.3.2 Role of the Great Lakes National Program Office

GLNPO has principal operational responsibility for coordinating USEPA actions aimed at improving Great Lakes water quality, including coordination with other Federal agencies, Canada, and State, Local, and tribal authorities (Figure 1-3). To this end, GLNPO works with USEPA Headquarters to ensure that Federal regulations and national policies consider the special concerns of the Great Lakes and that, at a minimum, they provide sufficient flexibility to allow facility- or site-specific permitting and other decisions made within the Great Lakes Basin to account for important priorities under the GLWQA.

GLNPO shares this interest with other geographically-based environmental programs, such as the Chesapeake Bay Program and the Puget Sound Program. GLNPO works with the Headquarter's Office of Marine and Estuarine Protection and individual estuary programs to support development of policies and programs that address the special needs of the complex ecosystems with which USEPA's geographic-based programs are concerned.

In addition to its major role of fostering cooperation among numerous and diverse institutions, GLNPO was instructed by Congress in the 1987 CWA Amendments to:

- Develop and implement specific action plans to carry out U.S. responsibilities under the Agreement;
- Establish a Great Lakes system-wide surveillance network, with emphasis on toxic pollutants;
- Develop a 5-year plan for reducing the flow of nutrients into the Great Lakes; and
- Carry out a 5-year study and a series of demonstration projects relating to the control and removal of toxic pollutants in sediments.



Key:

NOAA—National Oceanic and Atmospheric Administration
USCOE—U.S. Army Corps of Engineers
USFWS—U.S. Fish and Wildlife Service
USDA—U.S. Department of Agriculture
USCG—U.S. Coast Guard
USGS—U.S. Geological Survey

Figure 1-3. Coordination Responsibilities of the Great Lakes National Program Office

Each year, GLNPO develops a comprehensive work plan that defines its priority objectives for Great Lakes programs and describes the ways in which the Office will work at the international and national levels to ensure that environmental programs in the Great Lakes Basin uphold the principles and objectives of the GLWQA.

GLNPO's annual work plan is guided by a 5-year program plan and strategy that lays out the primary goals and directions of the Office for a 5-year period. Recently, in response to changing priorities and directions from the CWA and the 1987 Agreement with Canada, GLNPO completed a revised strategy for the period 1989 through 1993. This strategy is available on request from GLNPO.

GLNPO's accomplishments and progress in each of its major areas of responsibility are highlighted in subsequent chapters of this report.

1.3.3 Role of Other USEPA Offices

At USEPA Headquarters, program offices design and implement regulatory and other programs under each of USEPA's principal statutes. USEPA has primary or oversight authority for water pollution programs under the CWA of 1972 and the 1987 Amendments to the CWA, and the Safe Drinking Water Act (SDWA) of 1974, as amended in 1986. Other laws protecting inland, marine, and groundwater resources include the Resource Conservation and Recovery Act; the Comprehensive Environmental Response, Compensation, and Liability Act; and the Toxic Substances Control Act.

Under the mandate of the CWA, the USEPA developed regulations and programs to reduce pollutants entering all surface waters, including lakes, rivers, estuaries, oceans, and wetlands. The 1987 Amendments to the CWA ensure continued support for municipal sewage treatment plants, initiate a new State-Federal program to control nonpoint source pollution, and accelerate the imposition of tighter controls on toxic pollutants.

The SDWA requires the establishment of additional drinking water standards and protects underground sources of drinking water from underground disposal of fluids. The new amendments established two new major groundwater protection programs: the wellhead protection program and the sole-source aquifer demonstration program.

Under the Clean Air Act of 1970 (CAA), USEPA is responsible for conducting research and development programs, setting national standards and regulations, providing technical and financial assistance to the State, and where necessary, supplementing State implementation programs. USEPA is directed under the Act to set National Ambient Air Quality Standards for "criteria pollutants," pollutants commonly found throughout the country.

The CAA also requires USEPA to set National Emission Standards for Hazardous Pollutants -- those pollutants that can contribute to an increase in mortality or serious illness. These programs focus mainly on direct human exposure, however, and do not address food chain exposure to toxic substances that are atmospherically deposited and then accumulate in fish that are subsequently ingested by humans.

At the regional level within USEPA, line divisions implement each of USEPA's media programs (i.e., surface water, ground water, drinking water, air, hazardous waste, Superfund, toxic substances, and pesticides). Regional staff develop permit conditions for surface water discharges, air emissions, and hazardous waste management; review, evaluate, and select

remedial alternatives for Superfund sites; plan and implement compliance inspections; and develop and execute enforcement cases. GLNPO works with program staff in Regions II, III, and V to assist with these activities to ensure that important site-specific decisions uphold the provisions of the GLWQA to the maximum extent possible.

Regional line divisions also assist State programs with planning and implementing Federal programs that have been delegated to the States. Each year, USEPA Headquarters develops Agency Operating Guidance to communicate overall program priorities and objectives to Headquarters, regional, and State Staff. At the regional level, USEPA program offices develop Operating Guidance for State programs in order to communicate USEPA's priorities and objectives for the coming year. GLNPO works to ensure that Great Lakes priorities are accurately reflected in Agency Operating Guidance and annual State Program Plans.

Finally, to conduct research and analysis for the Great Lakes, USEPA's Office of Research and Development maintains two laboratories in Duluth, Minnesota, and Grosse Ile, Michigan.

1.3.4 Role of Other Federal Agencies

Numerous other Federal agencies have responsibilities that relate, directly or indirectly, to the achievement of GLWQA objectives. Federal agencies with major roles include the following.

National Oceanic and Atmospheric Administration (NOAA)

NOAA conducts interdisciplinary environmental research, through grant-funded Sea Grant program in the Great Lakes States and through its Great Lakes Environmental Research Laboratory in Ann Arbor, Michigan. Areas of study include lake hydraulics, synthesis of organic chemical and particle dynamics, physical limnology/meteorology, ecosystem nutrient dynamics, and ecosystem studies. Other key contributions include research conducted under the National Marine Fisheries Service, and weather and climate monitoring undertaken by the National Weather Service.

In addition, NOAA administers the Coastal Zone Management Program, through which four Great Lakes States currently fund Federally-approved programs to comprehensively manage their coastal resources, including regulations for wetlands and coastal development, protection of special areas, and other coastal activities that affect Great Lakes resources.

U.S. Army Corps of Engineers (COE)

The COE is vested with the authority to maintain navigable waterways and to issue permits for the transportation of dredged material for ocean dumping and for the discharge of dredged or fill material into the waters of the United States, including the Great Lakes. As the Federal organization that administers the dredge and fill permit programs in the Lakes, the COE programs are critical to the maintenance of water quality.

The Corps receives over 10,000 permit applications annually. Therefore, COE estuarine-related research primarily concerns the identification of solutions for dredged material disposal. Some of these efforts include determining the bio-magnification and bio-accumulation of contaminants in the estuarine environment, and developing guidelines for disposal of highly contaminated sediments.

U.S. Fish and Wildlife Service (FWS)

The FWS has general responsibility for maintaining the fish and wildlife resources in the United States and for providing public access to these resources. Its functions include responsibility for fish and wildlife resources and habitats of national interest through research, management, and technical assistance to other Federal and non-governmental agencies.

Major FWS activities and programs in the Great Lakes Basin include permit review and resource planning; land acquisition and habitat management (through refuges and easements); management of migratory birds, anadromous fish, and endangered species; and a broad research program addressing causes and effects of habitat change and coastal contaminants. These programs provide for the collection, synthesis, and interpretation of diverse information on species, populations, and habitats that is assembled, analyzed, and applied for management purposes.

The FWS also conducts periodic national inventories of wetlands and waterfowl populations, and operates the National Fisheries Center - Great Lakes. The Center's goal is to assess, protect, and rehabilitate fish resources and habitats in the Great Lakes.

U.S. Department of Agriculture (USDA)

Several offices within the U.S. Department of Agriculture are actively involved in activities that relate to Great Lakes water quality. The three agencies most directly involved all provide direct assistance to farmers: the Cooperative Extension Service, which provides information and education; the Agricultural Stabilization and Conservation Service (ASCS), which provides financial assistance, and the Soil Conservation Service (SCS), which provides technical assistance.

The SCS mission covers three major areas: soil and water conservation, natural resources surveys, and community resource protection and development. Through its nationwide network of conservation specialists, the SCS provides technical assistance to farmers, ranchers, and foresters on methods to control erosion and sedimentation through best management practices, and to control nonpoint sources of water pollution. The SCS maintains extensive data archives on wind and water erosion, land use and cover, conservation practices, and treatment needs. To assist land owners in protecting natural resources, the USDA also administers cost sharing programs that offer special assistance for installing certain conservation practices, protecting wetlands, and improving water quality.

Because of its close ties to landowners and an established delivery system for agricultural programs, USDA's role in planning and implementing activities identified in Section 319 State Water Management Plans continues to grow. As part of this increased activity, SCS water quality coordinators have been detailed to a number of State water quality agencies to assist in developing 319 plans, and SCS employees have also been assigned to EPA regional offices to further assist with coordination.

U.S. Coast Guard (USCG)

An important role of the U.S. Coast Guard in the Great Lakes is to respond to spills, encourge spill prevention, control shipping, enforce the prohibition of discharging of ship's waste into the lakes, and enforce the laws regarding the handling and transfer of hazardous substances and oil on the Lakes.

U.S. Geological Survey (USGS)

The USGS conducts a national program of water resources investigations, which includes flow and water quality monitoring of Great Lakes tributaries and a range of special studies on surface water and ground water. The USGS also works with the States, through its Federal-State Cooperative Program, to perform special studies of national and State interest. The USGS serves an important role in providing technical leadership on major issues, such as the effects of contaminated ground water on Great Lakes surface water quality.

1.3.5 Role of the States

In the area of water quality, the States have the primary responsibility for managing and protecting water resources, except on Native American lands, where tribal governments have primary responsibility. The eight Great Lakes States implement most of the water quality management and protection programs under the CWA and SDWA. In general, State programs must meet or exceed minimum standards established at the Federal level. The States report regularly to the USEPA and to Congress on the development and implementation of water quality management plans and on their progress in restoring and maintaining water quality.

2. ENVIRONMENTAL QUALITY OBJECTIVES UNDER THE AGREEMENT

Through the Great Lakes Water Quality Agreement (GLWQA), the United States and Canada have jointly established objectives that will guide their efforts to restore and enhance water quality in the Great Lakes System. Acknowledging the institutional complexity of their water quality management systems, both countries made commitments to achieve the objectives and to work toward achieving consistency between national objectives and those set by the States and Provinces.

The objectives of the original GLWQA were general, mainly addressing the issue of conventional pollutants in the Great Lakes system. The intent was to reduce sewage and industrial discharges that were largely responsible for the obvious degradation of some of the Lakes. In 1978, the GLWQA added more specific and more quantitative objectives for 41 physical, chemical, and biological parameters. It was recognized that objectives needed to account for the special problem of persistent toxic substances, especially those that are easily transferable from one medium to another (e.g., contaminants in sediments, which can re-enter the water column under certain chemical or physical conditions).

The 1978 GLWQA also added a focus on phosphorus load reduction, reflecting an improved understanding of the process of lake eutrophication. Target phosphorus loading rates for each basin, key bays, and channels were set. Further target reductions in these loading rates were set in 1983. (The phosphorus reduction initiative is discussed in Chapter 4.)

The 1987 Amendments to the Agreement introduced a number of new ideas for directing future water quality management efforts. An awareness of the increasing number of toxic substances found in the Great Lakes, as well as the rapid development rate of new chemicals in both the United States and Canada, led to a more cautionary approach to establishing new objectives. This approach requires the identification of "potentially" toxic substances, as well as those toxic substances that have the "potential" for being discharged into the Great Lakes System. It also envisions the review and modification of GLWQA objectives as necessary, at least once every 2 years.

Perhaps the most important addition to the GLWQA objectives in 1987 was the inclusion of Ecosystem Objectives. These Objectives are intended to represent the cumulative goals of limiting various physical, chemical, and biological parameters. Environmental Objectives allow water quality managers to better account for multimedia toxic pollutant problems, as well as the combined effects of multiple pollutants, since they address the ultimate effect of contaminants on the Great Lakes System. Once the causes of a problem can be determined, even if it represents the cumulative effects of multiple pollutants or multiple sources, the problem can be addressed using the full range of available regulatory and other environmental measures.

2.1 GENERAL OBJECTIVES

The general water quality management objectives of the GLWQA reflect earlier concerns with the problem of conventional pollutants contained in sewage and industrial discharges. Despite this orientation, the general objectives contain key references (e.g., beneficial uses, freedom from toxic conditions) that form a foundation for subsequent specific and ecosystem objectives. As described in Article III of the GLWQA, it was agreed that the waters of the Great Lakes should be free from:

- Substances that directly or indirectly enter the waters as a result of human activity and that will settle to form putrescent or otherwise objectionable sludge deposits, or that will adversely affect aquatic life or waterfowl;

- Floating materials such as debris, oil, scum, and other immiscible substances resulting from human activities in amounts that are unsightly or deleterious;

- Materials and heat directly or indirectly entering the water as a result of human activity that alone, or in combination with other materials, will produce color, odor, taste, or other conditions in such a degree as to interfere with beneficial uses;

- Materials and heat directly or indirectly entering the water as a result of human activity that alone, or in combination with other materials, will produce conditions that are toxic or harmful to human, animal, or aquatic life; and

- Nutrients directly or indirectly entering the waters as a result of human activity in amounts that create growths of aquatic life that interfere with beneficial uses.

2.2 SPECIFIC WATER QUALITY OBJECTIVES

The United States and Canada also have adopted a set of specific objectives intended to represent the minimum levels of water quality desired in the boundary waters of the Great Lakes System. Specific Objectives were developed as Annex 1 of the GLWQA to establish minimum acceptable conditions, and were expanded in 1978 to include a total of 41 chemical, physical, microbiological, or radiological parameters (Table 2-1).

The chemical parameters included in this list are organized according to three categories: persistent toxic substances, non-persistent toxic substances, and other substances. Objectives for persistent toxic substances include those for selected pesticides, metals, and other organic and inorganic substances known to be present in the Lakes and to have adverse toxic effects on human health, wildlife, or aquatic life. Objectives for persistent organic toxic substances are expressed as concentration limits for ambient water, fish tissue, or both.

Table 2-1. Specific Water Quality Objectives Under the Great Lakes Water Quality Agreement

Chemical	Persistent Toxic Substances	Organic	Pesticides	Substance	In Water	In Fish
				Aldrin/Dieldrin	0.001 µg/l (sum)	0.3 µg/g wet
				Chlordane	0.06 µg/l	
				DDT and metabolites	0.003 µg/l (sum)	1 0 µg/g wet
				Heptachlor/Heptachlor epoxide	0.001 µg/l (sum)	0.3 µg/g wet
				Lindane	0.01 µg/l	0.3 µg/g wet
				Methoxychlor	0.04 µg/l	
				Mirex	<detection	<detection
				Toxaphene	0.008 µg/l	
			Other Compounds	Dibutyl phthalate	4.0 µg/l	
				Di (2-Ethylhexyl) phthalate	0.6 µg/l	
				Other Phthalate esters	0.2 µg/l	
				Polychlorinated biphenyls		0.1 µg/g wet
				Unspecified Organic Compounds	<detection	<detection
		Inorganic	Metals	Mercury	0.2 µg/l	0.5 µg/g
				Arsenic	50 µg/l	
				Cadmium	0.2 µg/l	
				Chromium	50 µg/l	
				Copper	5 µg/l	
				Iron	300 µg/l	
				Lead	10 µg/l Lake Superior	
					20 µg/l Lake Huron	
					25 µg/l Other lakes	
				Nickel	25 µg/l	
				Selenium	10 µg/l	
				Zinc	30 µg/l	
			Other Inorganic Substances	Fluoride	1200 µg/l	
				Total Disolved Solids	200 µg/l Erie, Ontario, International Section of St. Lawrence River Detroit and Niagara Rivers, levels not to cause exceedence of objective for Lake Ontario	
	Nonpersistent Toxic Substances	Organic	Pesticides	Diazinon	0.8 µg/l	
				Guthion	0.005 µg/l	
				Parathion	0.008 µg/l	
				Other Pesticides	0.05 of 96-hr. LC50 on sensitive local species	
			Other Substances	Unspecified Compounds	0.05 of 96-hr. LC50 on sensitive local species	
				Oil and Petrochemicals	No sheen, no odor, no tainting, no shoreline deposits	
		Inorganic		Ammonia	20 µg/l (aquatic life) 500 µg/l (drinking water)	
				Hydrogen Sulfide	2 µg/l	
	Other Substances			Dissolved Oxygen	6 mg/l and not less than necessary to support cold water fish	
				pH	Between 6.5 and 9.0; discharge at boundary of limited use zone not > 0.5 units from ambient	
				Nutrients	Low enough to prevent nuisance growth of algae, weeds, and slimes	
				Tainting Substances	Raw public water supply sources essentially free of objectionable tastes and odors Levels of phenolic compounds <1.0 mg/l Other substances shall not affect the acceptabilty of edible organisms as determined by organoleptic tests	
Physical				Asbestos	Lowest possible level; adequate to prevent harmful effects on human health	
				Temperature	No change that would adversely affect any local or general use of the waters	
Microbiological					Substantially free from bacteria, fungi, or viruses that may produce enteric disorders, skin infections, or other human diseases and infections	
Radiological					TED50 from drinking 2 2 l lake water per day for 1 year shall not exceed 1 millirem to the whole body	

Chemical limits are set for three non-persistent pesticides (diazinon, guthion, and parathion) and two inorganic substances (ammonia and hydrogen sulfide). All other nonpersistent chemicals and complex effluents have objectives set in terms of their toxicity to sensitive local species. Objectives for oil and petroleum hydrocarbons also specify that these substances shall not cause sheens on the water, odors, tainting of fish, or deposits on the shoreline.

Other substances for which objectives have been set include dissolved oxygen, pH, nutrients, and tainting substances. The levels for all of these objectives are shown in Table 2-1.

2.3 ECOSYSTEM OBJECTIVES

The 1987 revisions of the GLWQA call for the development of Ecosystem Objectives for boundary waters of the Great Lakes System, or portions thereof, and for Lake Michigan. The agreement on Ecosystem Objectives includes the following commitments:

- Lake Superior should be maintained as a balanced and stable oligotrophic ecosystem with lake trout as the top aquatic predator of a cold-water community and the Pontoporeia hoyi as a key organism in the food chain.
- Ecosystem Objectives shall be developed for each of the Great Lakes as the state of knowledge permits.

Annex 11 of the GLWQA introduces the concept of ecosystem health indicators for use in measuring attainment of Ecosystem Objectives. For example, the indicator for lake trout in Lake Superior is described in terms of productivity greater than 0.38 kilograms/hectare; stable, self-producing stocks; and freedom from contaminants at concentrations that adversely affect the trout themselves or the quality of the harvested products.

Subsequent Ecosystem Objectives could take a number of forms, as there are many possible indicators of ecological condition, including biological diversity, stability, and productivity. Objectives may be developed to describe a general condition, the status of particular populations, or the relationships among the members of the biological community.

Ecosystem Objectives offer the advantage of collectively representing chemical, physical, and biological conditions. Therefore, they are better able to account for the cumulative or synergistic effects of multiple contaminants, multiple pollutant sources, and multiple pathways of exposure to toxic substances. Thus, the Ecosystem Objectives and indicators are potentially a better measure of attainment of the Agreement's broad goals.

2.4 PROCESS FOR PERIODIC REVISION OF OBJECTIVES

A 1987 supplement to Annex 1 outlines a process for the periodic review of existing objectives and the establishment of new objectives. The United States and Canada, working with the States and the Provinces, have agreed to consult at least once every two years to modify Specific Objectives and establish action

levels for persistent toxic substances. The Agreement also stipulates that the public will be involved in the development and adoption of objectives.

Information is continually being developed on the identity and toxicity of additional substances for which objectives may be appropriate. As this information is developed, it will be used to refine existing objectives, or establish new ones.

To assist in the review process, the United States and Canada are required to compile and maintain lists of substances for which objectives may be needed. These lists will identify all substances that are present or have the potential to be present within the water, sediment, or aquatic biota of the Great Lakes System and are believed, alone or when combined with another substance, to have toxic effects on aquatic, animal, or human life.

The development of new objectives requires that the effects of a substance on aquatic life, wildlife, and human health be considered. Once these effects are known, the level of the objective can be set for the use that is most sensitive or requires the greatest protection. Individual levels can be set for contaminant concentrations in various media. For example, the Specific Objective for DDT in the water column has been set to protect aquatic life, while the DDT objective for fish tissue is set to protect fish-eating birds (the animals most affected by the DDT concentrations in fish). Other levels are set to protect human consumers of fish.

3. STATE OF THE GREAT LAKES

Marking progress in attaining the objectives of the Great Lakes Water Quality Agreement (GLWQA) is a primary role of the Water Quality Board of the International Joint Commission (IJC). In its 1987 Report to the IJC, the Board offered mixed reviews, citing major strides in the reduction of phosphorus concentrations, but serious problems related to lakewide levels of certain persistent toxic substances and localized problems of sediment and water contamination.

The water quality of the Great Lakes has improved in many ways over the past two decades. The premature aging of the Lakes through the process of eutrophication has been slowed by reducing the volume of organic material and nutrients, especially phosphorus, that enters the system. Progress has also been made in reducing the levels of some toxic contaminants, including mercury and a number of pesticide compounds. However, the levels of some of the pollutants of early concern, including phosphorus, polychlorinated biphenyls (PCBs), dieldrin, and DDT, persist above acceptable levels in some areas. Moreover, a new cast of more than 300 other pollutants of concern has now been identified within the Great Lakes System. Concerted efforts are being made to understand the sources of these pollutants and their behavior in the environment, as well as the range of possible threats they may pose to human health.

Substantial reductions (over 80 percent from point sources) of nutrient loads to the Great Lakes during the 1970s and early 1980s have resulted in significant improvements of the Lakes from their more eutrophic status to their more natural meso- or oligotrophic status. The natural composition of algae and zooplankton has started to return.

Improvements have also been attained for some persistent toxic substances. Between 1969 and 1972, Federal legislation was enacted to restrict or ban the use of dieldrin, heptachlor, DDT, PCB, mercury, and mirex within the Great Lakes Basin. In nearly all Lakes, PCB concentrations in lake trout decreased during the late 1970s. This trend did not continue substantially, however; current concentrations in lake trout still remain above the Agreement objective in all the Great Lakes. PCB concentrations in forage fish remain at or below the objective level in all Lakes except Lake Michigan, where concentrations in bloater chub exceed the objective.

In the late 1970s, DDT concentrations also declined substantially in all Lakes but Lake Huron. DDT levels apparently have stopped declining, however. One possible explanation for the continuing presence of banned pesticides in the Great Lakes System is that these substances are being atmospherically transported from countries where they are still in use. This thesis is supported by the continuing presence of unweathered forms of such pesticides.

Despite improvements, the Water Quality Board has identified 42 Areas of Concern (AOCs) within the Great Lakes that exceed established GLWQA objectives and exhibit impaired beneficial uses. The Water Quality Board has also identified 362 chemicals of concern within the Great Lakes ecosystem, some of which are particularly persistent. In total, about 30,000 chemical compounds are used within the Great Lakes Basin and may be present in the system. An additional 1,000 new chemicals are developed each year within the United States, suggesting that the potential list of toxic contaminants in the Lakes is increasing over time.

3.1 LAKE SUPERIOR

Lake Superior, the largest (82,100 km^2) and deepest (maximum depth of 407 m and mean depth of 149 m) of the Lakes, has remained the most pristine and oligotrophic system. Concentrations of nutrients and major ions in the open waters of Lake Superior have consistently met Agreement objectives (Table 3-1). Species composition of phytoplankton and zooplankton communities are typical of waters that are naturally low in nutrients. Results of surveys conducted since 1968 indicate that phosphorus concentrations have remained around 3.5 micrograms/liter, the lowest level for any of the Great Lakes and well within GLWQA objectives.

However, concentrations of PCBs in lake trout in Lake Superior continue to exceed the Agreement objective (0.1 mg/kg in whole fish), while the DDT, dieldrin, and mercury objectives (1.0 mg/kg, 0.3 mg/kg, and 0.5 mg/kg, respectively, in whole fish) are being met. Although lower concentrations of DDT and dieldrin have been observed in lake trout since 1982-1983, PCB concentrations appear to be fluctuating, with no discernible trend.

Public health fish consumption advisories have been issued for lake trout taken from Lake Superior waters, recommending restricted consumption of fish up to 30 inches and no consumption of fish greater than 30 inches.

In addition, the Water Quality Board has identified seven AOCs in Lake Superior, where GLWQA objectives are not being met (Figure 3-1). The following three AOCs are located within the United States:

- St. Louis River/Bay - Bay sediments are moderately to heavily polluted with arsenic, chromium, and copper. Some localized areas of sediment are also contaminated by lead and mercury. The macrobenthic community is typical of polluted sediment environments. Public health advisories recommend restricted consumption of large northern pike, carp, white sucker, and walleye.

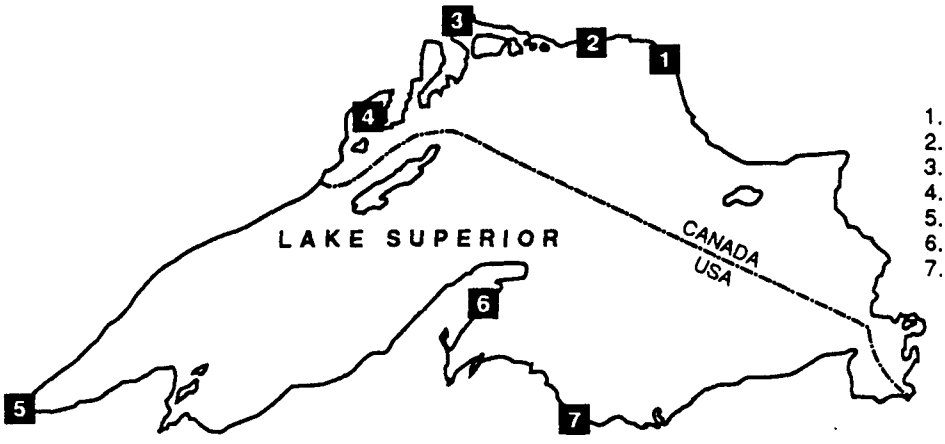
- Torch Lake - Copper levels are six to nine times higher than the GLWQA objective. Sediments are also contaminated by copper. The macroinvertebrate community is sparse. Walleye and sauger exhibit several types of tumors. State health advisories recommend no consumption of all sizes of walleye and sauger.

- Deer Lake, Carp Creek, Carp River - Sediments and fish are contaminated by mercury. No bald eagle offspring have been produced from nesting areas. Health advisories restrict consumption of all species of fish.

3.2 LAKE MICHIGAN

Lake Michigan, which lies completely within the United States, is the second largest Lake in terms of volume and depth, but the third in terms of surface area (57,800 km^2). Nutrient concentrations in Lake Michigan are generally higher than those in Lake Superior, placing the Lake in the oligotrophic to mesotrophic classification. This condition is reflected by the phytoplankton community. Open-water phytoplankton species composition and biomass are dominated by diatoms. Species associated with eutrophic waters are not common in the open waters of the Lake, but are present in the Green Bay region. The zooplankton community structure is indicative of oligotrophic conditions.

Figure 3-1. Areas of Concern within Lake Superior



1. Penninsula Harbor
2. Jackfish Bay
3. Nipigon Bay
4. Thunder Bay
5. St. Louis River
6. Torch Lake
7. Deer Lake

Table 3-1. Water Quality Conditions in Lake Superior Compared to Great Lakes Water Quality Agreement Objectives

Parameter	Objective in Water micrograms/L	Objective in Fish mg/kg	Lake Superior* Water micrograms/L	Lake Superior* Fish mg/kg
Aldrin/Dieldrin	0.001	0.3		0.05
Arsenic	50		0.52	
Cadmium	0.2		0.027	
Chlordane	0.06			0.02
Chromium	50		0.091	
Copper	5		0.89	
DDT/TDE	0.003	1	0.0002	0.3
Diazinon	0.08			
Dibutyl phthalate	4			
DEHP	0.6			
Endrin	0.002	0.3		T
Fluoride	1200			
Guthion	0.005			
Heptachlor/Heptachlor Epoxide	0.001	0.3		T
Iron	300		2.5	
Lead	25		0.029	
Lindane (- BHC)	0.01			ND
Mercury	0.2 (filtered)	0.5	0.002	
Methoxychlor	0.04			
Mirex	Less than DL		ND	ND
Nickel	25		0.58	
Other Phthalates	0.2			
Parathion	0.008		NM	NM
PCBs		0.1	0.0006	0.5
Phenols	1			
Selenium	10		0.12	
Toxaphene	0.008	5		5
Zinc	30		0.39	
Phosphorus	5		4	

* Values obtained from the draft Appendix B to the Water Quality Board Report to the International Joint Commission and staff at the USEPA Great Lakes National Program Office.

Public Health Fish Consumption Advisory
Lake Superior
(Applies to Michigan, Wisconsin, and Minnesota waters)

Restrict Consumption[1]	**Do Not Eat***
Lake trout up to 30", Walleye up to 26" (Wisconsin waters).	Lake trout over 30", Walleye over 26" (Wisconsin waters).

1 Also applies to tributaries into which migratory species enter

* Nursing mothers, pregnant women, women who anticipate bearing children, and children age 15 and under should not eat the fish listed in any of the categories listed above.

Phosphorus loading estimates for Lake Michigan were fairly stable between 1976 and 1980. Since 1981, estimated total phosphorus loadings to Lake Michigan have remained under the GLWQA target loading value of 5,600 metric tons/year.

PCB and DDT concentrations appear to be gradually declining in Lake Michigan lake trout, but still remain above the Agreement objectives (0.1 mg/kg and 1.0 mg/kg, respectively, in whole fish) (Table 3-2). PCB concentrations are about 40 times the objective; DDT about 2 times. Dieldrin concentrations have fluctuated over recent years, but remain near the Agreement objective level (0.3 mg/kg in whole fish).

Public health fish consumption advisories have been issued for lake trout, salmon, and brown trout taken from Lake Michigan waters, recommending restricted consumption of fish beyond specified sizes. In addition, the public has been advised not to eat any carp or catfish, or very large lake trout, chinook salmon, or brown trout.

The Water Quality Board has identified the following 10 AOCs in Lake Michigan, indicating local non-compliance with GLWQA objectives (Figure 3-2):

- Manistique River - The lower river and harbor have elevated levels of lead and PCBs. Harbor sediments contain cadmium, lead, PCBs, and zinc. Benthos in the area is dominated by pollution-tolerant species. A fish consumption advisory is in place for all carp.

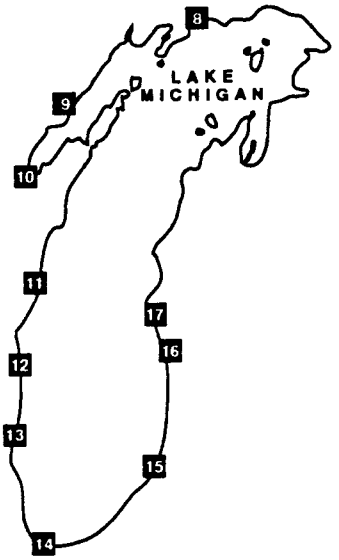
- Menominee River - Water in the lower river is contaminated with arsenic. Sediments are moderately to heavily contaminated by arsenic, mercury, and PCBs. A low frequency of tumors has been found in local fish, and river water has been found to be toxic to certain aquatic invertebrate larvae. A fish consumption advisory is in place for lake trout, chinook salmon, brown trout, carp, and catfish.

- Fox River and Southern Green Bay - Over 100 toxic substances, including 37 priority pollutants and 11 different resins and fatty acids, have been identified in discharges to the lower Fox River. Sediments in the lower river were heavily polluted with lead, mercury, oil and grease, PCBs, zinc, and DDT. A high frequency of tumors has been detected in some fish. Fish consumption is restricted for 10 species in the area. Reproductive impairments of cormorants and abnormal thyroids in herring gulls have been found. Bacteria densities periodically exceed Wisconsin limits for "full body contact." High phosphorus levels are responsible for eutrophic conditions in the lower bay.

- Sheboygan - Very high PCB levels have been found in the water column and the sediment. Pollution-tolerant species dominate the benthos and periphyton. Consumption of salmon and trout is restricted.

- Milwaukee Harbor - Residual open water pollution and heavy sediment contamination by cadmium, chromium, copper, lead, oil and grease, PCBs, and zinc exists. Chlordane and DDT are also present. Benthos and phytoplankton are dominated by pollution-tolerant organisms. Bacterial counts increase at area beaches after heavy rainfalls. High phosphorus loadings have contributed to eutrophic conditions. Fish consumption advisories are in place for northern pike. Consumption of small mouth bass, perch, redhorse sucker, and rock bass is also restricted.

Figure 3-2. Areas of Concern within Lake Michigan



8. Manistique River
9. Menominee River
10. Fox River and Southern Green Bay
11. Sheboygan
12. Milwaukee Estuary
13. Waukegan Harbor
14. Grand Calumet River and Indiana Harbor Ship Canal
15. Kalamazoo River
16. Muskegon Lake
17. White Lake, Montague

Table 3-2. Water Quality Conditions in Lake Michigan Compared to Great Lakes Water Quality Agreement Objectives

Parameter	Objective in Water micrograms/L	Objective in Fish mg/kg	Lake Michigan* Water micrograms/L	Lake Michigan* Fish mg/kg
Aldrin/Dieldrin	0.001	0.3		0.3
Arsenic	50		0.69	
Cadmium	0.2		0.044	
Chlordane	0.06			0.1
Chromium	50		0.68	
Copper	5		0.39	
DDT/TDE	0.003	1	0.0002	3
Diazinon	0.08			
Dibutyl phthalate	4			
DEHP	0.6			
Endrin	0.002	0.3		T
Fluoride	1200			
Guthion	0.005			
Heptachlor/Heptachlor Epoxide	0.001	0.3		T
Iron	300		75	
Lead	25		0.25	
Lindane (- BHC)	0.01			ND
Mercury	0.2 (filtered)	0.5	0.045	
Methoxychlor	0.04			
Mirex	Less than DL		ND	ND
Nickel	25		0.6	
Other Phthalates	0.2			
Parathion	0.008		NM	NM
PCBs		0.1	0.002	5
Phenols	1			
Selenium	10		2.7	
Toxaphene	0.008	5		2
Zinc	30		0.59	
Phosphorus	7		5.5	

* Values obtained from the draft Appendix B to the Water Quality Board Report to the International Joint Commission and staff at the USEPA Great Lakes National Program Office.

Public Health Fish Consumption Advisory Lake Michigan (Applies to Michigan, Illinois, Indiana, and Wisconsin waters)	
Restrict Consumption[1] Lake trout 20-23", Coho salmon over 26", Chinook salmon 21-32", Brown trout up to 23".	**Do Not Eat*** Lake trout over 23", Chinook over 32", Brown trout over 23", Carp, and Catfish.

1 Also applies to tributaries into which migratory species enter
* Nursing mothers, pregnant women, women who anticipate bearing children, and children age 15 and under should not eat the fish listed in any of the categories listed above.

- Waukegan Harbor - Very high PCB levels have been detected in water and sediment. There are indications of bioaccumulation of PCBs in local organisms. A fish advisory recommends against consumption of all species in the area.

- Grand Calumet River and Indiana Harbor Canal - GLWQA objectives have been exceeded for copper, lead, selenium, iron, zinc, ammonia, and phenolics. Sediments also are highly contaminated with chromium, lead, oil and grease, PCBs, and zinc. Some fish tumors and a high incidence of fin rot were found. A fish advisory recommends against consumption of all species in the area. Fecal coliforms and phosphorus levels exceed standards.

- Kalamazoo River - High PCB levels have been found in the water column and sediment. Elevated phosphorus levels are found downstream of Kalamazoo. Consumption of all fish species is restricted with no consumption of carp, suckers, catfish, and largemouth bass.

- Muskegon Lake - Some shoreline sediments are contaminated with cadmium, chromium, copper, lead, mercury, zinc, and pyrene. Excess nutrient enrichment has resulted in algal blooms.

- White Lake - Contaminants via ground water include chloroform, trichloroethylene, carbon tetrachloride, and perchloroethylene. Sediments are contaminated with chromium, and some benthos are affected in the vicinity of the contaminated groundwater plume. Carp consumption is restricted.

3.3 LAKE HURON

Lake Huron is the second largest Great Lake in terms of surface area (59,700 km^2). Like Lake Superior, Lake Huron has a drainage basin that supports lower population densities and more forested lands than the other Great Lakes. Consequently, the quality of the open waters of Lake Huron is generally high, with levels of nutrients and major ions within GLWQA objectives.

In general, the trophic status of the open waters of the Lake has remained stable, between the status of Lake Michigan and Lake Superior. Phytoplankton and zooplankton species assemblages in the open waters are consistent with those typically encountered in oligotrophic waters. Phytoplankton species composition and biomass are dominated by diatoms. Species typical of eutrophic waters are not common, although they occur in some lake areas subject to nutrient enrichment.

Levels of total phosphorus, measured during the spring months, have been stable from 1971 through 1985 (Table 3-3). Total phosphorus concentrations in the Georgian Bay have been consistently lower than those found in Lake Huron proper. Georgian Bay area phosphorus concentrations decreased by approximately 1.5 micrograms/liter from 1980 through 1985. The highest mean total phosphorus concentrations in Lake Huron occur in Saginaw Bay (21 micrograms/liter).

Although these concentrations are substantially lower than those observed in 1978, no significant decreases in phosphorus concentrations occurred from 1980 to 1985. Estimated total phosphorus loadings for Lake Huron indicate that the annual inputs have been near the loading objective target value (4,360 tons/year) since 1976. Inputs for Saginaw Bay remain 21 metric tons above its target of 440 metric tons, however.

Concentrations of dieldrin and DDT in Lake Huron lake trout are below the Agreement objective (0.3 mg/kg and 1.0 mg/kg, respectively, in whole fish), although there appears to be no decreasing trend in concentrations since 1979. As with most of the other Great Lakes, Lake Huron's PCB concentrations in lake trout continue to exceed the objective (0.1 mg/kg in whole fish). There also does not appear to be a trend of decreasing PCB concentrations since 1979. Public health fish advisories have been issued suggesting that the consumption of lake trout, rainbow trout, and brown trout caught in Lake Huron waters be restricted.

Of the four AOCs on Lake Huron, only one has been identified within U.S. boundaries (Figure 3-3):

- Saginaw River/Saginaw Bay - Contaminants in water include primarily metals, PCBs, and phenols. Bay sediments are also contaminated with metals and PCBs. A health advisory recommends no consumption of carp and catfish. Consumption of lake trout, rainbow trout, and brown trout is also restricted. Fish-eating bird populations are affected by contaminants as shown in reproductive failure and increased incidence of cross-beak syndrome.

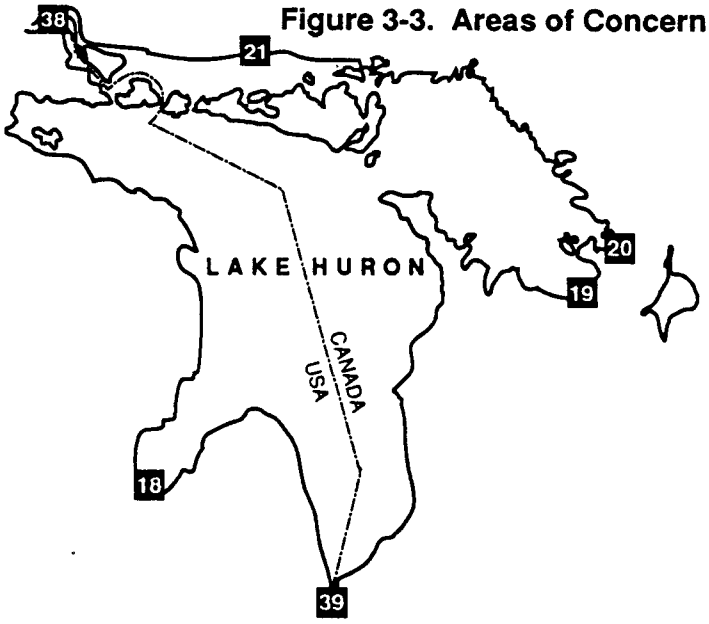
3.4 LAKE ERIE

Lake Erie is the fourth largest Great Lake in terms of surface area (25,700 km^2)and is the most shallow lake, with a mean depth of only 19 meters. It consists of three distinct basins, which differ in water quality characteristics. Its shores are highly urbanized and its major tributaries drain intensively farmed soils. Lake Erie was the first of the Lakes to show systemwide signs of cultural eutrophication, but was also quicker to respond than the other Lakes to cleanup efforts because of its relatively short retention time.

Even so, Lake Erie is characterized as a mesotrophic lake with eutrophic conditions dominating in the western and central basins. Diatoms dominate the biomass, and green algae are also an important component of the community. Zooplankton assemblages throughout the Lake are mixed, being more indicative of eutrophic conditions than oligotrophic conditions, although some oligotrophic species are present.

Data from 1985 and 1986 indicate that Lake Erie central basin mean annual total phosphorus concentrations fluctuate between 11 and 13 micrograms/liter (Table 3-4). In 1985, it was estimated that over 2,000 tons of soluble phosphorus are released annually from the central basin sediments through anoxic regeneration. In spite of these large contributions from internal processes, significant reductions in open lake total phosphorus concentrations have been documented. During the period from 1968 to 1985, total phosphorus concentrations declined at an annual rate of about 0.56 microgram/liter/year. A significant decrease in total phosphorus loadings to Lake Erie occurred during the same period, from a high of 28,000 tons/year in 1968 to the current level near 11,180 tons/year. However, the established target loading rate of 11,000 tons/year has not been achieved.

Figure 3-3. Areas of Concern within Lake Huron



18. Saginaw River System and Saginaw Bay
19. Collingwood Harbor
20. Pentang Bay to Sturgeon Bay
21. Spanish River
38. St. Mary's River
39. St. Clair River

Table 3-3. Water Quality Conditions in Lake Huron Compared to Great Lakes Water Quality Agreement Objectives

Parameter	Objective in Water micrograms/L	Objective in Fish mg/kg	Lake Huron* Water micrograms/L	Lake Huron* Fish mg/kg
Aldrin/Dieldrin	0.001	0.3	0.00037	0.1
Arsenic	50		0.21	0.4
Cadmium	0.2		0.015	
Chlordane	0.06		0.000032	0.05
Chromium	50		0.13	
Copper	5		0.4	
DDT/TDE	0.003	1	ND(0.002)	0.1
Diazinon	0.08			
Dibutyl phthalate	4			
DEHP	0.6			
Endrin	0.002	0.3	0.00005	T
Fluoride	1200			
Guthion	0.005			
Heptachlor/Heptachlor Epoxide	0.001	0.3	0.00021	T
Iron	300		4.8	
Lead	25		0.022	
Lindane (- BHC)	0.01		0.000835	T
Mercury	0.2 (filtered)	0.5	0.011	0.18
Methoxychlor	0.04		ND(0.002)	
Mirex	Less than DL		ND(0.002)	
Nickel	25		0.54	
Other Phthalates	0.2			
Parathion	0.008		NM	NM
PCBs		0.1	0.000394	2
Phenols	1			
Selenium	10		0.48	0.52
Toxaphene	0.008	5		
Zinc	30		0.29	
Phosphorus	5		4.5	

* Values obtained from the draft Appendix B to the Water Quality Board Report to the International Joint Commission and staff at the USEPA Great Lakes National Program Office

Public Health Fish Consumption Advisory Lake Huron	
Restrict Consumption[1] Lake trout, Rainbow trout, and Brown trout	**Do Not Eat*** —

1 Also applies to tributaries into which migratory species enter
* Nursing mothers, pregnant women, women who anticipate bearing children, and children age 15 and under should not eat the fish listed in any of the categories listed above.

Concentrations of DDT and dieldrin in Lake Erie remain below the Agreement objective for fish tissue concentration. PCB concentrations are elevated above the objective level, with concentrations in walleye being about five times the objective level. Both carp and catfish are the subject of public health fish consumption advisories, with restricted consumption being recommended in New York and no consumption recommended in other States bordering the Lake. The Water Quality Board has designated seven AOCs within the U.S. boundaries of Lake Erie (Figure 3-4):

- Clinton River - Sediments downstream of Red Run are contaminated with metals and oil and grease affecting benthic communities in the lower river. Fecal coliform bacteria levels exceed the objective, as does total phosphorus loading.

- Rouge River - Toxic substances in the lower river include PCBs and metals. Sediments are heavily polluted with metals. Other contaminants include dibenzofurans, HCB, PCBs, and PAHs. Health advisories recommend no consumption of carp. Fish kills occur regularly during the summer, and the benthos community reflects pollution-tolerant species. High fecal coliform levels are also a problem as a result of combined sewer overflows.

- River Raisin - Contaminants present in the water column include metals and PCBs. Sediments are contaminated with PCBs, chromium, copper, and zinc. Invertebrate populations decrease in the vicinity of Monroe Harbor. Elevated fecal coliform levels are experienced during wet weather conditions. Health advisories recommend no consumption of carp.

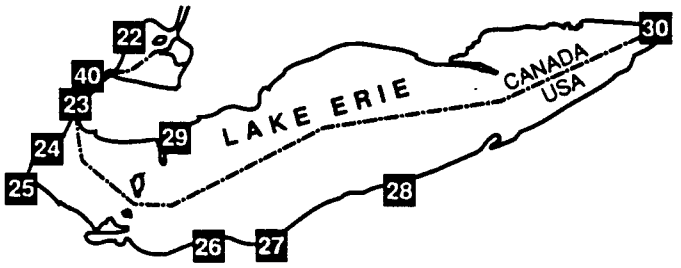
- Maumee River - Violations of Ohio water quality standards occur for ammonia, arsenic, lead, copper, zinc, cadmium, iron, and mercury. Sediments are heavily polluted with metals and were found toxic to minnows and invertebrates. PCBs have been detected in fish. Fecal coliform exceed Ohio EPA standards.

- Black River - Ohio water quality standards are violated for ammonia, iron, lead, phenol, cyanide, cadmium, copper, and zinc. Sediments are heavily polluted with oil and grease, metals, and PAHs. Benthos are severely degraded. Fecal coliform also violate Ohio standards. Health advisories recommend no consumption of all fish species.

- Cuyahoga River - Toxics in the water include cyanide, iron, copper, ammonia, phenol, lead cadmium, and zinc. Sediments are heavily polluted with metals and oil and grease, and moderately polluted with PCBs; DDT, PAHs, and phthalates. Benthos are degraded, and elevated levels of fecal coliform bacteria are common.

- Ashtabula River - Ohio water quality standards are violated for zinc, cadmium, and mercury. Sediments are heavily polluted with arsenic, cadmium, chromium, copper, lead, mercury, PCBs, and zinc. River water is acutely toxic to Daphnia. Health advisories recommend no consumption of all fish species.

Figure 3-4. Areas of Concern within Lake Erie



22. Clinton River
23. Rouge River
24. Raisin River
25. Maumee River
26. Black River
27. Cuyahoga River
28. Ashtabula River
29. Wheatley
30. Buffalo River
40. Detroit River

Table 3-4. Water Quality Conditions in Lake Erie Compared to Great Lakes Water Quality Agreement Objectives

Parameter	Objective in Water micrograms/L	Objective in Fish mg/kg	Lake Erie* Water micrograms/L	Lake Erie* Fish mg/kg
Aldrin/Dieldrin	0.001	0.3	0.000934	0.06
Arsenic	50		0.43	
Cadmium	0.2		0.72	
Chlordane	0.06		0.000084	0.05
Chromium	50		0.39	
Copper	5		1.8	
DDT/TDE	0.003	1		0.2
Diazinon	0.08			
Dibutyl phthalate	4			
DEHP	0.6			
Endrin	0.002	0.3		T
Fluoride	1200			
Guthion	0.005			
Heptachlor/Heptachlor Epoxide	0.001	0.3	0.000259	
Iron	300		100	
Lead	25		0.34	
Lindane (- BHC)	0.01		0.002148	T
Mercury	0.2 (filtered)	0.5	0.033	
Methoxychlor	0.04			
Mirex	Less than DL			ND
Nickel	25		1.1	
Other Phthalates	0.2			
Parathion	0.008		NM	NM
PCBs		0.1	0.00295	1.5
Phenols	1			
Selenium	10		2.1	
Toxaphene	0.008	5		
Zinc	30		1.2	
Phosphorus	10/15		16.6	

* Values obtained from the draft Appendix B to the Water Quality Board Report to the International Joint Commission and staff at the USEPA Great Lakes National Program Office.

Public Health Fish Consumption Advisory Lake Erie	
Restrict Consumption[1] Carp and Catfish (New York waters—eat no more than one meal per month).	**Do Not Eat*** Carp and Catfish (applies to Michigan, Ohio, and Pennsylvania waters).

1 Also applies to tributaries into which migratory species enter
* Nursing mothers, pregnant women, women who anticipate bearing children, and children age 15 and under should not eat the fish listed in any of the categories listed above.

3.5 LAKE ONTARIO

Lake Ontario is the smallest of the Great Lakes (19,520 km^2), but with a mean depth of 86 meters, is deeper than Lake Erie. Located at the end of the Great Lakes chain, Lake Ontario receives nutrients and toxic contaminants contained in the outflow of upstream systems. Because of this source and those within the drainage basin, Lake Ontario generally has high open water pollutant concentrations. Still, data on phytoplankton indicator species from the first two years of a bioindex monitoring program on Lake Ontario suggest that the rate of eutrophication has declined, changing its status from meso-eutrophic to meso-oligotrophic. These changes coincide with a decrease in phosphorus loadings. Zooplankton community structure is indicative of mesotrophic to oligotrophic conditions.

Since surface total phosphorus concentrations peaked in the Spring of 1973, all measured forms of phosphorus in Lake Ontario have declined markedly. Annual surveys conducted from 1973 to 1986 show total phosphorus decreasing significantly at an annual rate of 2.35 micrograms/liter. Spring total phosphorus levels in the offshore waters averaged 10.7 micrograms/liter in 1985 and 1986 (Table 3-5). This is consistent with a trend of declining total phosphorus loadings to Lake Ontario since 1976. Total phosphorus loading appears to be approaching the GLWQA target of 7,000 tons/year.

Lake trout in Lake Ontario contain PCB concentrations that greatly exceed the Agreement objective of 0.1 mg/kg. Even though there appears to be a slight downward trend in concentration over the last nine years, PCB levels still are ten times the Agreement objective. DDT concentrations in lake trout approach the GLWQA objective and apparently have not declined significantly in recent years. However, dieldrin concentrations in lake trout appear to be declining in Lake Ontario and are already lower than the Agreement objective of 0.3 mg/kg.

Regardless of these declines, the public has been advised not to consume more than one meal per month of white perch, coho salmon (under 21 inches), or rainbow trout (under 18 inches) from Lake Ontario. The public was also advised not to consume any of the following fish from Lake Ontario waters: American eel, channel catfish, lake trout, chinook salmon, coho salmon (over 21 inches), rainbow trout (over 18 inches), and brown trout (over 18 inches).

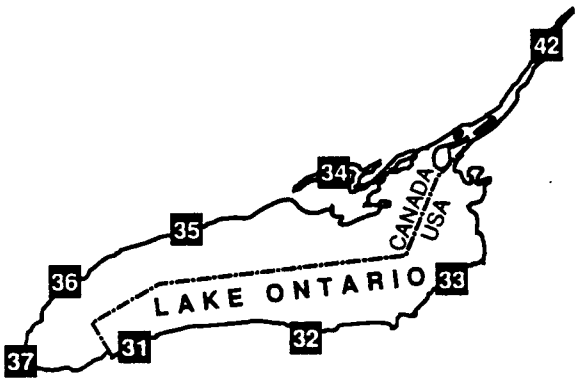
The Water Quality Advisory Board also identified four AOCs within the U.S. boundaries of Lake Ontario (Figure 3-5). These areas, which exceed GLWQA water quality objectives for at least one parameter, are as follows:

- Buffalo River - Water quality standards are exceeded for metals, dieldrin, BHC, and chlordane. River and harbor sediments are heavily polluted with iron, mercury, and oil and grease. Other contaminants include DDT, HCB, and PAHs. The macrobenthic community is dominated by pollution-tolerant species.

- Eighteenmile Creek - Trichlorofluoromethane has been found in the water. Cadmium, copper, lead, nickel, DDT, and dieldrin exceed GLWQA objectives. Sediments at the mouth are moderately to heavily polluted with chromium, copper, lead, nickel, and zinc.

- Rochester Embayment - Ammonia levels exceed the New York objective. Harbor sediments are moderately to heavily polluted with arsenic, copper, cyanide, nickel, and zinc. The macrobenthos show moderate effects of both toxic and organic pollution. Phosphorus levels remain high due to combined sewer overflows.

Figure 3-5. Areas of Concern within Lake Ontario



31. Eighteen Mile Creek
32. Rochester
33. Oswego River
34. Bay Quinte
35. Port Hope
36. Toronto
37. Hamilton Harbor
42. St. Lawrence River

Table 3-5. Water Quality Conditions in Lake Ontario Compared to Great Lakes Water Quality Agreement Objectives

Parameter	Objective in Water micrograms/L	Objective in Fish mg/kg	Lake Ontario* Water micrograms/L	Lake Ontario* Fish mg/kg
Aldrin/Dieldrin	0.001	0.3	0.000631	0.2
Arsenic	50		0.98	0.56
Cadmium	0.2		0.2	
Chlordane	0.06		0.000046	0.18
Chromium	50		1.1	
Copper	5		2.1	
DDT/TDE	0.003	1		0.5
Diazinon	0.08			
Dibutyl phthalate	4			
DEHP	0.6			
Endrin	0.002	0.3		T
Fluoride	1200			
Guthion	0.005			
Heptachlor/Heptachlor Epoxide	0.001	0.3	0.000375	T
Iron	300		19.9	
Lead	25		0.5	
Lindane (- BHC)	0.01		0.00185	ND
Mercury	0.2 (filtered)	0.5	0.01	0.14
Methoxychlor	0.04		0.000084	
Mirex	Less than DL		ND	0.14
Nickel	25		1.9	
Other Phthalates	0.2			
Parathion	0.008		NM	NM
PCBs		0.1	0.0031	5
Phenols	1			
Selenium	10		0.17	0.52
Toxaphene	0.008	5		
Zinc	30		1	9.7
Phosphorus	10		10	

* Values obtained from the draft Appendix B to the Water Quality Board Report to the International Joint Commission and staff at the USEPA Great Lakes National Program Office.

Public Health Fish Consumption Advisory Lake Ontario (New York waters)	
Restrict Consumption[1] White perch, Coho salmon up to 21". Rainbow trout up to 18" (eat no more than one meal per month).	**Do Not Eat*** American eel, Channel catfish, Lake trout, Chinook salmon, Coho salmon over 21", Rainbow trout over 25", Brown trout over 18".

1 Also applies to tributaries into which migratory species enter

* Nursing mothers, pregnant women, women who anticipate bearing children, and children age 15 and under should not eat the fish listed in any of the categories listed above.

- Oswego River - Water samples contain metals and chloroform. Ammonia levels exceed the Agreement objectives. Sediments are classified as moderately to heavily polluted with arsenic, copper, and manganese. Halophilic species dominate the diatoms populations due to high chloride levels.

3.6 THE CONNECTING CHANNELS

The Connecting Channels (i.e., St. Marys River, St. Clair River, Lake St. Clair, Detroit River, and Niagara River) are the major links between each of the Great Lakes. The St. Lawrence River is the major outflow of the Great Lakes System to the Gulf of St. Lawrence, and ultimately, the Atlantic Ocean. With the exception of Lake St. Clair, each of these channels has been designated an AOC because Agreement objectives have been exceeded and/or beneficial uses have been impaired. The specific reasons for their designation are listed below:

- St. Marys River - Elevated levels of phenols, iron, zinc, cyanide, and ammonia are found in the water. Certain sediments are contaminated with ether solubles, iron, oil and grease, PCBs, PAHs, and zinc. Benthos are impaired near Sault Ste. Marie, and bacterial counts exceed the provincial objective. Consumption of some gizzard shad is restricted. The major problems are associated with industrial sources in Sault Ste. Marie, Ontario.

- St. Clair River - Contaminants in the water include a range of organic chemicals (e.g., perchloroethylene, carbon tetrachloride, chloroform, methylene chloride). Sediment contaminants include chromium, copper, mercury, and zinc. Other contaminants include lead, PCBs, TCDD, and trace organics. Benthic communities are impaired and bacterial contamination is common due to combined sewer overflows. The major problems are associated with industrial and municipal sources in Sarnia, Ontario.

- Detroit River - In 1981, contaminants identified included phenols, iron, copper, and mercury. Sediments contain organics and metals such as benzo(a)pyrene, cadmium, DDT, HCB, mercury, and PCBs. Benthos are seriously disrupted. Fecal coliform bacteria violations occur and phosphorus levels are elevated. Consumption of some rock bass, walleye, and freshwater drum is restricted. Health advisories recommend no consumption of carp. Most of the problems are associated with discharges from the Detroit area, but some are from the Windsor, Ontario, area.

- Niagara River - Contaminants in the water include a variety of organics and metals. Sediments in excess of Ontario guidelines include arsenic, chromium, copper, lead, mercury, PCBs, and zinc. Benthos are disrupted, and toxicity is a limiting factor along the shoreline. Consumption of specific sizes of white sucker, american eel, rainbow trout, coho salmon, white perch, and lake trout is restricted. The major problems are associated with the Buffalo/Niagara Falls complex.

- St. Lawrence River - Agreement objectives were exceeded for phenols, heptachlor/heptachlor epoxide, cadmium, iron, copper, zinc, aldrin/dieldrin, and PCBs. Sediments are contaminated with metals and PCBs. Benthic populations exhibit reduced diversity and low numbers of taxa. Elevated fecal coliform levels are common in the summer. Consumption of 12 fish species are restricted. Health advisories recommend no consumption of large northern pike and walleye. The problems are associated with Massena, New York, and Cornwall, Ontario.

4. MANAGEMENT PLANS

The basic management framework of the Agreement consists of the Environmental Quality Objectives and beneficial uses discussed in Chapter 2, the monitoring of the state of the Lakes and pollutant inputs (see Chapter 7), and management plans to identify the remedial actions needed to attain the desired objectives and beneficial uses. The Agreement calls for remedial actions to occur at three geographic scales: Lakewide Management Plans (LMPs) will address Critical Pollutants that impair beneficial uses in open waters of the Lakes, Remedial Action Plans (RAPs) will address use impairments within designated Areas of Concern (AOCs), and Point Source Impact Zones adjacent to discharge points will be identified and minimized. Phosphorus Load Reduction Plans, mandated in Annex 3 in 1983, now fall within the context of LMPs. The requirements for LMPs and RAPs can be satisfied by implementating various provisions contained within the U.S. Clean Water Act (CWA), as amended in 1987.

Under Section 303 of the CWA, the States have primary responsibility for undertaking a continuous planning process for restoring and maintaining water quality. The Administrator of the U.S. Environmental Protection Agency (USEPA) must periodically review and approve these efforts. In addition to this overarching planning requirement, numerous other programs have been established to address more specific water quality management problems. These include: CWA Section 319-State Nonpoint Source Program Plans; Section 305(b)-Water Quality Inventories; Section 304(l)-State Toxic Substances Control Strategies; and State Groundwater Protection Strategies developed pursuant to the Safe Drinking Water Act Amendments of 1986.

Under Section 319, each State is required to submit a report that identifies navigable waters that are not expected to meet water quality standards, without additional nonpoint source controls. Reports required under Section 305(b) describe the overall water quality of all navigable waters in the State. During FY 1988, the USEPA and States worked to implement Section 304(l), which requires that the States identify waters that are not expected to meet water quality standards after dischargers have met current technology-based requirements. Under this Section, States were required to submit listings of nonattainment waters to USEPA by April 1, 1988. USEPA's Water Management Divisions in Regions II, III, and V are now reviewing lists submitted by the Great Lakes States. The Act also requires States to develop and submit strategies for reducing discharges of toxic substances to the listed waters and bringing water quality into compliance with applicable standards.

Implementation of Section 304(l) continues to be a priority for USEPA Regional and State water programs in FY 1989. The Great Lakes National Program Office (GLNPO) will participate with the USEPA's regional water programs in reviewing State lists and attainment strategies during FY 1989 to ensure that activities under Section 304(l) are consistent with the goals of the Great Lakes Water Quality Agreement (GLWQA). This effort will also be coordinated by GLNPO with other efforts toward reducing toxic pollution in the Great Lakes.

Section 118 of the CWA introduced new water quality management planning responsibilities that apply specifically to the Great Lakes Basin. Section 118 charges GLNPO with two management planning responsibilities: 1) in cooperation with appropriate Federal, State, tribal, and international agencies, to develop and implement specific action plans to carry out U.S. responsibilities under the GLWQA, and 2) to develop, in consultation

with the States, a five-year plan and program for reducing the amount of nutrients introduced into the Great Lakes.

USEPA is combining these planning requirements where appropriate and incorporating them within the existing water quality management framework. Requirements for the development of specific action plans under the CWA have been combined with those for RAPs and LMPs under the GLWQA. The provision calling for a five-year plan for nutrients is being met by the Phosphorus Reduction Plans. USEPA will also work to incorporate Phosphorus Load Reduction Plans, RAPs, and LMPs in State water quality management planning.

4.1 PRINCIPLES FOR REMEDIAL ACTION AND LAKEWIDE MANAGEMENT PLANS

Article IV(f) of the GLWQA states:

> The Parties recognize that there are areas in the boundary waters of the Great Lakes System where, due to human activity, one or more of the General or Specific Objectives of the Agreement are not being met. Pending virtual elimination of persistent toxic substances in the Great Lakes System, the Parties, in cooperation with State and Provincial Governments and the Commission, shall identify and work toward the elimination of: (i) Areas of Concern pursuant to Annex 2; (ii) Critical Pollutants pursuant to Annex 2; and (iii) Point Source Impact Zones pursuant to Annex 2.

This sets the stage for the action planning provisions of the Agreement that link together achievement of environmental quality objectives and remedial programs.

In Annex 2 of the GLWQA, four basic principles are given to guide the development of RAPs and LMPs. The principles state that the plans must:

- Clearly identify problems to be addressed, proposed remedial steps, and specific monitoring requirements for tracking progress in restoring beneficial uses
- Embody a comprehensive ecosystem approach
- Build on existing management plans
- Ensure that the public is consulted.

The GLWQA emphasizes that these principles are intended to lead to the attainment of long-term environmental quality goals, including the prohibition of all discharges of toxic substances, particularly those that have been shown to be persistent. In the short-term, they are intended to achieve reductions in the concentrations of toxic substances, especially in designated "Point Source Impact Zones" (areas contiguous to a point source where water quality does not meet GLWQA objectives) and AOCs.

4.2 LAKEWIDE MANAGEMENT PLANS

LMPs, described in Annex 2 of the GLWQA as an approach for reducing contaminant loadings in open lake waters, involve the same four basic principles as those for RAPs. However, LMPs differ from RAPs in the breadth of their focus, as they address entire lakes rather than the more localized AOCs. Given this scope, monitoring becomes more complex

and airborne deposition becomes a far more important factor. In addition, the selection of the appropriate mix of remedial actions and coordination among jurisdictions differ from those of the RAP process.

The Water Quality Board has developed a systematic method of identifying chemicals that should be given priority in the LMP process. This system is consistent with that enunciated in Annex 1 of the GLWQA and in Chapter 2 of this report.

Simultaneously, GLNPO has begun working with the States and EPA Regional Offices to define options regarding the prototype content and format of LMPs and to coordinate the development of specific plans. In particular, GLNPO is working with the States to relate this process to existing programs and requirements under the CWA.

LMPs will build upon the earlier experience with Phosphorus Plans and the initial lake management efforts now under way in Lakes Ontario and Michigan, described below. LMPs also will draw upon a number of recent and ongoing mass balance modeling studies, including studies of the upper Great Lakes connecting channels and Green Bay. (These studies are described in a subsequent chapter on surveillance and monitoring.)

Development of toxic control strategies for Lakes Michigan and Ontario was underway before the LMP requirement was added to the GLWQA in 1987. Both of those efforts contain major elements of the mandated LMPs. It is expected that they will continue to be developed in a manner that will fulfill the LMP provisions of the GLWQA.

The first plans to address lakewide loadings of a pollutant from all sources were the phosphorus load reduction plans called for in the 1983 Supplement to Annex 3 of the GLWQA. The central purpose of the load reduction plans is the same as envisioned in LMPs: "identification of the additional remedial measures that are needed to achieve the reduction of loadings and eliminate the contribution to impairment of beneficial uses."

4.2.1 Nutrient Management Plans

The GLWQA of 1978 set forth a general framework in Annex 3 for Canada and the United States to reduce phosphorus loadings to the Great Lakes. In 1983, a Supplement to Annex 3 was approved, delineating phosphorus loading levels of the lakes and embayments. The Supplement confirmed a belief that phosphorus loading objectives can be attained through existing programs in the Upper Lakes. However, additional actions were required to obtain target loads for Lake Erie, Saginaw Bay, and Lake Ontario. The 1987 GLWQA modified the reductions needed for Lake Ontario based on new analysis. However, the allocation of reduction requirements between the United States and Canada is not yet finalized.

The Great Lakes Phosphorus Task Force (including representatives of the States of Indiana, Michigan, New York, Ohio, and Pennsylvania) allocated Lake Erie target load reductions among each responsible State. In addition, Michigan and New York were assigned a target load reduction for Saginaw Bay and Lake Ontario, respectively. Federal agencies participating on the Task Force were the Soil Conservation Service and the Agricultural Stabilization and Conservation Service of the U.S. Department of Agriculture (USDA); the Cooperative Extension Service in New York, Michigan, and Ohio; and the USEPA (Regions II, III, V and GLNPO).

The allocation of target load reductions among these States reflects the potential for reducing nonpoint source pollution primarily from agriculture, while maintaining current

1 mg/l effluent limitations for municipal wastewater treatment plants discharging 1 MGD or greater. The nonpoint source pollution abatement components were based upon obtaining new funds to support an accelerated effort to meet the 1990 goal for phosphorus load reduction.

Interagency task forces in each of the Great Lakes States developed individual State Plans to achieve full compliance with point source discharge limits and reduction of agricultural phosphorus loads through conservation tillage and better nutrient management. Based on these Plans, the Great Lakes Phosphorus Task Force then prepared load reductions plans for Saginaw Bay and Lakes Erie and Ontario in 1986. Each Plan outlines the State and Federal efforts and activities that are necessary to ensure that the State meets its target load reduction. The State Plans assumed a base level program support from the Soil Conservation Service and Associated USDA agencies to implement the agricultural nonpoint source components and funding for an accelerated effort. The last State Plan was completed in September 1986.

Table 4-1 outlines the projected 1990 phosphorus load reduction versus the actual 1988 reductions, by waterbody. The data indicate that the actual phosphorus load reductions to Lake Erie, Lake Ontario, and Saginaw Bay were less than those that had been projected. The targeted phosphorus load reduction associated with implementation of agricultural management programs will require greater attention if the 1990 reduction goals are to be met. All the States except Indiana identified the need for increased funding to accelerate agricultural nonpoint source controls to achieve their 1990 goals. However, no new funding targeted to the implementation of the Phosphorus Load Reduction Plans, has been forthcoming at the Federal or State level.

Phosphorus load reductions to Saginaw Bay and Lakes Erie and Ontario as of 1988 were 207.8, 330.2, and 105.5 metric tons, respectively. These are significant reductions, given that they have been achieved with existing programs and competing priorities.

4.2.2 Lake Ontario Toxics Management Plan

In February 1987, USEPA, the New York State Department of Environmental Conservation, Environment Canada, and the Ontario Ministry of the Environment signed a declaration of intent to prepare a Toxics Management Plan for Lake Ontario. The development of this draft plan is a significant step in taking remedial measures for open lake waters. Lessons learned from developing and implementing this plan will be important to the preparation of a prototype LMP. The Lake Ontario Plan is to be completed in February 1989. The draft plan cites bioaccumulation of toxic chemicals in fish to levels that make fish unsafe for human consumption as the most serious known problem in the Lake.

Table 4-1. Summary of the U.S. 1990 Phosphorus Load Reduction Goals for Lake Erie, Lake Ontario, and Saginaw Bay, as compared to 1988 Reduction in Phosphorus Loads

Lake Erie:	
1990 Goal	1700
1988 Reductions	330
Reduction Needed to Meet 1990 Goal	1370
Lake Ontario:	
1990 Goal	235
1988 Reductions	106
Reduction Needed to Meet 1990 Goal	129
Saginaw Bay:	
1990 Goal	225
1988 Reductions	208
Reduction Needed to Meet 1990 Goal	17

The goal of the Lake Ontario Toxics Management Plan (LOTMP) is a Lake that provides drinking water and fish that are safe for unlimited human consumption, and allows natural reproduction within the ecosystem of the most sensitive native species, such as bald eagles, osprey, mink, and otters. To achieve this broad goal, the LOTMP envisions a sequence of four stages of remedial measures:

- Reductions in toxic inputs driven by existing and developing programs
- Further reductions in toxic inputs driven by special efforts in geographic AOCs
- Further reductions in toxic inputs driven by lakewide analyses of pollutant fate
- Zero discharge.

The draft plan calls for three principal actions:

- Full implementation of current programs, such as the State Pollutant Discharge Elimination System program in New York State and the Municipal Industrial Strategy for Abatement program in Ontario.
- The development and implementation of RAPs to address the problems in eight geographic AOCs, such as the Niagara River and Hamilton Harbor.
- The development and implementation of chemical-specific management plans to reduce the levels of problem toxics (e.g., polychlorinated biphenyls, mercury, mirex, chlordane, dioxin, DDT, dieldrin, and hexachlorobenzene) below protective

ambient standards. As a check on the effectiveness of chemical-specific management plans, ecosystem objectives and indicators will be developed and monitored.

Concurrent with the preparation of a final plan, the four Agencies began a number of significant activities in FY 1988, including:

- A system for categorizing toxics as a first step in implementing a chemical-by-chemical approach to toxics in Lake Ontario and for the Niagara River;
- A joint Lake Ontario Standards and Criteria Committee to ensure that a consistent set of adequately protective, legally enforceable standards are available;
- Development of mathematical models for relating toxic inputs to Lake Ontario and Niagara River responses, and to assist in the identification of source-specific problems; and
- Development of ecosystem objectives for Lake Ontario as a check on the effectiveness of the chemical-by-chemical approach to toxic control and as a first step toward the establishment of an ecosystem-based approach.

4.2.3 Lake Michigan Toxic Pollutant Control/Reduction Strategy

In 1986, USEPA and the States of Illinois, Indiana, and Michigan prepared a Lake Michigan Toxic Pollutant Control/Reduction Strategy. The objective of the strategy is to restore multiple human uses of Lake Michigan and to protect human health and the Lake Michigan ecosystem by achieving a significant reduction in the loading rates of toxic pollutants. The strategy includes specific commitments for each State and EPA that have been incorporated into the annual State program plans negotiated with the USEPA Region V Water Division. The strategy anticipates using a whole-lake mass balance approach to modeling toxic pollutants and evaluating potential regulatory controls. The Green Bay Mass Balance Study is identified by the strategy as a key milestone in the development of a LMP for Lake Michigan.

4.3 REMEDIAL ACTION PLANS

RAPs are the result of a process that began in 1981, when the Great Lakes Water Quality Board identified a number of geographic areas within the Great Lakes Basin that had severe water quality problems and named them AOCs. These areas were seriously out of compliance with Agreement objectives or jurisdictional standards, criteria, or guidelines established to protect beneficial uses. The present 42 AOCs include lake areas adjacent to most of the major metropolitan and industrial centers within the Basin. Of the total number of AOCs, 41 suffer from toxic substances contamination. Most of these have problems related to contaminated bottom sediments.

RAPs are to include eight major components defined in Annex 2.4(a):

(i) A definition and detailed description of the environmental problem in the Area of Concern, including a definition of the beneficial uses that are impaired, the degree of impairment, and the geographic extent of such impairment

(ii) A definition of the causes of the use impairment, including a description of all known sources of pollutants involved and an evaluation of other possible sources

(iii) An evaluation of remedial measures in place

(iv) An evaluation of alternative additional measures to restore beneficial uses

(v) A selection of additional remedial measures to restore beneficial uses and a schedule for their implementation

(vi) An identification of the persons or agencies responsible for implementation of remedial measures

(vii) A process for evaluating remedial measure implementation and effectiveness

(viii) A description of surveillance and monitoring processes to track the effectiveness of remedial measures and the eventual confirmation of the restoration of uses.

Annex 2 also identifies three stages in the RAP development process at which the RAP should be submitted to the International Joint Commission (IJC):

- When a definition of the problem has been completed under subparagraphs (i) and (ii) (listed above);
- When remedial and regulatory measures are selected under subparagraphs (iii), (iv), (v), and (vi); and
- When monitoring indicates that identified beneficial uses have been restored under subparagraphs (vii) and (viii).

The call for review of the RAPs at the problem definition stage is based on early efforts to develop RAPs. Obtaining concensus among the concerned units of government, interest groups, and the public on the definition of the AOC problems was more difficult than expected and resulted in major reworking of some RAPs that were thought to be near completion. The two major contributing factors were the late entry of some participants in the RAP process and the difficulty in focusing on use impairments, rather than on pollution control.

In the United States, the States have assumed the primary responsibility for preparing RAPs. USEPA has provided technical assistance and guidance to the States to facilitate RAP preparation. In addition, USEPA has requested that the States submit their completed RAPs to USEPA as updates to their Statewide Water Quality Management Plans. The Water Management Divisions of USEPA Regions II and V have integrated the RAP preparation and review process into the continuing planning process required under the CWA. GLNPO is responsible for reporting progress in RAP development to the IJC.

Each of the Great Lakes States, except Illinois and Pennsylvania, have undertaken a program to complete RAPs for their AOCs. The State of Illinois has one AOC, Waukegan Harbor, Illinois. This site is also a Superfund site and will be cleaned up based upon a USEPA and Outboard Marine Corporation consent decree. There are currently no AOCs in the State of Pennsylvania. Table 4-2 lists the status of each AOC by State. At the end

of FY 1988, the Water Quality Board had received and reviewed seven U.S. RAPs. Seven more U.S. RAPs are scheduled for completion in FY 1989 and four in FY 1990.

Throughout the RAP development process, public involvement has played an important role. Both the Water Quality Board and the Science Advisory Board encouraged the jurisdictions to involve the public from the outset in the preparation of the RAPs. In addition, the Water Quality Board sponsored a number of workshops on RAP preparation. Citizen involvement is viewed as particularly important because strong local support will be critical to control nonpoint sources and to raise the funds necessary to support the needed remedial actions. A strong base of public support is especially important for remedial actions involving contaminated sediment cleanup, since there are no established government programs specifically dedicated to these types of activities. However, some Federal support may be available through GLNPO's demonstration project program, Superfund, or Federal maintenance dredging programs.

4.4 POINT SOURCE IMPACT ZONES

While not a formal part of LMPs or RAPs, the commitment to identify Point Source Impact Zones and reduce their size and effect is an important aspect of attaining the objectives of the GLWQA. The first report on Point Source Impact Zones is due September 30, 1989. USEPA is currently working with the Great Lakes States to establish consistent definitions and methods of reporting.

4.5 FEDERAL/STATE INTERACTIONS

The successful completion and implementation of management plans in the Great Lakes Basin will require a close working relationship between the Federal Government and the States. The States have primary responsibility for water quality management, implementing most of the environmental measures called for by environmental plans.

The States also have the lead in preparing the U.S. RAPs. USEPA has provided support in the form of contractor assistance and grants to the States for RAP development. In addition, USEPA has requested that the RAPs not only be submitted to the Water Quality Board for review, but also to USEPA under provisions of the CWA. This allows integration of the RAPs into the Federal management structure.

While the GLWQA assigns responsibility for completing LMPs to the Federal Government, it is essential that the plans be developed in partnership with the States. The USEPA is already involving each of the States in defining the process and schedule of the development of these management plans. As with the RAPs, USEPA expects that the completion of the LMPs will integrate the tools and requirements of existing Federal and State laws and regulations. In the case of both the Lake Michigan Toxics Strategy and the Lake Ontario Management Plans, the efforts are Federal/State combined programs.

The Great Lakes States also have worked jointly toward achieving the goals of the GLWQA. In June 1986, the Governors of the eight Great Lakes States signed "The Great Lakes Toxic Substances Control Agreement." This Agreement pledges the States to treat the Lakes as a single ecosystem despite political boundaries, acknowledges that toxic pollutants are the foremost problem to be addressed, and lays out goals for the States.

Table 4-2. Status of U.S. Remedial Action Plans

Areas of Concern by State	Projected Date to Submit Completed RAPs for IJC Review
Illinois	
Waukegan Harbor	Deferred
Indiana	
Grand Calumet/ Indiana Harbor	1989
Michigan	
Torch Lake	1987
Deer Lake/Carp River	1987
Manistique River	1987
Kalamazoo River	Pending Civil Litigation
Muskegon Lake	1987
White Lake	1987
Saginaw River/ Saginaw Bay	1988
Clinton River	1988
Rouge River	1988
River Raisin	1987
Michigan/Ontario	
St. Mary's River	1989
St. Clair River	1989
Detroit River	1989
Minnesota/Wisconsin	
St. Louis River	1990
New York	
Buffalo River	1989
Eighteenmile Creek	1990
Rochester Embayment	1990
Oswego River	1989
New York/Ontario	
St. Lawrence River	1990
Niagara River	1991

Table 4-2. Status of U.S. Remedial Action Plans (continued)

Areas of Concern by State	Projected Date to Submit Completed RAPs for IJC Review
Ohio	
Maumee River	1989
Black River	1990
Cuyahoga River	1991
Ashtabula River	1989
Wisconsin/Michigan	
Menominee River	1989
Wisconsin	
Fox River/ Southern Green Bay	1987
Sheboygan Harbor	1989
Milwaukee Estuary	1990

More recently, the Governors agreed to establish a permanent fund for Great Lakes studies. Many of the activities under both of these State agreements will lead directly and indirectly to the completion of and implementation of management plans, and ultimately to the attainment of the Agreement objectives. Considerable progress has already been made toward this goal by USEPA Headquarters and regional regulatory and remedial programs by the States.

While the provisions of the CWA and the GLWQA that pertain to the development of management plans are not literally identical, they are conceptually consistent. The USEPA will meet the "Action Plans" requirement of Section 118 of the CWA Amendments by working with the States, other Federal agencies, tribal organizations, and Canada to complete RAPs and LMPs. In addition, the requirements of the CWA Amendments to complete individual toxic control strategies and nonpoint source management plans are intended as direct support for the development of RAPs and LMPs.

5. REMEDIAL PROGRAMS

Remedial programs to control pollution have been under way within the Great Lakes Basin for many years. These include regulatory programs such as discharge permits, and non-regulatory programs such as construction grants or information/education programs. Although existing programs have been successful, many water quality problems remain, including critical pollutants that result in fish consumption advisories and reproductive disorders in biota, and localized use impairments occuring in Areas of Concern (AOCs). Many of these problems are caused by persistent toxic substances, some of which continue to enter the Great Lakes System. A major source of persistent toxics, however, is the recycling from historic unregulated discharges that are stored in contaminated sediment deposits. To resolve these critical outstanding problems, current programs must be coordinated more effectively and new programs may have to be initiated.

Within the prescribed management planning framework, the Great Lakes Water Quality Agreement (GLWQA) identifies a number of specific pollutant sources that require control, abatement, and remedial efforts in the United States and Canada:

- Point source discharges of pollutants to surface water
- Nonpoint discharges to surface water
- Contaminated sediment
- Atmospheric deposition of pollutants to surface water
- Groundwater discharges of contaminants to surface water
- Discharges from vessels and related shoreline facilities.

Progress in each of these areas, including remedial action programs to address them, are discussed in this Chapter.

5.1 OVERVIEW OF REMEDIAL PROGRAMS

A wide variety of approaches exist for improving water quality. Government regulatory programs are a primary mechanism for controlling pollution discharges. Nonregulatory Government programs, which encourage or enable communities and individuals to reduce pollutant loads, are also important. The private sector can independently contribute to water quality improvements by changing production processes to improve the quality or reduce the volume of discharges entering the Great Lakes.

Government approaches for remedial action include regulatory and incentive/grant programs, such as those provided under the Clean Water Act (CWA), the Clean Air Act (CAA), and the Resource Conservation and Recovery Act (RCRA) (Table 5-1). Cleanup of hazardous waste is accomplished under authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or Superfund, and RCRA. Immediate concerns for human health hazards are addressed by U.S. Environmental Protection Agency (USEPA) programs (i.e., under the Toxic Substances Control Act and the Federal Insecticide, Fungicide, and Rodenticide Act) and programs administered by the U.S. Food and Drug Administration and State health departments. Other programs administered by USEPA and other Federal agencies provide grants for research and public information and education related to Great Lakes issues.

Table 5-1. Major Federal Programs Contributing to Great Lakes Water Quality Improvement

Programs	Statutory Authority/ Implementing Measure	Explanation
REGULATORY PROGRAMS		
Clean Water Act (CWA)	Federal Water Pollution Control Act of 1972 as amended	
National Pollutant Discharge and Elimination System (NPDES) Permit Program	Section 402 of the CWA (33 USC 1342); NPDES Permit Regulations (40 CFR 125; 40 CFR 122)	Water quality criteria and EPA regulations for issuing permits for the discharge of "any pollutant or combination of pollutants" into waters of the U.S.; discharges regulated under Section 404 are excepted. All eight Great Lakes States have received NPDES approval authority.
NPDES Pretreatment Program	Section 402 of the CWA (33 USC 1342; General Pretreatment Regulations (40 CFR 403)	Four of the Great Lakes States have received pretreatment program delegation and three others have been active in the pretreatment program implementation, although they have not assumed the program.
Dredge and Fill Permit Program	Section 404 of the CWA (51 FR 219, at 41220 et seq) (November 13, 1986; 33 CFR 320 et seq)	The Secretary of the Army, acting through the U.S. Army Corps of Engineers, issues discharge of dredged or fill permits for the material into the waters of the United States.
Section 401 of the CWA (33 USC 1341)	Agreements made on a State-by-State basis	Section 404 permit applicants must obtain State certification that proposed discharges would comply with water quality standards. Some States generally waive exercise of this authority.
Section 10 of the Rivers and Harbors Act of 1988	Section 10 Permit Regulations for Structures or Work Affecting Navigable Waters (51 FR 41220; 33 USC 322)	The Corps issues Section 10 permits for dredge or fill activities and building of structures (e.g., piers or docks) to ensure that these actions do not adversely affect navigability.

Table 5-1. Major Federal Programs Contributing to Great Lakes Water Quality Improvement (continued)

Programs	Statutory Authority/ Implementing Measure	Explanation
Manufacture and Sale of Substances	Toxic Substance Control Act (TSCA)	Enpowers EPA to regulate Toxic chemical substances and mixtures that present an unreasonable risk to human health or the environment.
Pesticide Control	Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)	FIFRA governs the licensing or registration of pesticide products.
Resource Conservation and Act (RCRA)	Standards for Owners and Operators of Hazardous Waste Disposal Facilities (40 CFR 264 et seq)	RCRA authorizes USEPA to Recovery regulate the transportation, as amended treatment, disposal, and storage of solid and hazardous wastes.
Environmental Impact Statement Requirements	National Environmental Policy Act (NEPA)	NEPA directs all Federal agencies to determine the potential environmental impacts of their proposed activities and to consider those impacts in the decision-making process.
Fish and Wildlife Coordination Act (16 USC 661 et seq)	Administrative agreements between agencies	Federal permit actions related to water projects are subject to requirements of the Coordination Act. The U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) ensure that "equal consideration" be given to fish and wildlife.
Section 307 of the Coastal Zone Management (CZM) Act (16 USC 1456)	Regulations on Federal Consistency with Approved Coastal Management Programs (15 CFR 930.1 et seq)	Requires applicants for Federal license or permits to conduct an activity in the coastal zone of a State with an approved CZM plan and to obtain State certification of consistency with the plan.

Table 5-1. Major Federal Programs Contributing to Great Lakes Water Quality Improvement (continued)

Programs	Statutory Authority/ Implementing Measure	Explanation
NONREGULATORY PROGRAMS		
Executive Order 11990 on the Protection of Wetlands (45 FR 26961 (1977))	Incorporated within organizational policies and procedures on an agency-by-agency basis	Strong directive to Federal agencies, including Federal and licensing agencies, to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance their beneficial wetlands.
Executive Order 11988 on Floodplain Management (45 FR 26951 (1977))	Incorporated within organizational policies and procedures on an agency-by-agency basis	Strong directive to Federal agencies, including Federal and licensing agencies, to reduce flood risks and preserve the natural and beneficial values of floodplains.
Endangered Species Act (16 USC 1531 et seq)	Endangered Species Committee Regulations (50 CFR 402 et seq)	The USFWS and the NMFS issues joint guidelines on review procedures for ensuring that Federal actions (including permitting) would not jeopardize listed species.
Construction Grants Program	Clean Water Act (Section 201)	Section 201 provides funding for the development and implementation of waste treatment management plans and practices, including construction of wastewater treatment facilities.
Superfund Program	As amended by the Superfund Amendments and Reauthorization Act of 1987 (SARA)	CERCLA authorizes the Federal Government to develop a system for identifying and cleaning up chemical and hazardous substance releases harmful to public health and the environment.
EPA Nonpoint Source Program	CWA Section 319	States are required to develop an assessment of nonpoint source impact on surface waters. To qualify for funding, States must develop management programs to correct NPS impacts identified in their assessment reports.

Table 5-1. Major Federal Programs Contributing to Great Lakes Water Quality Improvement (continued)

Programs	Statutory Authority/ Implementing Measure	Explanation
Food Security Act	Food Security Act (FSA) of 1985	FSA requirements include development and implementation of erosion control plans on highly erodible agricultural lands as a means for maintaining eligibility for USDA programs. Within FSA, the Conservation Reserve Program (CRP) provides for temporary retirement from production of some of the most highly erodible of these lands.
Small watersheds projects	Public Law 83-566 (PL-5-66)	SCS provides technical and financial assistance to landowners on a watershed basis to correct resource problems.
Agricultural Conservation Program (ACP)	Section 17 of the Domestic Soil Conservation and Allotment Act (PL 74-461)	Through the ACP, USDA's Agricultural Stabilization and Conservation Service provides direct financial assistance to landowners in the application of conservation practices and other Best Management Practices for water quality improvement and erosion control. The Soil Conservation Service provides technical assistance.
Environment Impact Statements (EISs)	National Environmental Policy Act (NEPA) of 1969	NEPA's most far-reaching provision requires every Federal agency to prepare an Environmental Impact Statement (EIS) for each proposed major Federal action significantly affecting the quality of the human environment, including major Federal dredging projects. Title II of NEPA created the Council on Environmental Quality, which oversees environmental improvement programs.

As a result of the GLWQA's new focus on ecosystem management, USEPA and the States are working to integrate the full range of regulatory and nonregulatory mechanisms to improve environmental quality.

5.2 REGULATORY PROGRAMS

Particular efforts have been made to coordinate the many programs administered by the USEPA that contribute, directly and indirectly, to achieving GLWQA objectives (Figures 5-1 and 5-2). For the purposes of this discussion, the contributions of each program are determined by the terms of authorizing statutes (i.e., whether the statute grants authority for regulation and establishes compliance enforcement powers or provides for another form of environmental management) and by the maturity of the program (i.e., its stage of development or implementation).

Some Government programs are well established in the Great Lakes Basin and have long contributed to water quality improvement. For example, National Pollutant Discharge Elimination System (NPDES) permits have been issued to direct dischargers in all eight Great Lakes States for more than a decade, resulting in the reduction of discharges of conventional and toxic pollutants.

In contrast, other Government programs are only in formative stages and have yet to result in tangible environmental improvements. For example, programs addressing contaminated sediment problems are currently focused on research and development to discover the extent and significance of the problem, and on technology development and demonstration for purposes of identifying feasible technological alternatives and institutional mechanisms (i.e., criteria for cleanup) for program implementation. Programs for groundwater protection, such as the RCRA land disposal restrictions program, are in initial implementation phases, but are also active in technology development and demonstration. Therefore, achievements regarding point source discharges are measurable in terms of environmental results, and achievements for other programs are better characterized in terms of progress toward implementation.

5.2.1 Point Sources

Preliminary mass balance studies on selected Great Lakes systems suggest that point sources of pollutants contribute varying proportions of the total, depending upon the pollutant and the lake. As control of point sources improves, they account for a decreasing proportion of total loadings. Past point sources are the original cause of many current problems of sediment contamination and atmospheric deposition of pollutants, even though current sources have been controlled. Point sources are regulated by a variety of mechanisms identified in the following discussions.

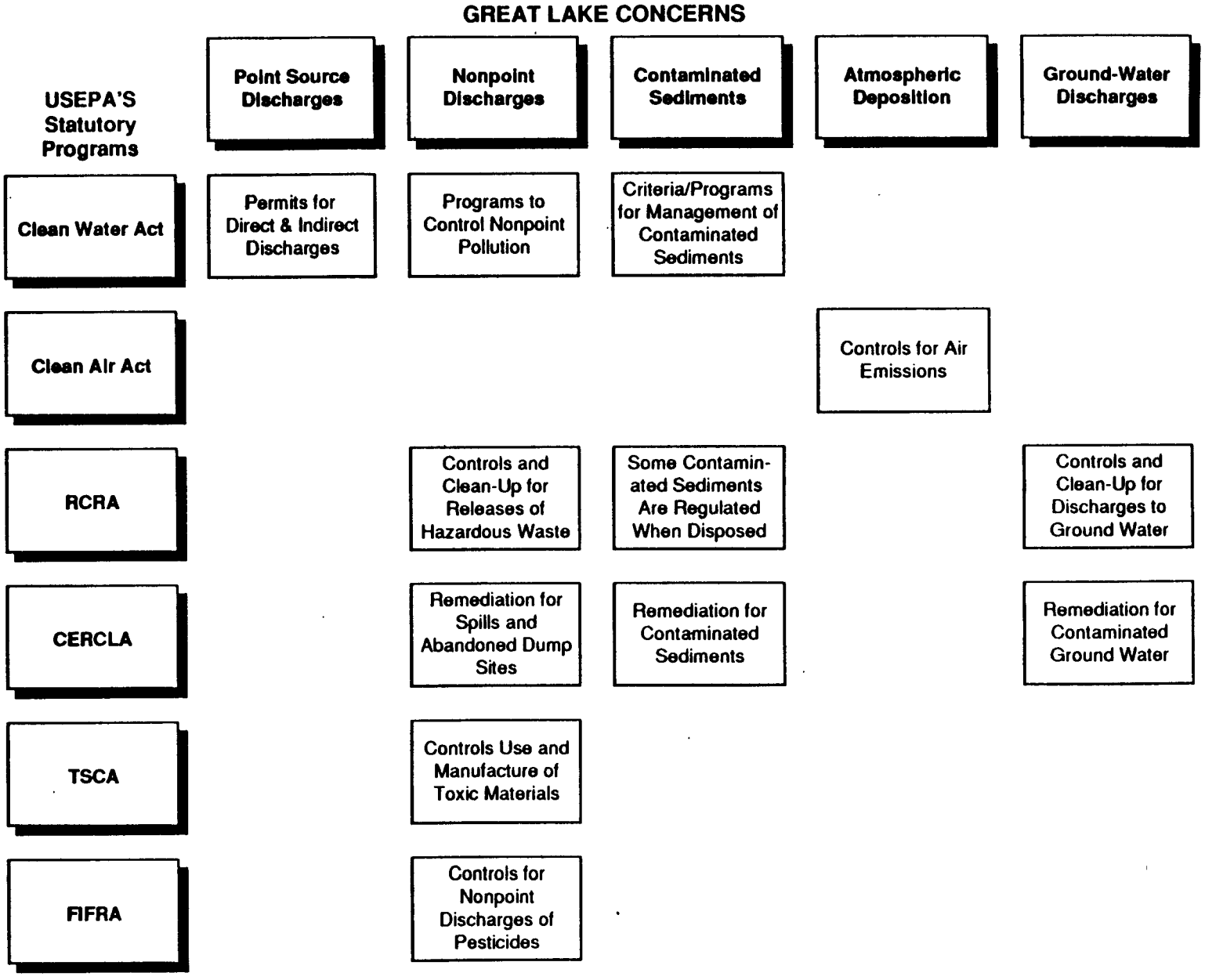


Figure 5-1. Direct Linkages Between USEPA's Statutory Programs and Great Lakes Concerns

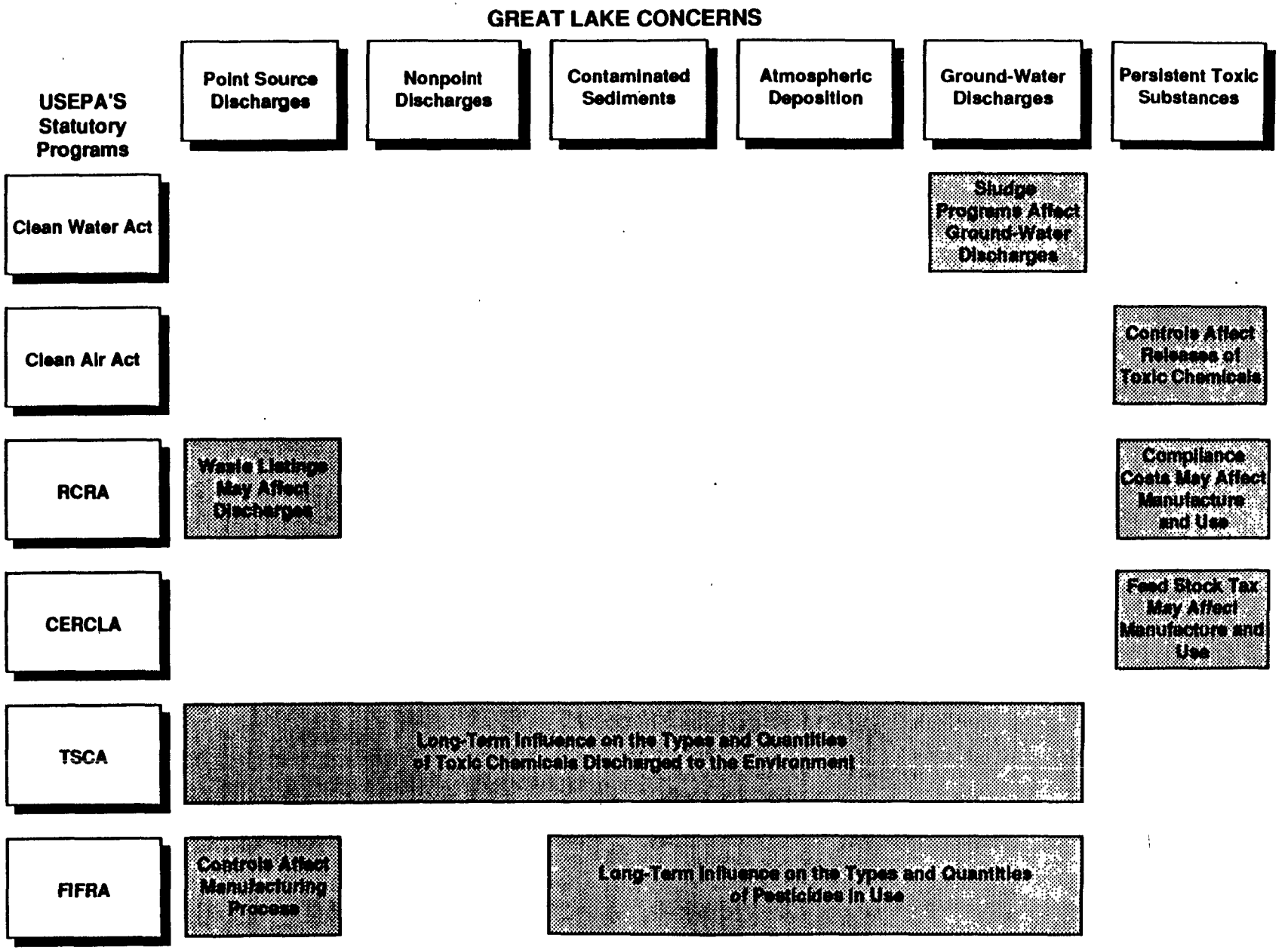


Figure 5-2. Indirect Linkages Between USEPA's Statutory Programs and Great Lakes Concerns

National Pollutant Discharge Elimination System

Direct discharges of pollutants to the Great Lakes System are regulated by permits issued as part of the NPDES, established under the CWA. (The NPDES program is under the jurisdiction of the USEPA, although permitting activities are administered by the eight Great Lakes States, in accordance with CWA provisions for State delegation by the USEPA.) Within the United States, discharges to the Great Lakes Basin are regulated by 3,675 NPDES permits: 2,531 apply to industrial facilities and 1,144 to municipal facilities. Of the total number of major industrial and municipal facilities permitted in New York State, 70 percent of the industrial facilities and 50 percent of the municipal facilities are located in the Great Lakes portion of the state.

The total number of permits in the basin has remained fairly stable over the past decade, with some changes in localized distribution. However, permit provisions have become more restrictive over this period, especially with regard to concentrations of phosphorus, heavy metals, and certain toxic constituents. A new trend may be developing toward further restriction of discharges of toxic substances, based upon the principle of disallowing any further degradation of ambient water quality.

Regulatory requirements and Government support have collectively resulted in a significant reduction of point source discharges of phosphorus to the Great Lakes. In 1985, 79 percent of all sewered municipal discharges was subject to additional treatment for phosphorus removal. State bans on the use of detergent products containing phosphates have also aided progress by reducing phosphorus concentrations in raw municipal waste water. As a consequence, at least 163 of 187 major municipal sewage treatment facilities in the Basin now comply with the 1 milligram per liter effluent limit for phosphorus set by the GLWQA. Overall, phosphorus discharges from point sources in the Great Lakes Basin have declined about 80 percent since 1972.

Pretreatment

Another provision of the CWA calls for the establishment of approved Pretreatment Programs for publicly-owned treatment works (POTWs). In the Great Lakes States, a total of 476 POTWs are subject to these pretreatment requirements. (Of this total, 222 POTWs have effluent flows greater than 5 million gallons per day.) The program approval rate within the Great Lakes States has been better than the national average. There are 33 approved pretreatment control authorities in New York State counties containing areas that drain into the Great Lakes area. A total of 466 facilities, or 97.9 percent of those POTWs subject to the new requirements, received program approval by September 30, 1988.

Efforts are currently under way to delegate administration of the CWA Pretreatment Program to the States. As of September 30, 1988, four Great Lakes States have received approval for State Administration; three other States have been active in Pretreatment Program implementation, although program administration has not yet been officially delegated. (Nationwide, 25 of the 39 NPDES States and territories had received delegation of the Pretreatment Program.)

National Municipal Policy

The CWA required that by July 1, 1987, POTWs meet NPDES permit effluent limits based on secondary treatment or any more stringent limit necessary to meet water quality standards. Because of historic problems with municipal compliance, the Agency developed

the National Municipal Policy (NMP) in January 1984, placing renewed emphasis on improving municipal compliance rates in order to protect the Nation's water quality. NMP established enforcement priorities for facilities that did not meet the July 1, 1987 deadline.

As of July 27, 1988, 87 percent of Region V's major POTWs had met the requirements of the NMP. Ninety percent of the Region's minor facilities are also in compliance, compared to 77 percent before NMP. As a result, 95 percent of the total sewage processed in the United States receives at least secondary treatment. Voluntary compliance and Federal and State enforcement are responsible for achieving the compliance record. Of the 13 percent of POTWs that did not achieve compliance, most are on enforceable timetables leading to compliance or litigation. USEPA Region V or the States have court actions pending against 62 large cities that have failed to meet the NMP, and have placed 29 city plants on court-ordered compliance schedules. Figure 5-3 provides a summary of progress in meeting the NMP goals.

In addition to the NMP, there has been an increase in State and USEPA enforcement actions in 1988. Figure 5-4 shows State and Federal enforcement actions taken against Great Lakes Basin dischargers in Region V. In FY 1988, Federal and State enforcement actions were at an all-time high. As of September 30, 1988, over 585 Administrative Orders were issued in the Great Lakes Basin by the USEPA and the States. Over 232 State and Federal judicial actions (civil referrals) were initiated in 1988, more than in any previous year. Many of these actions were taken against POTWs under the NMP, while many others were initiated for violators of NPDES permit limitations. This enforcement has a direct link to improving effluent quality, as fines collected as part of enforcement actions provide a strong deterrent to noncompliance for other permittees.

Under the wastewater compliance programs, State and USEPA inspected 92 percent of the major dischargers in Region V in FY 1988. Nearly 900 inspections of major NPDES permitted facilities were conducted in the Great Lakes Basin between USEPA Regions II, III, and V. Through these inspections, the State and USEPA evaluate compliance with permit conditions and check to ensure that the self-reported data generated by the permittee are accurate and complete.

USEPA Region V will focus on four areas to maintain and improve on water quality gains:

- Implementation of compliance maintenance programs with the States;
- Correction of combined sewer overflow (CSO) problems;
- Transition of construction grant programs from the Federal Government to the States; and
- Control of toxic chemicals from municipal discharges.

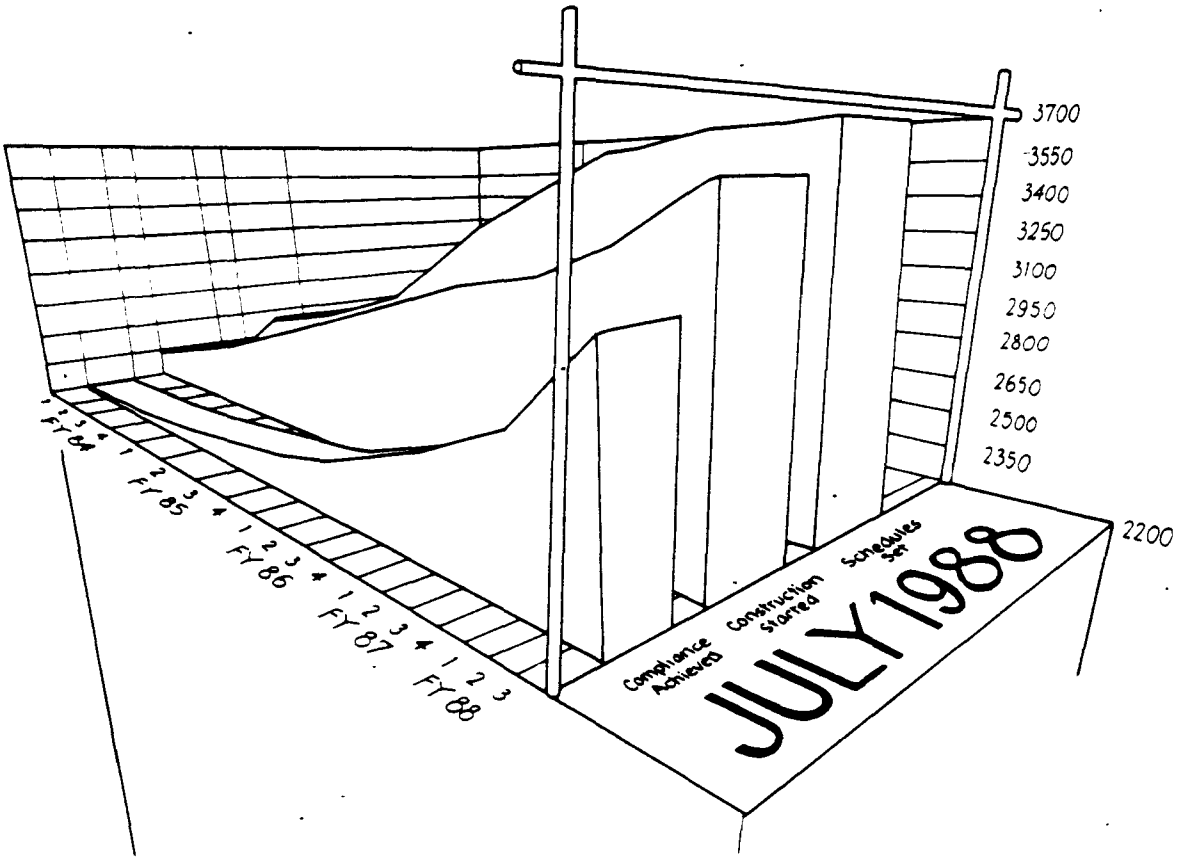


Figure 5-3. Progress in Meeting NMP Goal

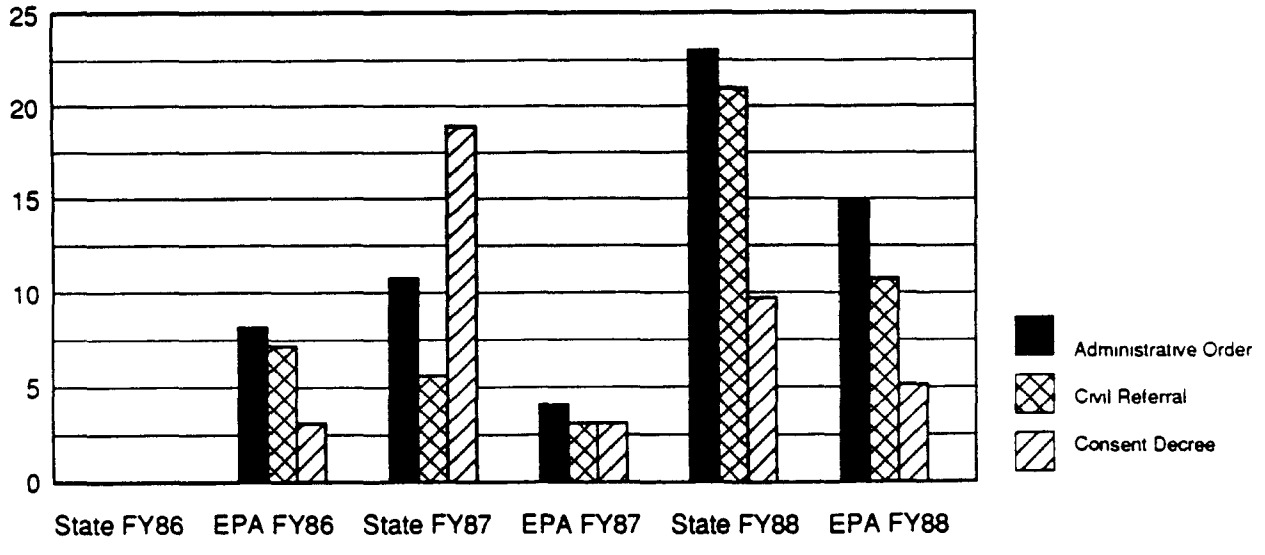


Figure 5-4. Enforcement Action Trends—Region V Great Lakes Major Permitees

Combined Sewer Overflows

Future efforts to reduce discharges will be expanded to include programs to control combined sewer overflow and, where necessary, develop and issue permits for nonpoint source discharges. USEPA is leading efforts to develop a national permitting strategy for the control of CSOs. It is estimated that between 15,000 and 20,000 CSOs are in operation nationwide. USEPA Region V has developed a Strategy to complement control programs for sanitary sewers and separate storm sewers by fashioning CSO permits on technology- and water quality-based standards. The Strategy will result in more effective community management of combined sewer systems through planned operation and maintenance procedures, and construction, if needed to attain designated uses and meet water quality standards.

Storm Water

The USEPA regards storm water as a point source to the extent that it is discharged by way of industrial and municipal storm drains. Under the 1987 Amendments to the CWA, industries discharging storm water must apply for a permit and must equip storm drains with the best available technology or the best conventional pollution control technology available. Similarly, municipalities serving more than 250,000 people must decrease discharges from storm drains to the maximum extent possible. Regulation on issuing stormwater permits as required by these provisions is expected in 1989. Meanwhile, in FY 1988, a prototype permit for stormwater discharges was developed for the Rouge River that will serve as a model for similar efforts elsewhere in the Great Lakes Basin.

Point source loadings of virtually all toxic substances have also declined in recent years. For the most persistent pollutants of concern (i.e., the organochlorine pesticides and polychlorinated biphenyls (PCBs)) in the Great Lakes system, the reduction in their point source loadings can be attributed in part to bans or restrictions on their use and disposal under national pesticide and toxic substances control statutes. For other toxic substances, particularly the heavy metals, permits re-issued over the last five years increasingly contain both technology-based and water quality-based effluent limitations.

Vigorous enforcement of point source effluent limitations, combined with the adoption of ever more stringent water quality standards in successive 3-year revision cycles, should result in further significant load reductions from point sources over the next decade.

5.2.2 Nonpoint Sources

Progress has been made toward controlling or reducing concentrations of conventional pollutants that flow to the Great Lakes from nonpoint sources. However, nonpoint source programs are still in the beginning stages for both nutrients and toxics. Nonpoint sources of toxic pollutants, particularly pesticides, have long been a concern. The emerging nonpoint source programs will provide some reduction in quantities that enter the lakes, but extensive surveillance work is required to characterize the nature and extent of toxic pollutants reaching the Lakes from nonpoint sources before it can be determined whether special programs are needed for toxics as they are for phosphorus.

Recent U.S. efforts to control nonpoint sources of pollution have arisen because of statutory requirements specified in Section 319 of Amendments to the Clean Water Act. Each State was required to develop a Nonpoint Source Assessment and a Nonpoint Source Management Program by August 4, 1988. The assessments are designed to determine those waters of each State that are adversely affected by nonpoint source inputs, identify the

categories of nonpoint sources that contribute to water quality degradation, and describe existing programs designed to control each significant category of nonpoint source pollution. The majority of the Great Lakes States have prepared draft assessments and management programs. These documents are now being reviewed by USEPA.

In the Great Lakes, nonpoint source programs for controlling phosphorus are of particular concern in Lake Erie, Lake Ontario, and Saginaw Bay. Nonpoint source control of phosphorus has emphasized the management of crop residues to prevent nutrient loss by soil erosion, proper management of livestock wastes, and proper management of fertilizers. Past cooperative efforts between the USEPA, the U.S. Department of Agriculture (USDA), and the States have involved demonstration programs, public outreach efforts, and other projects intended to promote the use of proper tillage and animal waste and fertilizer management techniques by farmers throughout the Great Lakes Basin. USDA programs, particularly those under the Food Security Act, provide important assistance in reducing agricultural nonpoint sources. Of particular benefit are programs that encourage improved management of crop residues and the Conservation Reserve Program (CRP), which takes highly erodable land out of production.

In FY 1988, the Great Lakes Phosphorus Task Force evaluated progress in reducing phosphorus loadings from nonpoint sources. Substantial progress has been made by New York in reducing nonpoint source phosphorus loads to Lake Ontario, with over half of the targeted load reduction already met. Similarly, Michigan has attained 36 percent of its load reduction goal for Saginaw Bay. In Lake Erie, a 25-percent reduction has been achieved, although New York, Ohio, and Pennsylvania have achieved considerably lower load reductions than necessary to meet the reduction schedule. Ohio must still achieve a greater load reduction than all other States combined.

Under an Interagency Agreement with the U.S. Soil Conservation Service, the USEPA recently funded a project to track conservation tillage practices using remote sensing techniques in 58 counties in Indiana, Michigan, and Ohio. The study will continue in FY 1989 and will provide an improved estimate of phosphorus load reductions achieved as a result of continuing use of conservation tillage. Also in FY 1988, USEPA initiated a special study to evaluate conservation tillage practices in Ohio, an area where nonpoint phosphorus discharges are particularly high. Based on the results of these studies, the Great Lakes National Program Office (GLNPO) and the States will determine whether present programs are capable of providing the level of reduction required to meet the goals of the GLWQA. If further reductions are necessary, recommendations for additional measures will be developed.

In FY 1988, GLNPO funded a workshop on developing watershed management plans for State agencies in the Great Lakes Basin. This workshop was the first step toward fulfilling the requirements of the GLWQA to place necessary controls on toxic pollution from nonpoint sources. In FY 1989, USEPA will continue to characterize the extent of nonpoint sources of toxic pollution and identify toxic pollutant demonstration projects similar to those conducted to assist with programs for conventional pollutants.

Because nonpoint sources of pollution are often reduced as they flow through wetland areas, wetland protection is an important component of watershed management planning. The U.S. Army Corps of Engineers (USCOE), in cooperation with the USEPA, administers a permit program under Section 404 of the CWA to regulate the discharge of dredged or fill material in waters of the United States, including wetlands. In FY 1988, over 680 standard permits were issued in the Great Lakes States (USCOE Northcentral Division), a decline of 19.5 percent from 1987.

Other efforts to protect wetlands include the advanced identification (ADID) of significant wetlands. The process of advanced identification identifies wetland areas unsuitable for filling. In Region V, four ADID studies have been completed involving over 2,500 acres of wetlands. The study areas include the Grand Calumet River/Indiana Harbor Canal, Indiana; Lake County, Illinois; Green Bay, Wisconsin; and Lake Calumet, Illinois.

5.2.3 Contaminated Sediment

Contaminated sediment is believed to be an important contributor of toxic pollutants to the waters of the Great Lakes. As noted in Chapter 3, all of the U.S. AOCs are known to have contaminated sediment problems. RAPs are in various stages of preparation for these areas (see Chapter 4 for details). No remedial actions (e.g., excavation or containment of contaminated sediment) have been undertaken yet.

During FY 1988, GLNPO began implementing its contaminated sediment study, entitled the Assessment and Remediation of Contaminated Sediments, laying the foundation for demonstration projects for remedial actions. Accomplishments are discussed in Chapter 6, on Demonstration Programs.

The Buffalo, Chicago, and Detroit District offices of the USCOE have responsibility for maintaining adequate depths for navigation on the Great Lakes at selected harbors and river channels, as determined by Congress. In order to achieve this goal, dredging of many of these navigation channels is required. Because much of the sediment that is dredged from the harbors and lake bottom is considered to be polluted, confined disposal facilities have been built around the Lakes to contain this material. The result of this process is beneficial to Great Lakes water quality, because the contaminated sediment is removed from the aquatic system rather than remaining in the channel or being transported into the Lake. Over 2 million cubic yards of contaminated bottom sediment was removed and confined in 1988 from 10 Great Lakes harbors.

Other activities undertaken by the Corps include conducting routine sediment testing at harbors scheduled for dredging, construction of confined disposal facilities, and special studies to characterize contaminated sediments. The Corps also operates the Waterways Experiment Station in Vicksburg, Mississippi, which contributes to the state-of-the-art knowledge regarding navigation and water quality impacts.

5.2.4 Airborne Contaminants

Existing regulatory programs for air pollution control have been effective in reducing conventional pollutant concentrations, especially of sulfur and nitrogen compounds. In FY 1988, Regions V and II of the USEPA were allocated $980,000 to support existing control programs under the CAA. There are currently 609 regulated facilities in the counties of the Great Lakes area that are in compliance with the requirements of the CAA. Of the 26 facilities that are in violation, 7 are already on compliance schedules.

However, atmospheric transport and deposition are believed to be an important source of toxic contaminants to the Great Lakes. For instance, atmospheric deposition is the most likely means of transport for some toxic pollutants found in the Upper Great Lakes, where neither direct discharges nor land runoff can account for their presence.

There is considerable uncertainty as to specific sources and source categories that are causing the concentrations of toxics observed in the Great Lakes ecosystem. The source

categories of primary concern are: 1) municipal waste combustors (MWCs) for mercury, dioxin, dibenzofurans and PCBs, 2) electrical transformers for PCBs and dibenzofurans, 3) pesticide application for toxaphene, aldrin, and chlordane, and 4) mercury ore processing plants, chlor-alkali plants, and sewage sludge incinerators for mercury.

On July 7, 1988, under Section 111 of the CAA, USEPA published a decision to regulate MWC emissions, including constituents such as dioxins, dibenzofurans, heavy metals, and other organics such as PCBs. The regulations will be based on the use of best demonstrated technology considering cost and other impacts. USEPA has issued interim operation guidance under the new source review requirements of the CAA that would effectively require emission limits for new MWC permits to be based on good combustion controls plus acid gas scrubbers followed by fabric filters or electrostatic precipitators. These requirements will substantially reduce the toxic components of MWC emissions.

For controlling mercury emissions from other sources, USEPA has listed mercury as a hazardous air pollutant under Section 112, and has regulated mercury ore processing plants, chlor-alkali plants (which produce chlorine gas and alkali metal hydroxide), and sewage sludge incinerators.

As described in Chapter 7, Monitoring and Surveillance, GLNPO and the Great Lakes States have implemented the Great Lakes Atmospheric Deposition monitoring network to measure deposition of nutrients and toxics throughout the Basin. As a sufficient data base is assembled and evaluated, the USEPA, in conjunction with the States, will evaluate the need for regulatory or other controls on air toxics emissions needed in the Great Lakes Basin to meet the goals of the GLWQA. If special controls are indicated, recommendations will be developed.

5.2.5 Contaminated Ground Water

Contaminated ground water in the Great Lakes Basin, derived from both direct and tributary sources, has recently been recognized by Congress, the International Joint Commission, and the GLWQA to be an important source of contamination for the Great Lakes. Both Section 118 of the CWA and the GLWQA require that the impacts of contaminated ground water on water quality in the Great Lakes be investigated and evaluated.

The USEPA made considerable progress during FY 1988 toward addressing groundwater contamination in the Great Lakes Basin. The Agency's hazardous waste programs implemented under RCRA of 1976 (as amended) and under CERCLA (as amended) have continued to address both active and inactive hazardous waste sites, one of the principal sources of contaminated ground water in the Great Lakes Basin and throughout the United States. Additionally, the USEPA is now implementing a Wellhead Protection Program, as mandated by the 1986 Amendments to the Safe Drinking Water Act.

Under RCRA, the USEPA and the States have continued to issue permits for active hazardous waste treatment, storage, and disposal facilities in the basin, and have begun to implement the corrective action program mandated by the 1984 Amendments to RCRA. In addition, during FY 1988, USEPA began promulgating regulations that restrict certain hazardous waste from land disposal. This program, together with minimum technology standards for landfills and surface impoundments that became effective this year, provides considerable protection against future groundwater contamination caused by placement of hazardous waste on the land. In Region II, there are currently 55 facilities subject to

RCRA. Extensive corrective action programs are being carried out at two facilities in Niagara Falls, New York: CECOS and Occidental Chemical Corporation.

Under CERCLA, USEPA regional programs and State environmental agencies have continued to identify, characterize, and address abandoned hazardous materials dumpsites in the Great Lakes Basin. Presently, the National Priorities List (NPL) includes over 131 sites located within the Basin. In addition, States such as Michigan, New York, Ohio, and Minnesota have created their own State Superfunds to address sites that do not warrant listing on the NPL but have high State priority for cleanup. New York State has the third largest number of Superfund sites in the country, with 76 sites on the NPL. A total of twenty-four sites are located in the Great Lakes Basin, including some of the most complex hazardous waste sites in the country, such as Love Canal, OCC Hyde Park, S-Area, 102nd Street, Pollution Abatement Services, and GM Central Foundry. Four Great Lakes Areas of Concern are included on the NPL because of contaminated sediment problems: Sheboygan, Waukegan, Torch Lake, and Ashtabula.

The 1986 Amendments to the Safe Drinking Water Act require the development of Wellhead Protection Programs at the State level. All States within Region V of the USEPA are including wellhead protection activities in their State grant applications. Four States (Indiana, Ohio, Illinois, and Minnesota) are committed to developing program plans which will be supported by $2.5 million of CWA, Section 106 funds.

Currently, Illinois has the most sophisticated wellhead protection strategy of all the Great Lakes States. The State Legislature recently passed the Illinois Ground Water Protection Act, requiring the establishment of setback zones around public water supply wells. The Act also places restrictions on land use in relation to wellhead areas.

Minnesota, Wisconsin, Indiana, and Ohio have begun preliminary wellhead protection projects as well. Michigan has delegated authority for wellhead protection programs to the Michigan Department of Natural Resources and the State Department of Health. The State agencies will participate in a USEPA Region V task force during FY 1989 to generate consensus regarding the State wellhead protection program.

5.2.6 Discharges from Vessels

In addition to permitted discharges, some pollutants have entered the Great Lakes System as a result of accidental spills from vessels. As reported by the U.S. Coast Guard (USCG), the frequency of spills has been generally stable over the past decade, with a total of 218 incidents occurring in U.S. waters of the Great Lakes during calendar year 1987. Of this total, nine incidents involved the accidental release of hazardous chemicals and the remainder involved oil spills. Interagency response teams, led by the USCG, assessed each incident and monitored cleanup activities. Cleanup costs, excluding those for Government oversight, have been borne by private firms responsible for spills.

In FY 1989, the Loading and Sources Subcommittee of the Great Lakes Water Quality Board is requesting annual discharge loading summaries of all discharges, including spills of hazardous polluting substances from onshore and offshore sources (including vessels) into the Great Lakes.

In addition to conventional and toxic pollutants, exotic species of organisms can pose a threat to the Great Lakes. Nonindigenous fish have entered the Great Lakes and disrupted the balance of native species. The most recent example is the discovery in Lake Superior of the River Ruffe, a European perch-like fish. The River Ruffe were probably

transported via ballast water. The Great Lakes Fishery Commission recommends controls on ocean going ships discharging their water ballast in the Lakes.

5.3 NON-REGULATORY PROGRAMS

Non-regulatory programs are also necessary to achieve GLWQA objectives, some taking the form of direct government subsidy of activities that improve water quality. The most important of these is the Construction Grants program of the CWA, under which over $500 million was obligated for Great Lakes States in FY 1988. Federal and State support, exceeding $8 billion in sewage treatment facility construction grants through FY 1988, has been provided to assist municipalities throughout the Great Lakes Basin in meeting more restrictive effluent limitations. As a result of the Construction Grants Program, all major population centers in the Great Lakes Basin are now served by municipal wastewater treatment facilities. By 1985, for example, more than 95 percent of the population within Region V of the USEPA (i.e., Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin) was served by treatment facilities, and 99 percent of the sanitary wastes in sewered areas received at least secondary treatment.

Non-regulatory programs also can take the form of financial incentives, such as tax deductions for pollution control modifications, or new technology development and transfer, such as demonstration programs for new technologies or encouragement of no-till farming practices by the USDA's Soil Conservation Service field personnel. More information on these demonstration programs is provided in Chapter 6.

6. DEMONSTRATION PROGRAMS

Demonstration projects are an important step in the continuum of activities required to bring an environmental pollution control program from conception to implementation and, ultimately, to the point where measurable environmental results are achieved. Demonstration programs have played an integral role in the overall progress achieved in the Great Lakes Basin toward reduction of phosphorus inputs to the Lakes. The U.S. Environmental Protection Agency (USEPA) has conducted or participated in demonstration projects for phosphorus reduction from point and nonpoint sources for many years, involving many State, Federal, and local agencies working in cooperation.

Demonstration projects can also result in substantial cost savings, by showing the feasibility of alternative technologies and practices. For instance, a Section 10B demonstration project in Saginaw, Michigan, presented alternative means of controlling combined sewer overflows at a savings of $17 million in capital costs, together with lower annual maintenance.

The 1987 Amendments to the CWA call for Great Lakes National Program Office (GLNPO) to conduct a study that includes demonstration projects addressing remedial technologies for removal of toxic pollutants from the Great Lakes, with an emphasis on their removal from contaminated bottom sediments. The contaminated sediments study, in particular, the accompanying demonstration projects, will be important in developing and estimating the costs of Remedial Action Plans, as so many of the Areas of Concern (AOCs) have contaminated sediment problems. Moreover, the lessons learned in the contaminated sediments study should prove to be of national relevance.

Demonstration projects may take many forms. Most commonly, they involve demonstration of a hardware device or engineering technique for pollution cleanup or abatement. Demonstration projects may also involve development and testing of institutional models or regulatory alternatives for addressing environmental problems. Such projects typically involve cooperative efforts by several government organizations at the Federal, State, and/or local levels.

In the Great Lakes, as programs evolve to respond to the need for ecosystem approaches to environmental management, demonstration projects are likely to address the problems of intra-jurisdictional and cross-program coordination, within the United States as well as between the United States and Canada. In the future, GLNPO's demonstration programs are expected to combine both the technical and scientific aspects of pollution problems and increasingly complex coordination issues.

This Chapter describes recent demonstration projects conducted in the Great Lakes Basin in the three areas of particular concern to the Great Lakes Water Quality Agreement (GLWQA): contaminated sediments, point source discharges, and nonpoint discharges.

6.1 CONTAMINATED SEDIMENTS

As noted previously, the CWA requires that GLNPO conduct demonstration projects concerning cleanup of toxic pollutants, with special emphasis on removal or containment of contaminated sediments. The Act requires that GLNPO give priority consideration to demonstration projects in five locations: Saginaw Bay on Lake Huron, Sheboygan Harbor (Wisconsin) and the Grand Calumet River on Lake Michigan, and the Ashtabula and Buffalo Rivers on Lake Erie.

Accomplishments during FY 1988 included work on assessment protocols for sediment, a sediment problems severity index for site ranking, predicting the fate and effects of contaminated sediments, and work with EPA's Headquarters Office of Water on cleanup criteria for pollutants in sediment. Also in FY 1988, GLNPO neared agreement on an interagency agreement with the U.S. Army Corps of Engineers (USCOE) to assist with planning the demonstration program. Under the agreement, the Corps will assist GLNPO with researching and evaluating remedial technologies for sediments, accompanied by a literature review. GLNPO will also cosponsor a public interest workshop on contaminated sediments.

The contaminated sediment study, like other Great Lakes programs, will entail cooperation between Federal, State, and local agencies and cooperation between different USEPA programs at the Federal and State levels. Efforts to coordinate with other USEPA programs and to ensure that contaminated sediment problems are given adequate consideration in other USEPA regulatory and remedial programs will be very important. In FY 1989, GLNPO will be working with USEPA (Headquarters and regional Superfund programs), as well as with the USCOE, U.S. Fish and Wildlife Service, and others to conduct assessments in selected AOCs, and continue research on the effects and costs of alternative remedial actions.

6.2 POINT SOURCES

Demonstration projects for addressing point sources of pollution on the Great Lakes have concentrated on controlling conventional pollutants and reducing eutrophication. GLNPO has participated in evaluating and demonstrating techniques for phosphorus uptake from sewage, anaerobic oxidation phosphorus removal techniques, and in-line storm flow control devices. Each of these has shown potential for reducing discharges of phosphorus and other pollutants to the Lakes at a lower cost.

In future years, Great Lakes programs for point sources will focus on controlling discharges of toxic pollutants. During the next two years, several important new programs for controlling point source discharges of toxic pollutants will be developed and implemented under the CWA, including programs under Section 304(l), discussed in Chapter 4.

In FY 1989, GLNPO will begin developing a process for addressing Point Source Impact Zones in the Great Lakes, as required by the GLWQA, and will continue to work toward development of Lakewide Management Plans. These programs will require new or improved biological and chemical monitoring techniques and new regulatory approaches that will be the subjects of future Great Lakes demonstration projects.

6.3 NONPOINT SOURCES

Demonstration programs for nonpoint source pollution control techniques have had many successes in the Great Lakes. In 1972, Section 108(a) of the CWA authorized $20 million for USEPA to demonstrate the engineering and economic feasibility of pollution control in the Great Lakes Basin. This program was perhaps the largest nonpoint source control demonstration program in the United States.

GLNPO has worked closely with USEPA's Office of Research and Development, Headquarters and regional water programs, and State and local government organizations to conduct demonstration projects that covered a range of objectives, including demonstrating specific control technologies, controlling agricultural pollution through implementation of Best Management Practices, increasing public awareness of water pollution issues, documenting water quality results through monitoring, evaluating combined sewer systems, and evaluating various sewage land application techniques.

Management projects conducted under the Section 108(a) program included development of a watershed management computer model for identifying important pollution sources, development of model ordinances for pollution control, and development of other management tools. Other projects involved demonstrating sewage sludge land application techniques and conservation tillage practices. A key aspect of the tillage demonstration projects was the institutional aspect, which showed that by providing funding and technical assistance to local soil and water conservation districts, tremendous amounts of local support could be developed.

These projects have provided important institutional and technical insights beneficial to State and local programs. USEPA will continue to sponsor nonpoint source demonstration projects to ensure that the reductions in phosphorus discharges already achieved in the Basin are maintained. If ongoing evaluations show that more controls are necessary, USEPA will work toward further reductions through new demonstration and public education projects.

In FY 1988, GLNPO funded a workshop on developing watershed management plans for State agencies in the Great Lakes Basin. This workshop was the first step toward fulfilling the requirements of the GLWQA for placing necessary controls on toxic pollution from nonpoint sources. In FY 1989, USEPA will continue to characterize the extent of nonpoint sources of toxic pollution and identify toxic pollutant demonstration projects similar to those conducted to assist with programs for conventional pollutants.

For the Agricultural Demonstration Project, the programs of USDA have provided essential support, particularly in the form of technical assistance from the SCS and information and education support from the Cooperative Extension Service.

7. ENVIRONMENTAL SURVEILLANCE, MONITORING, AND RESEARCH

Meeting the objectives of the Great Lakes Water Quality Agreement (GLWQA) and the Clean Water Act (CWA) requires extensive surveillance, monitoring, and research efforts. Information is required to support the development of water quality objectives, prepare reports on conditions and trends in the Lakes, identify the causes of water quality degradation, and design and enforce effective remedial strategies.

Information needed to support the GLWQA and the CWA is currently provided by a number of government-supported programs within the Great Lakes region. However, these programs are undertaken by a variety of Federal, State and local agencies, each with their individual missions and responsibilities.

The 1987 Amendments to the CWA require the Great Lakes National Program Office (GLNPO) of the U.S. Environmental Protection Agency (USEPA) to establish a Great Lakes system-wide surveillance network, and to coordinate the many environmental activities relating to the Great Lakes undertaken by Federal, State, and local authorities.

Substantial progress has been made in the coordination of surveillance, monitoring, and research activities relating to Great Lakes water quality. These activities have evolved from the past focus on nutrients to obtaining toxic substance information as well. Major surveillance, monitoring, and research program objectives are to:

- Provide definitive information on the achievement of water quality objectives;
- Evaluate water quality trends;
- Identify emerging environmental problems;
- Support the development of Lakewide Management Plans (LMPs) and Remedial Action Plans (RAPs), including assisting in the development of pollutant mass balance models for the Great Lakes; and
- Assess the degree to which jurisdictional pollution control requirements are being met.

This chapter summarizes progress in developing a coordinated framework for Great Lakes environmental surveillance, monitoring, and research. It highlights the role of each of these areas in developing a major management framework innovation envisioned by recent Amendments to the GLWQA: the pollutant mass balance approach.

7.1 BACKGROUND

Surveillance and monitoring are necessary to identify and assess pollutant sources, determine pollutant loadings, measure water quality trends, identify emerging problems, assess the efficacy of remedial actions, and confirm compliance with source control or cleanup standards. Carrying out surveillance and monitoring in a system as large as the Great Lakes is difficult, however, and requires the use of large vessels.

Also, as concern has shifted from problems related to nutrient enrichment to those related to toxic pollutants, the cost and complexity of surveillance have grown exponentially.

Thus, an important component of the Great Lakes surveillance and monitoring program is setting surveillance priorities, in terms of pollutants of concern, media and sources to monitor, and areas to survey.

The first major surveillance program to address the objectives of the GLWQA was the Great Lakes International Surveillance Plan (GLISP), developed jointly by the United States and Canada in 1975. The original GLISP called for a cycle of intensive surveys of the Great Lakes conducted in a serial fashion (one lake at a time, with each lake surveyed once or twice a decade).

The first set of surveys was completed in 1983, and provided baseline data on water chemistry and microbiology, including information crucial to assessing problems of lake eutrophication caused by excessive levels of phosphorus. Since completion of the initial intensive cycle of studies, USEPA has continued a modified open lake sampling program to provide annual updates to our understanding of water quality on all Lakes except Lake Superior. Because of its high quality and slow rate of change, Lake Superior is sampled less frequently.

Great Lakes surveillance programs have evolved substantially in recent years, in response to changing priorities and increasing demand for information. As discussed earlier, the GLWQA reflects an increasing concern about toxic substances, especially those that are persistent in the environment. Responding to the problem of toxic pollutants requires an increased understanding of ecosystem structure and functions, interactions among physical, chemical, and biological components of the ecosystem, and the responses of organisms to various environmental conditions. As shown in Table 7-1, Federal and State surveillance and monitoring programs are responding to these increased information needs, with steadily increasing emphasis on toxic substances and biological systems.

Many of the environmental surveillance programs in operation within the Great Lakes region are part of, or make use of, larger national surveys or studies. For example, the National Weather Service of the National Oceanic and Atmospheric Administration (NOAA) monitors nationwide weather and climatic conditions, documenting precipitation patterns, which are essential to understanding Great Lakes hydrology. NOAA, the U.S. Army Corps of Engineers (USCOE), and the U.S. Geological Survey (USGS) survey bathymetric and hydrologic conditions within the Lakes and their tributaries, providing a foundation for other studies. The U.S. Fish and Wildlife Service (USFWS) monitors populations of fish and waterfowl and conducts the National Wetlands Inventory. (NOAA also surveys wetlands in coastal areas of the United States.) And finally, the USEPA carries out regional and national surveys of air quality and drinking water conditions.

These and other such programs contribute information that is vital to a full understanding of Great Lakes water quality conditions. Conversely, Great Lakes monitoring programs contribute data to national networks and data bases. For example, results from the Great Lakes Atmospheric Deposition (GLAD) network are transferred to the National Atmospheric Deposition Program. Also, results from open lake and tributary monitoring, together with fish contaminant data, are transferred to STORET, the national water quality data base.

The core U.S. program for surveillance of the Great Lakes is coordinated, and to a large extent, conducted by GLNPO, and is directly focused on the requirements of the GLWQA. This program consists of four major components: open lake, nearshore/harbor, pollutant loadings, and sources of pollutants.

Table 7-1. U.S. Environmental Surveillance and Monitoring Programs in the Great Lakes Region

Programs/Activities	Explanation	Relevant Institutions
Open Lake Water Quality Surveillance Program	Systematic field surveys of water chemistry and plankton.	USEPA-Great Lakes National Program Office
Fish Contaminant Monitoring: Wholefish	Smelt, lake trout, and walleye (Lake Erie only) from the open lakes are analyzed for a wide variety of known or emerging problem pollutants to evaluate trends and lake-wide response to regulatory actions. Periodic scans to detect new contaminants are also conducted.	USEPA-Great Lakes National Program Office, U.S. Fish and Wildlife Service (USFWS)
Fish Contaminant Monitoring: Edible Portions	Skin-on fillets of salmon are collected from Great Lakes harbors and tributary mouths during spawning runs. In Lake Erie, Rainbow Trout are also collected. The fish are analyzed for known problem contaminants to evaluate trends and provide information on human exposure.	Great Lakes States, USEPA-GLNPO, and U.S. Food and Drug Administration (USFDA)
Local Area Fish Contaminant Surveys	Non-migratory fish are sampled to identify local hot spots and trends.	USEPA-Great Lakes National Program Office and Great Lakes States
Harbor and Connecting Channels Sediment Surveys	Periodic collection of samples from all major tributary mouths and harbors and the connecting channels for broad-scan analyses, including heavy metals and persistent organics.	USEPA-Great Lakes National Program Office, U.S. Army Corps of Engineers Section 10 and 404 Program outputs
Open Lake Sediment Surveys	Preliminary program initiated in Lake Ontario during 1987.	USEPA-Great Lakes National Program Office, Region II Superfund Office, Office of Research and Development, and New York State Department of Environmental Conservation

Table 7-1. U.S. Environmental Surveillance and Monitoring Programs in the Great Lakes Region (continued)

Programs/Activities	Explanation	Relevant Institutions
Tributary Sediment Surveys	Samples collected in zones of degraded sediment quality, usually downstream of significant point or nonpoint sources. Often performed in conjunction with use attainability analyses or National Pollutant Discharge Elimination System (NPDES) permit reissuance.	Great Lakes States
Tributary Fish Collection Surveys	Popular sport fish are collected and analyzed for pesticides and other persistent toxicants.	Great Lakes States
Colonial Bird Contaminant Surveys	Eggs of fish-eating colonial birds are collected and analyzed for contaminants.	Great Lakes States and USFWS
Bathymetric and Hydrologic Surveys of Open Lake Areas	Map lake bottom topography, determine water budgets, monitor lake levels and water withdrawals.	National Oceanic and Atmospheric Administration (NOAA)
Bathymetric and Hydrologic Surveys in Navigation Channels and Harbors	Map bottom contours in navigational channels to support channel maintenance projects and provide navigational aids.	U.S. Army Corps of Engineers
Fishery Surveys	Monitor fish populations and commercial activities including surveys of fish abnormalities such as tumors.	NOAA-National Marine Fisheries Service, USFWS, USEPA and States
National Contaminant Biomonitoring Program	Nationwide sampling system, including fish and wildlife tissue analysis for persistent pollutants.	U.S. Fish and Wildlife Service
Point Source Effluent Biomonitoring	Biomonitoring of discharges to detect and prevent toxicity.	USEPA and States
National Resources Inventory	Broad, comprehensive survey of the nation's soil, water and related resources. Prepared every 5 years.	USDA-Soil Conservation Service

Table 7-1. U.S. Environmental Surveillance and Monitoring Programs in the Great Lakes Region (continued)

Programs/Activities	Explanation	Relevant Institutions
National Human Tissue Contaminants Data Base	Samples of fatty tissues analyzed, with results stored in national data base.	U.S. Environmental Protection Agency
Climate and Weather Monitoring	Monitor temperature, precipitation, and other weather parameters.	NOAA-National Weather Service and State Agencies
Waterfowl Surveys	Conduct national surveys of waterfowl populations and determine trends.	U.S. Fish and Wildlife Service
National Wetlands Inventory	Map all U.S. wetlands and determine national trends.	U.S. Fish and Wildlife Service
Coastal Wetlands Inventory	Map wetlands in coastal areas and determine trends.	National Oceanic and Atmospheric Administration
National Mapping Program	Systematic mapping and characterization of land use and land cover, including surface topography, surface waters and wetlands, natural forests, agricultural lands, urban centers, and major industrial complexes.	U.S. Geological Survey
Point Source Discharge Monitoring	Self-monitoring of effluent characteristics as provisions of NPDES permits.	Permittees, States, U.S. Environmental Protection Agency
Pesticide Use Inventory	Estimates of pesticide use by crop and acres planted per crop yields calculated statewide pesticide use figures.	USEPA-Office of Pesticide Programs
Tributary Mouth Water Quality Monitoring	Systematic sampling of tributary water for pollutants. Flow and concentration data are reported to International Joint Commission (IJC) for calculation of phosphorus loads to the Lakes.	Great Lakes States and U.S. Geological Survey

Table 7-1. U.S. Environmental Surveillance and Monitoring Programs in the Great Lakes Region (continued)

Programs/Activities	Explanation	Relevant Institutions
Streamflow Monitoring and National Stream Quality Accounting Network	Routine monitoring of flow and core set of quality parameters for major tributaries.	U.S. Geological Survey
Great Lakes Atmospheric Deposition Network (GLAD)	Monitoring network to measure deposition of nutrients and toxics, throughout the Basin.	Great Lakes National Program Office and States

7.2 OPEN LAKE SURVEILLANCE AND MONITORING

Open lake surveys measure the conditions and trends in the open waters of the lakes. These waters reflect long term changes, as they are far more uniformly mixed than the shallower, nearshore waters that are directly influenced by pollutant discharges and are far more variable in quality. Open lake waters are generally defined as being greater than 30 feet in depth.

Most open lake surveillance is conducted using large vessels, although water sampling is done by helicopter, and some useful information is obtained from municipal drinking water intakes that are located in open lake waters. The GLNPO research vessel, the R.V. *Roger Simons*, has been used for many years to gather open lake water samples to measure chemistry and plankton populations. However, at 49 years of age, the vessel is nearing the end of its useful life, and its ship-board laboratory is very limited. At the close of 1988, arrangements were nearing completion for the purchase of a replacement vessel that will be outfitted during FY 1990. By 1991, the new vessel should be available to conduct surveys, including the measurement of toxic contaminants.

7.2.1 Limnology

The limnology program carried out by GLNPO characterizes the biological and chemical status of the Lakes by measuring water chemistry (with particular emphasis on nutrients), plankton populations, and biological productivity. This program supports the development, testing, and refinement of eutrophication models used to estimate the phosphorus assimilative capacity of the Lakes, which in turn, provides a basis for developing target load reductions.

The models are also used for interpreting data, defining the applicability of specific data sets, and designing improved monitoring programs for the collection of data. The transfer of models from the USEPA's mainframe computer to personal computers began in 1986 and new software continues to be developed to assist the surveillance-research-management process.

The productivity measurements made as part of the limnology program will assist in describing the trophic status and assessing the response of the Lakes to nutrient control programs. The measurements will also assist in interpreting trends in algal and plankton populations and in anticipating resultant impacts on fish communities in response to phosphorus source control measures.

7.2.2 Water Column Contaminants

Toxic contaminants in Great Lakes waters can exert adverse effects on aquatic and terrestrial populations ranging from subtle behavioral changes through increased susceptibility to diseases, birth defects, tumors, reproductive failure, and premature death. Over the past ten years, GLNPO has sponsored surveys of toxic metals in the Great Lakes. Other programs, most notably the Sea Grant Program of NOAA, have funded studies of various contaminant distributions in one or more of the Great Lakes.

Polychlorinated biphenyls (PCBs) in Lake Michigan have been of special interest to academic researchers trying to understand and measure the rates of the processes that distribute and transform toxic pollutants in the Great Lakes ecosystem. No routine program to monitor toxic organics in water of the open Lakes currently exists in the United States,

due to technological limitations in such trace level analyses. A major anticipated product from the Green Bay Mass Balance Study is the further development of needed technology to perform such analyses and the transfer of that technology to open Lake monitoring programs.

7.2.3 Sediment Contaminants

Initial strides have been taken toward developing an open lake sediment sampling program. In 1987, with the financial assistance of the USEPA's Region II Superfund program, the R.V. *Roger Simons* collected open lake sediment samples from approximately 60 locations in Lake Ontario to characterize the concentration and distribution of persistent toxic pollutants along the bottom of the Lake, with particular focus on 2,3,7,8-TCDD. This information is fundamental to developing a mass balance model for the Lake. In FY 1989, GLNPO will begin to take open lake sediment samples in Lake Michigan.

7.2.4 Fish Contaminants

Most toxic pollutants are found in very small concentrations in lake water, making them very difficult to detect or measure. However, some toxic pollutants accumulate in the tissues of organisms and increase in concentration through the food chain. The primary program for detecting and tracking such pollutants in the Lakes has been the Great Lakes Fish Contaminant Monitoring Program. This program, initiated in 1977, has involved the participation of 20 different State and Federal agencies.

Fish tissue monitoring complements not only water chemistry studies, but also provides a means of estimating fish bioaccumulation factors that are a critical component in the development of water quality standards to protect human health, as well as fish-eating land-based predators. Through this program, major declines in concentrations of contaminants such as DDT, PCB, and dieldrin have been documented in top predator fish collected in the open waters of the lakes over the past 15 years.

However, during the same period, numerous other persistent pesticides and industrial chemicals have been identified in Great Lakes fish as part of the early warning component of the program. For some of these compounds, such as toxaphene, mirex, and dioxin, regulatory action has since been taken. For the majority of these compounds, however, insufficient information is available to judge their effects on human health and the environment. Until further information on such compounds is obtained, needed regulatory measures cannot be adequately defined.

7.3 NEARSHORE AND HARBOR SURVEILLANCE

Nearshore surveys are conducted using a combination of large and small vessels. Water, living organisms, and sediment are all sampled, but emphasis is often placed on fish and sediment as the best places to sample for toxic substances.

Severely degraded nearshore areas have been designated as Areas of Concern (AOCs) and surveillance plans are being developed for them as part of the RAPs that are being prepared to guide their restoration. Surveillance within the AOCs is to be conducted by State and local organizations. An exception to this is the surveillance to be conducted as part of the GLNPO demonstration projects for contaminated sediments.

In other nearshore areas, GLNPO conducts surveys from time to time to identify hot spots and trends. A major interagency nearshore study of the Upper Great Lakes Connecting Channels is nearing completion.

To focus limited surveillance resources on "hot spots," GLNPO is expanding its routine fish monitoring program to include non-migratory fish collection. Non-migratory nearshore fish, such as the young-of-the-year spottail shiner, do not range far from their place of birth, thus accumulating toxicants from a fairly narrow area of the Great Lake shoreline. When analyzed for a broad spectrum of toxic substances, these fish can serve to focus in on existing or new pollution sources. After source control or cleanup measures have been instituted, such fish will aid in measuring the response of the harbor and nearshore aquatic ecosystems to those remedial activities.

7.4 POLLUTANT LOADINGS

In addition to measuring ambient open Lake and nearshore water quality, USEPA is concerned with estimating the extent of actual ongoing loadings of pollutants to the Lakes. This information is vital to understanding the ecosystem and the extent of pollution and the control needed to attain the water quality objectives set by the GLWQA. It also reveals the relative significance of various types of pollutant sources. This knowledge will be used to guide environmental management decisions through mass balance modeling of the ecosystem (described in Section 7.6).

To determine total loadings, information must be obtained on inputs through all pathways. The two principal routes are through the atmosphere and through tributary streams. An intermediate category is that of contaminated sediments that can recycle significant quantities of stored contaminants back into the water and biota. Sources of pollutants that are conveyed by tributaries are discussed in Section 7.5 and include point source discharges, nonpoint sources, and contaminated ground water.

7.4.1 Atmospheric Deposition Monitoring

In 1981, GLNPO established an atmospheric deposition monitoring network to provide basic data on the nature and magnitude of the atmospheric deposition problem in the Great Lakes. The network is based on the pre-existing GLAD network begun in 1976. By 1982, this network consisted of 36 wet-only precipitation samplers located at rural, urban, and background sites around the Great Lakes shoreline and on some islands.

Since 1985, GLNPO has been involved in a major undertaking to plan and implement an enhanced atmospheric research and monitoring program capable of detecting and quantifying toxic organic substances in wet and dry deposition to the Great Lakes. This planning process recongizes the need for a fully coordinated, joint U.S. and Canadian program with compatible sampling and analytical protocols.

Two major workshops of experts have been held to assess the problem of atmospheric deposition and to assist in the design of an atmospheric research and monitoring program. The first was sponsored by GLNPO and the University of Minnesota and the second was sponsored by the IJC at Scarborough, Ontario. In addition, the IJC Surveillance Work Group established the Atmospheric Deposition Task Force, charged with the design of an atmospheric research and monitoring network.

As a result of the activities described above, there are two major research and monitoring plans to address the deposition of air toxics to the Great Lakes. The first was completed in 1987 for GLNPO and is entitled, "Proposed Modification of the Great Lakes Atmospheric Deposition (GLAD) Network to Include Toxic Organics." This plan calls for the establishment if five master stations across the Great Lakes to support necessary research on deposition and exchange processes along with development of improved samplers.

Concurrent with establishment of the master stations, the plan calls for the enhancement of twelve routine GLAD stations to include sampling for toxic organics using currently available sampling equipment. Under a joint grant to the Illinois State Water Survey and DePaul University, GLNPO established the first master station and two routine stations on Green Bay in 1988 to begin deployment of the planned network and to support the ongoing Green Bay Mass Balance Study. In addition, GLNPO has continued to participate in planning discussions with Canadian and U.S. experts to further refine the enhancement of the GLAD Network to achieve compatibility with and concurrence of Canadian programs.

In 1988, the IJC Atmospheric Deposition Task Force completed its plan entitled, "A Plan for Assessing Atmospheric Deposition to the Great Lakes." The IJC plan calls for the establishment an operation of two master station over a two-year period, followed by the phased establishment of routine stations as research results become available. This plan was submitted to the Water Quality Board with a recommendation for its inclusion in the Great Lakes International Surveillance Plan.

In December 1988, the Parties established a small committee to review the two existing plans, to resolve the remaining differences in the plans, and to recommend a joint U.S.-Canadian research and monitoring plan on atmospheric deposition. It is anticipated that the joint plan will be completed by June 1989. Concurrently, three ad hoc committees of experts are completing detailed planning of quality assurance/quality control procedures, analytical methods, sampler design, and siting criteria to be used in the deployment of the joint network.

There are three projects recently completed or ongoing in the Great Lakes Basin that will further contribute to understanding of the air sources of problem toxic pollutants entering the Great Lakes. The first is the Air Toxic Emission Inventory for the Southeast Chicago (Summerhays and Croke 1987), phase one of a two-phase study recently completed by USEPA Region V's Air Management Division. The first phase attempted to estimate the emissions rates of a wide variety of inorganic and organic pollutants in a well-defined, highly industrialized geographic area of the shores of Lake Michigan. In the second phase, mathematical modeling will relate emissions rates to concentrations at ground level and the corresponding health risks to exposed humans.

The second pilot project is the Emissions Inventory and Deposition Modeling of Air Toxics in the Lake Michigan Region, now underway, with a preliminary report by USEPA Region V's Air Management Division to be completed in early 1989. Once air source data from the major metropolitan areas are collected, USEPA will attempt to model deposition of toxic pollutants to the Lake Michigan watershed and directly to the Lake to estimate total atmospheric deposition loadings from near-field sources in the Lake Michigan airshed.

The third project, the Great Lakes Air Toxics Transboundary Project, focuses on sources located in a 50-kilometer-wide corridor on either side of the shores of the Detroit River-St. Clair River systems, including the Detroit/Windsor and Port Huron/Sarnia urban/industrial centers. The project includes an emissions inventory, dispersion modeling,

human risk assessment, and deposition analysis of pollutants of concern in the watershed basin.

Taken together, these projects will add considerably to USEPA's understanding of the significance of air deposition to the water quality of the Great Lakes and their connecting channels. These projects represent an important step in implementing the total load management approach embodied in the LMPs required in Annex 2 of the GLWQA.

Also in FY 1988, through Region V Air and Water Divisions, GLNPO negotiated new State air and water program plans, encouraging the States to inventory combustion sources and sample and analyze them for Critical Pollutants. Data obtained will be used to further guide development of LMPs.

7.4.2 Tributary Monitoring

Tributary loadings are estimated by combining USGS river flow data with water quality sampling data gathered by the States. Intensive studies of storm flows have been sponsored by GLNPO in recent years to determine the adequacy of existing routine monitoring for sediment and phosphorus. An intensive surveillance project is being conducted as part of the interagency study of Green Bay that will provide important information on the feasibility of monitoring toxic organic compounds in tributary waters.

7.4.3 Contaminated Sediment

Information for estimating the release of pollutants from sediments can be obtained from various sources. Chemical analyses and toxicity testing of tributary and harbor sediments can be required in the course of USCOE dredging projects or as a provision of private dredge and fill actions, which are permitted by the Corps under Section 404 of the CWA. The States must certify the consistency of permitted dredge and fill actions with their water quality regulations.

Hazardous waste regulations can involve data collection and analysis that is relevant to Great Lakes water quality management. For example, an open lake sediment survey was undertaken by Region II of the USEPA to determine the maximum acceptable rate of loss of 2,3,7,8-TCDD from the Hyde Park landfill to Lake Ontario. With this information, the Regional Superfund office will negotiate final containment requirements for the landfill.

To further evaluate the extent of the contaminated sediment problem, GLNPO will begin an open Lake sediment survey program in FY 1989. This program will initially survey Lake Michigan. In addition, it is anticipated that some States will sponsor surveys of sediment contamination in AOCs as part of their development of RAPs.

7.5 SOURCES OF POLLUTANTS

The identification and monitoring of pollutant sources is essential to support regulatory programs. The sources of pollutants are varied. Numerous monitoring programs are in place or else are in the development phase to determine compliance and improvements in the system.

7.5.1 Point Sources

Point source dischargers are required by their permits to report the concentrations of their discharges. This information is useful in identifying sources of pollutants and to a limited degree, in estimating loadings entering the tributaries. Also, toxicity testing requirements are included in some permits, providing useful information.

The Agreement mandates that municipal wastewater treatment facilities meet a technology-based 1 mg/l phosphorus limitation to achieve lakewide target nutrient load reductions. In addition, the Agreement calls for the virtual elimination of the discharge of persistent toxic substances to the Great Lakes, requires that toxic discharges cease, and directs the Parties to reduce the size of the zones of degraded water quality in the vicinity of point source discharges to the maximum practicable extent.

GLNPO, with the assistance of USEPA Regions II, III, and V, analyzes point source discharge data submitted by facilities that are required to monitor their waste waters for compliance with effluent limitations in permits issued and enforced under the National Pollutant Discharge Elimination System (NPDES). Phosphorus loading estimates for point sources based on these data are submitted to the Great Lakes Water Quality Board for inclusion in its biennial report on Great Lakes water quality. Phosphorus loading estimates are also used to judge progress of the United States under the Phosphorus Load Reduction Plan developed under the GLWQA.

Existing information on toxic pollutants of concern in wastewater discharges within the Great Lakes system is still too scant for accurate estimates of point source load contributions to each of the Great Lakes. Some permits require routine toxicity testing of effluents, involving tests such as bioassays. While these tests are carried out by the permittee, results are shared with State and Federal agencies. Surveys to assess compliance with permit limitations are also conducted by regulatory agencies.

Permittee self-monitoring data are stored in a computer information system known as the Permit Compliance System. The results of Federal or State agency compliance inspection monitoring and select self-monitoring data are also contained in STORET, USEPA's general water, sediment, and biota quality data base. Permittee and agency whole effluent toxicity test results are summarized in the CETIS data base.

To analyze the contributions of persistent toxic pollutants by point sources, GLNPO has supported a national data base of monitoring data from Form 2c NPDES permit applications. In addition, USEPA Region V and GLNPO have supported the Michigan Department of Natural Resources in updating and expanding its Critical Materials Register, a list of toxic substances meriting State surveillance. Each year, Michigan facilities are required to report the production/use, discharge, and disposal in solid residuals of critical materials.

These data are compiled in a computer data base developed under the Toxic Substances Control Act. Total loadings of Great Lakes pollutants of concern can be compiled on an individual facility, river or lakewide basis. GLNPO is using these loading estimates as part of a larger effort to calculate total loadings of persistent toxicants to the Great Lakes from all sources.

7.5.2 Nonpoint Sources

Annex 3 of the GLWQA sets forth a general framework for Canada and the United States to reduce phosphorus loading to the Great Lakes. Subsequent supplements to the Annex recognized that nonpoint source controls on phosphorus, particularly from agricultural activities, would be required to meet the Agreement goals. The Great Lakes Phosphorus Task Force, comprised of Federal, State, and local entities, allocated phosphorus load reductions for each State.

Each State currently monitors phosphorus levels and reports on progress in meeting targeted reduction goals. Routine monitoring of pollutant loads from nonpoint sources is seldom conducted through direct measurement of runoff. More often, changes in loadings are estimated by tracking changes in land management and farming practices and calculating expected changes in pollutant runoff. These calculations are based on intensive research surveys used to identify the results of various management practices.

7.5.3 Contaminated Ground Water

Pollution from contaminated ground water is the subject of Annex 16 of the GLWQA. The United States and Canada must report on progress made to control sources of contamination of groundwater aquifers and prevent movement of polluted ground water to the boundary waters of the Great Lakes. Each responsible State and province must first identify existing and potential sources of contaminated ground water to the Great Lakes.

USEPA Region V has adopted a Ground Water Protection Strategy, focusing on multiprogram groundwater issues and designed to unify the many groundwater initiatives at the Regional level. The Strategy's goals and objectives will guide Region V's future groundwater protection activities, and promote a coordinated approach to groundwater decision making.

The goals of the Strategy encompass groundwater protection and restoration, and promote an area-wide groundwater perspective. The Strategy objectives center on including groundwater objectives in Regional decision making, and developing risk based health and environmental decision-making criteria. The objectives also addresss the identification and restoration of ground water impacting surface water, assisting in the implementation of State groundwater strategies, and increasing the collection and accessibility of water quality data.

Other U.S. efforts in support of Annex 16 include the following: GLNPO initiated a training program for staff to use the Geographic Information System to map the hydrogeologic conditions of the Great Lakes. The Green Bay Study will include compiling a comprehensive inventory of known and potential sources of groundwater contamination in the Green Bay Basin. The USGS recently completed a 4-year study in cooperation with Canada on the environmental conditions in the Upper Great Lakes Connecting Channels. One objective of the study was to be determine groundwater loadings into the Connecting Channels.

7.6 MASS BALANCE STUDIES

As described in Chapter 4, the pollutant mass balance concept is crucial to developing the systematic and comprehensive ecosystem approach to water quality management that is envisioned under the recently revised GLWQA. Mass balance models must draw upon

established surveillance and monitoring programs for information, but also rely on research programs for study design, development, and interpretation.

USEPA regards the "mass balance" approach to be integral to satisfying the GLWQA principle of systematic and comprehensive remedial planning. The mass balance approach adopts the concept of conservation of mass in evaluating the sources, transport, and fate of contaminants. Its underlying principle is that the quantities of contaminants entering the system, less quantities stored, transformed, or degraded in the system, must equal quantities leaving the system.

Using computer models and data concerning the sources and quantities of toxic pollutants, their physical properties, and the descriptive characteristics of the Great Lakes, the mass balance approach allows scientists to identify the most significant sources of pollutants and to evaluate potential effects of changes in pollutant loadings. This, in turn, helps managers to set priorities for funding of research, remedial actions, and regulatory programs.

A number of surveillance and monitoring programs provide information on the magnitude and types of pollutant loadings to the Great Lakes. Data is required on pollutant loadings from all potential pathways. Some of these pathways are monitored directly, such as atmospheric deposition. Other pathways, such as point source loadings to surface water, are monitored by States with assistance or advice as needed from the GLNPO. Still others, such as pollutant transfers from sediments, are or will be estimated using predictive models and limited environmental monitoring data. The Upper Great Lakes Connecting Channel Study and the Green Bay Mass Balance Study are providing valuable data with which to assess these pathways.

The Upper Great Lakes Connecting Channel Study was a four-year binational effort, involving the coordinated efforts of 11 Federal, State, Provincial, and local agencies, to investigate toxic chemicals and other environmental concerns in the Upper Great Lakes Connecting Channels. The objective of the study was to improve regulatory management of point and nonpoint pollution sources in the Detroit, St. Clair, and St. Mary's Rivers, and in Lake St. Clair. The study was organized so that the participating agencies could coordinate ongoing studies in the areas and identify priorities for remedial actions.

The overall goal of the Green Bay Mass Balance Study is to test models for toxics to improve our understanding of the sources, transport, and fate of toxic compounds, to evaluate the technological capability to measure multimedia loadings to a system, and ultimately to guide and support regulatory activity. The study will serve as a pilot for future modeling studies of Great Lakes ecosystems.

During FY 1987, field reconnaissance was done in the Bay and tributaries, and the first atmospheric deposition monitoring stations were established in preparation for the main field season -- August 1988 through September 1989. Samples to be collected during this time include bottom sediments, Bay-lake exchange, atmospheric deposition, water and suspended sediments, tributary loads, point and nonpoint sources, ground water, and biota.

The Mass Balance Study will apply models to PCBs, dieldrin, cadmium, and lead. The physical/chemical models will be coupled with a food chain model to allow estimation of body burdens in target fish species: carp, brown trout, and walleye. The integrated model will then be used to predict concentrations in the water, sediment, and biota under alternative regulatory and remedial actions.

7.7 RESEARCH

Research on the Great Lakes is carried out to improve our fundamental understanding of the physical, chemical and biological processes of the Lakes and their interrelationships. Research is conducted primarily by universities that are funded by the National Science Foundation, USEPA's Office of Research and Development (ORD), and NOAA's Sea Grant Program. The results of these studies provide a context for addressing problems of water quality restoration and protection, habitat maintenance, and fisheries management.

Applied research in the Great Lakes is conducted on a wide range of topics by a number of Federal agencies. Much of this work is undertaken by the ORD Large Lakes Research Station at Grosse Ile, Michigan, and at its National Water Quality Laboratory at Duluth, Minnesota; NOAA's Great Lakes Environmental Research Laboratory (GLERL) at Ann Arbor, Michigan; and the USFWS, which operates the National Fisheries Research Center-Great Lakes.

NOAA also provides grants to Universities for Great Lakes research under its Sea Grant Program, and the USFWS funds Cooperative Fishery Research Units at selected universities. GLNPO provides grant money for research directly to universities and through interagency agreements with other governmental organizations, including NOAA, the USFWS, and the USCOE.

Great Lakes research consists of three general areas: water quality management, ecosystem dynamics, and fishery resources (Table 7-2). Many of the major Great Lakes research organizations contribute to multiple research areas, although one organization has assumed a leadership role for each area (Figure 7-1). Projects within each area are planned and conducted to ensure that overlap is minimized and that each project makes a needed and unique contribution that furthers the scientific understanding of physical, chemical, or biological processes working in the ecosystem. Similarly, the results of projects in each area are used to identify emerging research needs and to design effective research plans.

GLNPO has supported research by the Argonne National Laboratory, the Illinois Water Survey, and various universities on atmospheric deposition to Lake Michigan. Argonne has also carried out research on Lake Michigan biological systems. Research by the USCOE has focused on Great Lakes water levels and flows and on dredging and disposal of dredged materials. In FY 1988, GLNPO provided funds for research on contaminated sediments to the USCOE under an interagency agreement. GLNPO also funded research and development activities to address toxics in the Great Lakes during 1987 and 1988, including studies on improved tributary monitoring methods for toxics and an investigation of the toxic effects of contaminants unique to the Great Lakes.

Research support for the Green Bay Mass Balance Study was the top GLNPO priority in FY 1988. Matching funds were provided to GLERL for investigating the rate of exchange of contaminants between Green Bay and Lake Michigan. This work will support the development of a mathematical model by EPA's Large Lakes Research Station to simulate pollutant exchanges as part of the overall pollutant transport component of the mass balance study.

Also in FY 1988, GLNPO funded research at the University of Minnesota to investigate the rate of uptake of PCBs, an important contaminant in Green Bay, by phytoplankton. This work will also support the development of a mathematical model to be used in the mass balance. Both of these projects and other developmental work for the Green Bay study are continuing in FY 1989.

In addition, GLNPO funded research to support its contaminated sediments study in FY 1988. Through an interagency agreement with the ORD, GLNPO funded research at several universities to investigate the extent of sediment contamination in Lake Ontario and to study sediment resuspension, deposition, and fate in the Lakes. This latter work will support the development of mathematical models to describe the rates at which contaminants are transferred from water to sediment and from sediment to water. In addition to supporting the contaminated sediments study, this project will contribute important information to the Green Bay Mass Balance Study. Both projects are continuing in FY 1989.

The recent trend toward understanding Great Lakes pollution problems in the context of their significance for the whole ecosystem (the ecosystem management approach called for by the GLWQA), will shape research priorities for Great Lakes programs in the future. Because an ecosystem approach to research and management requires the integration of many different disciplines and perspectives for problem solving, many Federal and State organizations will continue to be involved in Great Lakes research. Thus, the need for effective coordination will likely increase in the future.

One area in which GLNPO will continue to be an important contributor to research programs is the development and implementation of demonstration programs for pollution abatement and remediation on the Great Lakes, which is addressed in Chapter 6.

To perfect available methodologies for quantifying ultratrace concentrations of persistent and highly bioaccumulative toxic pollutants, GLNPO is testing a number of high-volume sample concentration techniques. The use of such methodologies will be demonstrated in the Green Bay Mass Balance Study, where water column levels of PCBs and dieldrin must be measured to quantify the relationship between loadings and concentrations, and between concentrations and the rate of various water column removal processes.

In FY 1989, GLNPO plans to start sampling sediments in the main body of the Lakes to measure the distribution, storage, and fate of toxic pollutants in the ecosystem. This sampling will provide a chronology of toxic inputs to the Lakes and support mass balance models for Critical Pollutants. Sampling will also support the development of LMPs as required in the GLWQA and the contaminated sediments study mandated by the CWA Amendments of 1987. GLNPO coordinates this work with the development of national sediment criteria and sediment contaminant cycling studies conducted by USEPA's ORD Laboratories at Duluth, Minnesota, and at Grosse Ile, Michigan.

In addition, GLNPO has co-funded the development of a technique for measuring the tumor-producing potential of contaminated sediments in nearshore bottom feeders, such as the brown bullhead. Such methods are critical for surveying the toxicity potential of contaminated sediments. This work may lead to more refined studies and assays of chemical carcinogenesis, to determine the relative severity of effects of different toxic chemicals.

Finally, under a grant from GLNPO, the University of Texas is developing an assay for estimating the carcinogenic potency of a mixture of contaminants extracted from Great Lakes fish. This assay may aid in estimating the health risks associated with the complex mixture of contaminants in Great Lakes fish eaten by humans and wildlife. This approach is being extended by the U.S. Fish and Wildlife Service's Lansing District Office under a grant to Michigan State University to study the eggs of fish-eating birds in the Great Lakes.

Table 7-2. U.S. Great Lakes Research Programs

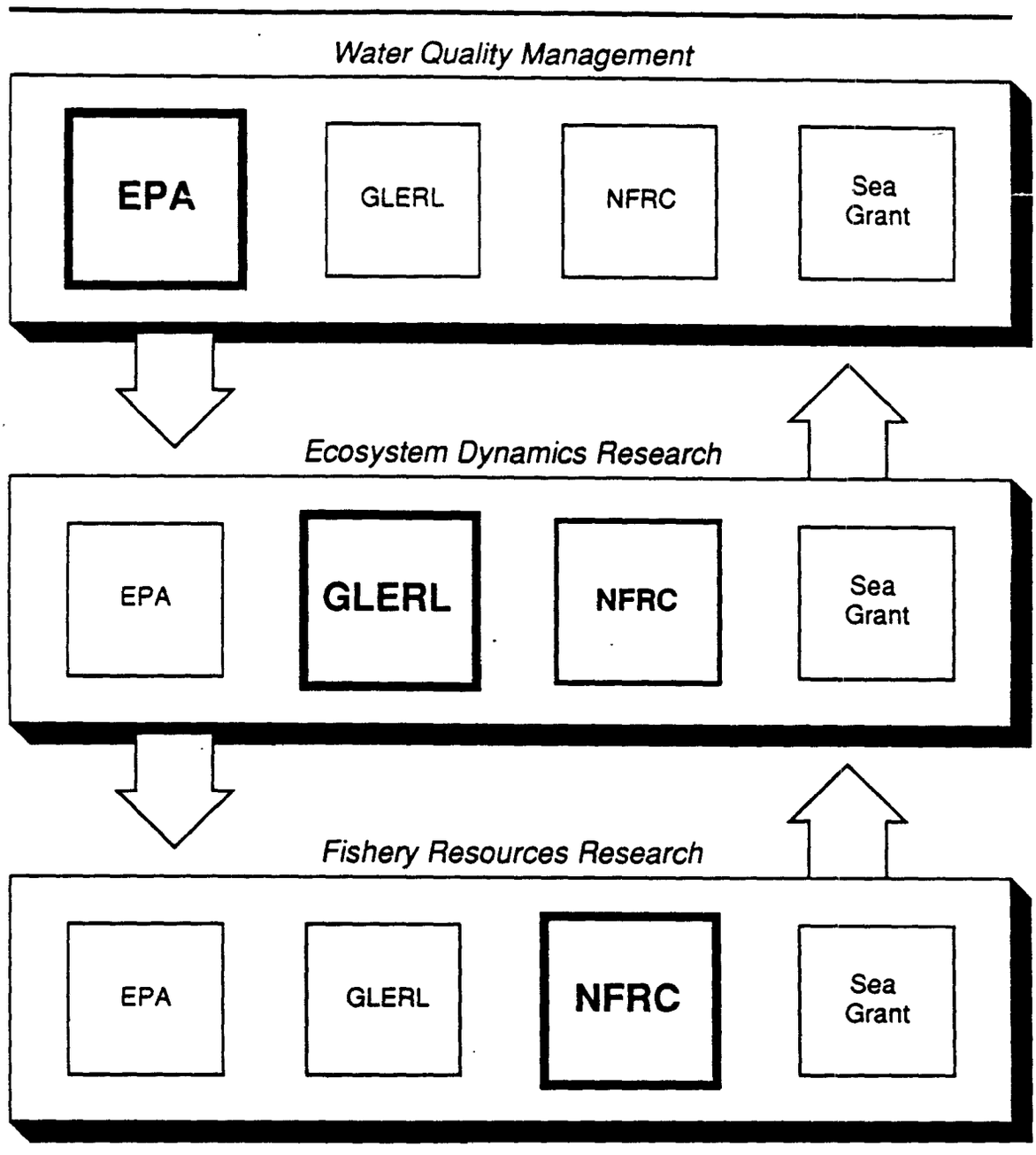
Programs/Activities	Explanation	Relevant Institutions
Water Quality Management		
Contaminated Sediment Studies	Engineering research and remediation technologies. Sediment resuspension, deposition and fate for remediation activities and mass balance models.	U.S. Army Corps of Engineers, USEPA, ORD, and LLRS
Atmospheric Deposition	Research into methodologies and technologies for air particle and vapor contract to USEPA-Great Lakes collection, measuring wet and dry deposition, linking receptor patterns to sources. Preliminary quantification of wet and dry deposition loads to Green Bay in 1988.	DePaul University under National Program Office
Mathematical Models	Development of mathematical models representing the processes of transport, dissipation, accumulation, transformation, and loss of particles, nutrients, and pollutants in large aquatic ecosystems.	USEPA's Large Lakes Research Station (LLRS)-Grosse Ile
Water Quality Criteria to Protect Aquatic Life	Studies of acute, chronic and life cycle toxicological effects of high priority chemicals, including those found in the Great Lakes.	USEPA's Environmental Research Laboratory (ERL)-Duluth

Table 7-2. U.S. Great Lakes Research Programs (continued)

Programs/Activities	Explanation	Relevant Institutions
Sediment Quality Criteria	Development of a land use and management-driven model to aid in the identification of agricultural nonpoint source pollution. The model, AGNPS (Agricultural Nonpoint Source), includes components related to pollutant transport and loading, groundwater contamination, and lake hydrology.	USDA Agricultural Research Servi North Central Soil Conservation Research Laboratory, Morris, MN
	Studies of the rates of release and biological availability of toxic pollutants from contaminated sediments to test methodologies for deriving water quality-equivalent sediment quality criteria.	USEPA's ERL-Duluth, USEPA's LLRS-Grosse Ile and USFWS-Columbia, MO/Ann Arbor
Risk Assessment	Research into the sources of and methods for reducing uncertainties in exposure and toxicity estimates upon which source control and cleanup activities are based.	USEPA
Quantitative Structure Activity Relationships (QSARs)	Research into methods for estimating physical, chemical, biological, and toxicological properties affecting risk using QSARs and readily measured or estimated property data. Development of a menu driven expert system to guide regulatory uses of these methods.	USEPA's ERL-Duluth
Fisheries Resources		
Impacts of Contaminants on Fisheries	Impacts of tumors on fish productivity and health, effects of parentally transferred contaminants on lake trout, effects of nutrient loading on lake trout habitat.	U.S. Fish and Wildlife Service (USFWS)-National Fisheries Center-Great Lakes Ann Arbor

Table 7-2. U.S. Great Lakes Research Programs (continued)

Programs/Activities	Explanation	Relevant Institutions
Ecosystem Dynamics		
Green Bay Studies	Research in support of pilot mass balance modeling effort: water volume and sediment transport; sediment resuspension; exchange across air/water and sediment interfaces; development of a bottom-resting flume to determine bottom erosion thresholds; fish food web, nutrient, and contaminant dynamics.	NOAA-Great Lakes Environmental Research Laboratory
Human Health Water Quality Criteria	Development and application of pharmacodynamic models for transfer of dose-response relationships from animal models to humans.	USEPA-ORD-Cincinnati



Key:

EPA: U.S. Environmental Protection Agency
GLERL: Great Lakes Environmental Research Laboratory (NOAA)
NFRC: National Fisheries Research Center, Great Lakes (U.S. Fish and Wildlife Service)

Figure 7-1. Federal Agency Participation in Great Lakes Research

8. INTERNATIONAL/INTERAGENCY PROGRESS

The relationship between Federal and State environmental programs and the Great Lakes Water Quality Agreement (GLWQA) is complex and involves numerous planning, permitting, and enforcement efforts that serve both the purposes of various environmental statutes and the objectives of the Agreement. Environmental management decisions are made within the Great Lakes Basin at all levels of government: Federal, State, and local. Many agencies and organizations, therefore, work collaboratively and independently toward achieving both the goals of their authorizing statutes and the goals of the GLWQA. This complex interaction requires communication and coordination, one of the principal functions of the Great Lakes National Program Office (GLNPO).

Although coordination efforts have been discussed throughout the report, this chapter provides a consolidated summary of progress during FY 1988 in accomplishing specific coordination objectives set out in the recent Amendments to the GLWQA and the Clean Water Act (CWA). Both include provisions for more formal interactions between organizations involved in environmental programs in the Great Lakes Basin. These provisions, in turn, form the basis for a new coordination strategy for GLNPO that includes regular meetings with State government representatives, twice-yearly meetings of the Parties (the United States and Canada), and formal Memoranda of Agreement regarding roles and responsibilities in Great Lakes programs between GLNPO and other U.S. Environmental Protection Agency (USEPA) organizations and between USEPA and the Great Lakes States.

8.1 INTERNATIONAL COORDINATION

Three major types of international activities and coordination are required by Section 118 of the CWA and the GLWQA:

- Coordination of U.S. and Canadian implementation;
- Reporting of progress to the International Joint Commission (IJC); and
- Support to IJC Boards and Committees in their evaluative role.

In coordinating implementation, U.S. and Canadian staff members work together as representatives of their respective governments to solve mutual problems and conduct coordinated projects.

The 1987 changes to the Great Lakes Water Quality Agreement require that the United States and Canada meet twice each year to "...coordinate their respective work plans with regard to the implementation of [the] Agreement and to evaluate progress made." Article X of the Agreement further requires that these meetings be conducted in conjunction with the State and Provincial governments. In response to this new requirement, GLNPO began in August 1988 to implement a schedule of regular meetings with State program representatives in preparation for the twice-yearly meetings between the Parties.

Under the Agreement, the United States and Canada have responsibility for setting water quality objectives, preparing management plans, implementing remedial programs, and monitoring water quality.

In FY 1988, GLNPO personnel began serving on joint groups to address specific requirements of the Agreement for coordinated projects on air deposition monitoring, contaminated sediments, and development of specific objectives for toxic substances. One important activity in this area was work on the Upper Great Lakes Connecting Channels Study final report, discussed in Chapter 4. Considerable progress was made in FY 1988 and the report will be released in early FY 1989. Joint U.S. and Canadian activities in these areas will continue in FY 1989 and beyond.

In supporting the IJC, U.S. and Canadian staff members serve on various committees and task forces as nonpartisan experts to prepare reports and develop recommendations for the Commissioners. They also assist the Water Quality Board and Science Advisory Board by participating in special projects and on task forces.

GLNPO and Canada prepare and submit to the IJC reports on progress achieved implementing the provisions of the GLWQA. Reports reflect the various requirements of the Agreement Annexes. The IJC evaluates the progress made by both governments on a regular schedule and determines the adequacy of programs in satisfying the requirements and objectives of the Agreement.

One special initiative begun in FY 1988 involved a restructuring of the IJC's Water Quality Board Programs Committee. The Committee structure, under the co-direction of the Director of GLNPO and its Canadian counterpart, has assumed responsibility for management of all Water Quality Board activities. During FY 1988, the Programs Committee began establishing new subcommittees and reorganizing procedures for the Water Quality Board. To support the work of the IJC during 1989 and beyond, USDA SCS expects to detail an employee to the IJC Regional Office in Windsor, Ontario.

8.2 INTER- AND INTRA-AGENCY COORDINATION

One of GLNPO's major responsibilities under Section 118 of the CWA is to "...in cooperation with the appropriate Federal, State, tribal, and international agencies...develop and implement specific action plans to carry out the responsibilities of the United States under the Great Lakes Water Quality Agreement of 1978." The Act further requires that GLNPO "...coordinate the actions of the Agency (including actions by Headquarters and regional offices thereof) aimed at improving Great Lakes water quality" and that GLNPO "...coordinate actions of the Agency with the actions of other Federal agencies and State and local authorities, so as to ensure the input of those agencies and authorities in developing water quality strategies and obtain the support of those agencies and authorities in achieving the objectives of the Agreement."

In FY 1988, GLNPO worked to improve its coordination within USEPA and with other Federal agencies and the Great Lakes States. During the year, GLNPO established interagency agreements with the:

- U.S. Army Corps of Engineers for assistance with the contaminated sediments study;
- National Oceanic and Atmospheric Administration to participate in field monitoring for the Green Bay Mass Balance Study;

- U.S. Department of Agriculture Soil Conservation Service (SCS): to conduct studies of conservation tillage usage in Indiana, Michigan, and Ohio; and in cooperation with the USDA Extension Service, develop an interagency agreement for the purpose of updating and expanding the SCS Field Office Technical Guide to better reflect current water quality management technology.

- U.S. Fish and Wildlife Service for assistance with sediment monitoring efforts with dissolved oxygen survey of Lake Erie; and

- U.S. Geological Survey for assistance with groundwater contamination studies.

Within USEPA, GLNPO has established agreements for participation by other USEPA programs and offices in Great Lakes initiatives. In FY 1988, GLNPO entered into agreements with the Office of Research and Development to fund Great Lakes work at the Large Lakes Research Station and the National Water Quality Laboratory. These two laboratories are making important contributions to the Green Bay Mass Balance Study, the contaminated sediments study, and other GLNPO initiatives. Also in FY 1988, GLNPO entered into an agreement with the Region V Air Program to conduct inventories of toxic air emissions in the regions of Detroit and Lake Michigan. This project will continue through FY 1989.

During FY 1988, GLNPO participated with USEPA Headquarters in development of the Agency Operating Guidance for water programs and with regional water divisions in developing State water program guidance. These two activities are the principal methods by which USEPA program priorities are communicated throughout the Agency and to the States. In FY 1989, GLNPO plans to expand its efforts in this area to include participation in program guidance development for other USEPA programs as well.

GLNPO participated in many joint efforts with States during FY 1988. Some important accomplishments included:

- Providing support to the States of Michigan, Minnesota, Wisconsin, Ohio, and Pennsylvania and to various academic institutions including DePaul University, the Universities of Minnesota, Illinois, and New York State University for 19 Great Lakes Atmospheric Deposition (GLAD) Stations, 2 enhanced GLAD stations, and 1 enhanced GLAD master station;

- Providing support to the Ohio Department of Natural Resources for a remote sensing study to evaluate the effectiveness of the transect survey technique;

- Establishing support to the Wisconsin Department of Natural Resources for fish and tributary montioring in Green Bay;

- Providing support to the Minnesota Pollution Control Agency for preparing Remedial Action Plans for Areas of Concern in Minnesota;

- Providing support to the New York Department of Environmental Conservation for developing Remedial Action Plans and conducting special studies on the Niagara River;

- Providing support to the State of Indiana for studying contaminated sediments in the Grand Calumet/Indiana Harbor Area of Concern;

- Providing support to the Ohio Environmental Protection Agency for developing Remedial Action Plans; and

- Providing support to the Council of Great Lakes Governors to assist with implementation of the Great Lakes Toxic Substances Control Agreement, signed by the Governors in 1986.

9. GREAT LAKES OUTLOOK

Although substantial progress has been made toward restoring the beneficial uses of the Great Lakes, major challenges remain. Water quality management and protection are becoming increasingly complex, both technically and institutionally. Earlier water pollution control efforts focused almost exclusively on point sources. These sources could be readily identified and addressed, mainly by government regulatory and grant programs.

Conversely, the control of nonpoint sources of pollution has been more complicated, in part, because nonpoint sources are varied and diffusely distributed (e.g., runoff from agricultural areas, urban areas, and waste sites). It also has been difficult to determine the relative contribution of various nonpoint sources to specific pollution problems, and therefore, to identify the most important targets for control. Finally, the implementation of nonpoint source controls tends to require the cooperative efforts of various Federal, State, and local agencies, including those concerned with agriculture, waste management, land use planning, zoning, and construction permits.

The problem of certain persistent toxic contaminants and the management of many chemicals being introduced into the environment have added new dimensions to the difficulty of water quality management and protection. Toxic chemicals can enter the environment through a variety of media, including point sources, nonpoint sources, the atmosphere, and ground water. Some contaminants may originate great distances from the Lakes. Others may cycle through the environment, appearing at various times in the atmosphere, water column, sediment, and aquatic organisms. Because of the complex nature of the problem, identifying and implementing effective remedial strategies for the problems of persistent toxic chemicals present major technical and institutional challenges.

9.1 CURRENT CHALLENGES

In the near term, additional reductions in certain conventional pollutants, notably phosphorus, must be achieved in order to meet long-standing water quality objectives. The transition must be made from planning to remedial action for specific areas with serious localized water quality or sediment contamination problems. Efforts to develop and implement an effective management framework for systematically reducing lakewide levels of toxic substances must be successful.

9.1.1 Further Reductions of Pollutant Loadings

Additional reductions in phosphorus loadings to the Great Lakes are anticipated. The compliance records of publicly-owned treatment works (POTWs) continue to improve. As discussed earlier in this report, all POTWs in the Great Lakes Basin should be meeting a 1 mg/l effluent limit for phosphorus by 1990. The detergent phosphate ban adopted by Ohio in 1988 will help reduce phosphorus loads, particularly from system overflows and treatment plant bypasses. Phosphate detergent bans are now in effect for all of the Great Lakes Basin, except a small portion in Pennsylvania. Implementation of the Phosphorus Management Plan developed by the U.S. Environmental Protection Agency (USEPA), in conjunction with key states (Indiana, Michigan, Ohio, Pennsylvania, and New York), should fully achieve target load reductions, although it is not clear that the means to carry out the needed actions are available.

Canada has recently introduced a technology-based point source permit program that is designed to reduce loadings of both nutrients and toxic chemicals to the Lakes. The resulting reduction of nutrient loadings from Canadian industrial sources is expected to have positive impacts on all of the Lakes.

Progress has also been made in reducing levels of many toxic contaminants. Actions from 1969 to 1972 to ban uses of dieldrin, heptachlor, DDT, polychlorinated biphenyls (PCB), and mirex within the Great Lakes Basin resulted in initial marked decreases in environmental concentrations of these pollutants. The concentration of some contaminants have since stabilized at levels above established objectives, however. In particular, PCB and dieldrin concentrations, and in some areas DDT concentrations, found in the flesh of certain fish species remain unacceptably high. Until the concentration of these pollutants can be reduced further, public fish consumption advisories and concern regarding adverse effects on human health and wildlife will continue.

In addition to contaminants that have been early targets of source controls, there is an extensive list of hundreds of toxic chemicals that must be addressed in the coming years.

9.1.2 Eliminating Localized Contamination Problems

A major step toward further water quality improvement has been the designation of specific areas of localized contamination for cleanup initiatives. Remedial Action Plans (RAPs) are at various stages of development for all U.S. Areas of Concern (AOCs).

To realize anticipated water quality improvements, however, the RAP process must progress from the planning phase to actual implementation of remedial measures. In some cases, additional point source reductions will be required, placing the burden on specific industrial or municipal dischargers. In other cases, special projects for remediating contaminated sediment problems will be necessary. If responsibility for sediment contamination cannot be assigned to a particular source, the general public will have to bear the costs of remedial action.

9.1.3 Developing an Ecosystem Approach to Management

The best prospect for protecting and restoring the beneficial uses of the Great lakes lies in developing and implementing management approaches that are more responsive to actual ecosystem conditions. Traditionally, in the Great Lakes and elsewhere, water quality has been determined mainly based upon chemical criteria. Although such criteria will continue to serve as important benchmarks against which progress can be measured, consideration also must be given to "Lake Ecosystem Objectives" envisioned by the GLWQA.

Water quality managers must develop and implement an effective ecosystem-based management framework, as well as the information base necessary to support that framework. The Lakewide Management Plan (LMP) concept, described in Chapter 4, builds upon some initial toxic substance control strategy development efforts underway in Lakes Ontario and Michigan. These efforts, which focus on the development of "mass balance models," will be important in guiding management decisions on pollutant load reduction.

Lakewide Management Planning is particularly complex, both technically and institutionally. Substantial amounts of data must be gathered and analyzed to develop useful models. This typically entails close cooperation by numerous government agencies to ensure

that individual studies mesh and standardized sampling and analytical protocols are employed.

The selection of strategies for remedial action are likely to be equally complex. Some remedial action options can be effected through the existing patchwork of regulatory and nonregulatory programs. For example, in the United States, remedial actions could entail additional restrictions for particular discharges permitted under the CWA or hazardous waste cleanup under Superfund provisions. In some cases, however, special remedial initiatives may be necessary. For example, USEPA, the U.S. Army Corps of Engineers, and the States would have to collaborate to accomplish a major dredging project to remove contaminated sediments. Assigning responsibility for such initiatives and financing them will present major challenges in the coming years.

9.2 GENERAL STRATEGY FOR MEETING CURRENT CHALLENGES

The Great Lakes National Program Office (GLNPO) of the USEPA recently released its "Five Year Program Strategy for Great Lakes National Program Office, FY 1989-1993." The principal goals of the five-year program strategy for GLNPO are to:

- Conduct a study and demonstration program to assess and address contaminated bottom sediments;
- Support the completion of LMPs for Lakes Michigan, Ontario, and Erie to determine the steps needed to make fish safe to eat;
- Obtain sufficient information about sources, fates, and effects of pollutants to support a mass balance approach in remedial programs;
- Support the completion and implementation of RAPs to restore beneficial uses in all geographic AOCs;
- Evaluate results of point source and nonpoint source remedial programs to determine whether additional controls are needed to restore oxygen levels in Lake Erie;
- Strengthen partnerships with the Great Lakes States, other EPA programs, and other Federal agencies in carrying out all responsibilities; and
- Protect the Lakes from human abuse by improving public understanding of the Great Lakes system and related issues.

The activities described in the Strategy are responsive to requirements of both the CWA and the GLWQA. Highlights of the GLNPO program plan for FY 1989, are detailed below.

9.2.1 Eutrophication

GLNPO will work with the States and other Federal water programs to update the U.S. Phosphorus Load Reduction Plan, incorporating nonpoint source management programs developed under Section 319 of the CWA. The Office will also work with the States and non-government organizations to develop techniques for monitoring the adoption of nonpoint source management practices. It will convene a technology workshop for State and local

governments on low-cost nutrient control techniques and initiate an inventory of sources of nitrogen in the Great Lakes.

9.2.2 Toxic Pollutants

GLNPO program plans for FY 1989 include coordinating an interagency effort to develop an approach for designating Critical Pollutants, as required under the GLWQA. Work will continue on the mass balance pilot study in Green Bay. Analyses of toxic pollutant control efforts will be carried out to meet reporting requirements of the GLWQA.

9.2.3 Surveillance and Monitoring

GLNPO will acquire a research vessel, replacing the 50-year old *Roger Simons*, to continue comprehensive water quality monitoring, fish contaminant monitoring, and limnological studies. It will establish air toxic deposition monitoring sites for Lake Huron and Lake Erie and continue to coordinate multi-agency efforts related to the U.S./Canadian air deposition network. In addition, GLNPO will work to establish approaches for assessing the impacts of contaminated ground water and the intermedia transfer of toxic contaminants.

9.2.4 Environmental Management Plans

In FY 1989, GLNPO will continue to support the States in the development and implementation of RAPs and will continue to monitor progress in restoring beneficial uses within the AOCs. It will convene a workshop with the States and Canada on substantive and process requirements for LMPs. GLNPO will also coordinate the development and implementation of a strategy to reduce Point Source Impact Zones in accordance with the GLWQA.

9.2.5 Remedial Activities

GLNPO will develop a strategy and ranking scheme for the Assessment and Remediation of Contaminated Sediment program, which will be used initially to select sites for demonstration projects. Cooperative efforts will continue with USEPA and State regulatory offices to continue development of regional programs for the control of combined sewer overflows, air quality protection, Superfund actions, and wetlands and groundwater protection. GLNPO will also work with the USEPA's Offices of Information Resources Management and Research and Development, Region II and III, as well as State agencies and the International Joint Commission (IJC) to develop supporting Geographic Information System approaches for Great Lakes water quality management.

9.2.6 Research

In FY 1989, GLNPO will work with the National Oceanic and Atmospheric Administration to develop a listing of overall research needs for the Great Lakes and will continue to help coordinate multi-agency research efforts within the Basin.

9.2.7 Technology Development and Transfer

GLNPO will continue to transfer phosphorus control technology to State and local agencies by co-sponsoring a workshop and participating in technology transfer forums. It will work with the Office of Marine and Estuarine Protection to develop a general technology transfer strategy.

9.2.8 International/Interagency/Intra-agency Coordination

GLNPO will continue to provide senior staff support to U.S. and Canadian principals in the implementation of the GLWQA. It will continue to work with other Federal agencies, developing other formal interagency agreements as appropriate. It will continue to conduct regular meetings with State representives and will track regional and State developments.

9.2.9 Public Education and Involvement

In FY 1989, GLNPO will complete a comprehensive strategy for public education and involvement. It will compile and disseminate existing teaching material on Great Lakes issues and will continue to conduct regular meetings with public interest groups.

9.3 LONG-TERM PROSPECTS FOR GREAT LAKES RECOVERY

The long-term prospects for fully restoring and enhancing the Great Lakes depend in part on our success in resolving current water quality issues. However, the future of the Lakes will also be determined by the nature of emerging or unforeseen problems and our success in responding to them.

Emerging and future water quality issues need to be considered within the context of the economic and cultural conditions that will evolve over the next 20 years. Economic growth and development have slowed in many areas of the Great Lakes Basin. The nature and degree of the economic revitalization or decline that occurs within the region will be major factors determining the kinds of pollution problems that will be faced, as well as the resource base available for responding to those problems.

Conditions outside the Great Lakes Basin will also influence the long-term prospects for restoring beneficial uses of the Lakes. Changes in national and worldwide demand and prices of commodities or natural resources will influence the regional economy and environmental conditions. For example, a substantial increase in oil and gas prices could stimulate the development of energy resources within the Great Lakes Basin. Shifting markets and technological developments could change regional industrial profiles and demographic patterns.

Some issues are likely to be particularly important in shaping the future of the Great Lakes. As described below, issues include the problem of toxic chemicals, increased water withdrawals, global warming, ecosystem manipulation and biotechnology, and waste management.

9.3.1 Toxic Substances

As discussed throughout this report, some toxic chemicals of current concern, such as PCBs and DDT, appear to be particularly difficult to eliminate from the Great Lakes System. Even identifying the sources of some contaminants can be complicated, especially where atmospheric deposition or contaminated ground water are suspected. Once sources can be identified, eliminating or reducing contaminant loadings is usually a long-term or gradual process, which allows industries and communities time to adjust to new requirements or adopt new ways of doing business. Remediating problems related to past activities (e.g., contaminated sediment or leaking hazardous waste sites, both of which serve as important reservoirs for toxic substances in the Great Lakes) will take years to accomplish and will require a continuing major commitment of public funds.

In addition to responding to continuing problems associated with toxic substances of current concern, numerous new toxic chemical challenges are likely to surface. It is estimated that each year, 1,000 new chemicals are developed within the United States. It is probable that some of these chemicals will prove toxic and be incorporated into the Great Lakes System.

9.3.2 Increased Water Withdrawals

Lake levels are controlled in accordance with an agreement between the United States and Canada. In the coming years, increased demands for both consumptive and nonconsumptive uses of Great Lakes water are likely. Any growth within the Basin may require the withdrawal of more water to support new industrial or community development. There may also be continued pressure, especially during drought years, for the diversion of water to commerical navigation routes, such as the Mississippi River System. Increasing demands for municipal water supplies and irrigation water are also likely to result in growing pressure for the transfer of water outside the Great Lakes Basin.

Increased water withdrawals and changes in lake volumes could have a wide range of effects on beneficial uses of the Great Lakes System. Additional withdrawals within the Basin could signal increasing discharges of pollutants, depending upon the purpose of the withdrawals and the efficacy of pollution control technologies employed. Increased consumptive uses within the Basin and interbasin transfers of water would result in some reduction of lake levels. Navigation and recreational uses of the Great Lakes could be affected by even modest changes in lake level. Groundwater flow patterns and the hydrologic regime of wetland areas could also be altered. Such hydrologic changes could adversely affect water quality.

9.3.3 Global Warming

The "greenhouse effect," caused by rising levels of carbon dioxide in the atmosphere attributable to burning of fossil fuels, in conjunction with the destruction of the atmospheric ozone layer by chlorofluorocarbons and other gaseous emissions, could result in gradual global warming.

Even very small changes in average temperature can result in major environmental effects. A change of only a few degrees can change precipitation patterns, the natural distribution of plants and animals, and agricultural productivity. Within aquatic ecosystems, temperature affects the rates of chemical and biological processes, community composition, and biological productivity.

9.3.4 Ecosystem Manipulation and Biotechnology

The Great Lakes Ecosystem has been substantially modified by human activities. These modifications have included major changes in water quality (e.g., nutrient enrichment) and shifts in the composition of the biological community through harvesting of commercially valuable species and habitat modification.

In recent years, efforts have been made to restore ecosystem integrity by improving water quality conditions and reintroducing or strengthening key populations (e.g., lake trout). As our understanding of ecosystem dynamics continues to improve, our ability to

manipulate natural systems to meet particular societal objectives (e.g., provide more sportfishing opportunities) will also increase.

Biotechnology, composed of genetic engineering and biotransformation of enzymes, is one particular area of scientific advancement that may play an important role in efforts to manipulate or manage the Great Lakes Ecosystem. Individual species may be modified or enhanced to increase biological production or alter population or community dynamics. As noted by the Water Quality Board of the IJC, biotechnology may also have future relevance in addressing particular pollution problems. For example, genetically engineered organisms may be used to increase the performance of wastewater treatment facilities or reduce farmers' reliance on chemical pesticides.

9.3.5 Waste Management

Waste management is emerging as an important issue affecting the long-term prospects for the recovery of the Great Lakes System. As noted by the Water Quality Board in its 1987 Report to the IJC, the disposal of sewage sludge, dredged materials, and solid wastes will continue to pose major problems. Incineration, considered by some to be a promising solution, raises concerns with regard to atmospheric deposition of residual products. Waste minimization and resource recovery are held out as other options worthy of greater emphasis.

10. FUNDING FOR GREAT LAKES PROGRAMS

The Federal government expends more than $500 million annually on programs intended to improve Great Lakes water quality. More than 90 percent of this funding goes to the construction of sewage treatment facilities, under the Construction Grants program administered by the U.S. Environmental Protection Agency (USEPA). Major Federal research and management programs account for an additional $33 million, or about 7 percent of total expenditures. Pollution abatement and control programs, including State grants and support for USEPA permitting and enforcement responsibilities, account for an additional $15 million, or 3 percent of the total for major programs.

Many other Federal programs contribute directly or indirectly to environmental improvements in the Great Lakes. For example, USDA supports programs that contribute to the management and restoration of Great Lakes water quality (e.g., nonpoint source management). Funding for these programs is not represented within the reported totals for selected Federal programs. The costs and benefits of these types of programs are difficult to apportion. Certainly, the Superfund program administered by the USEPA, and the numerous research and assessment programs undertaken by various Federal natural resource management agencies, represent major government commitments with important implications for regional environmental quality.

10.1 FEDERAL RESEARCH AND MANAGEMENT PROGRAMS

As discussed earlier in this report, numerous Federal research and management programs contribute, directly and indirectly, to efforts to improve water quality in the Great Lakes System. A broad base of Federal support is provided under large national programs, such as those funded by the National Science Foundation (NSF) and particular offices within major environmental protection and natural resource management and development agencies: USEPA's Office of Research and Development (ORD); the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service, National Ocean Service and Office of Oceanic and Atmospheric Research; the U.S. Geological Survey's Water Resources Division; the U.S. Fish and Wildlife Service's (FWS) Research and Development Division; the U.S. Army Corps of Engineers Waterways Experiment Station; and the U.S. Department of Agriculture's Soil Conservation Service, and Agricultural Research Service.

In addition to the broad base of national support, which benefits the Great Lakes region along with the rest of the nation, a number of Federal programs are specifically dedicated to Great Lakes research and management. These central Federal Great Lakes programs are:

<u>USEPA</u>

- Great Lakes National Program Office (GLNPO)
- Large Lakes Research Station

NOAA

- Great Lakes Environmental Research Laboratory
- Sea Grant
- Coastal Zone Management (CZM)

USFWS

- Great Lakes National Fishery Research Laboratory

10.1.1 The 1988 Budget

In 1988, the Congress allocated $31.6 million for major Federal Great Lakes research and management programs. As shown in Table 10-1, NOAA programs collectively account for $15.6 million or 49 percent of this total, USEPA programs account for $12.9 million or about 41 percent, and the FWS Great Lakes Fishery Laboratory accounts for $3.1 million or about 10 percent. (The Fishery Laboratory also receives some funds from other agencies, under various interagency agreements.)

The 1988 budget for these programs represents a $6.2 million increase over the 1987 budget. Most of this increase is attributable to a doubling of the budget for GLNPO (from $5.3 million in 1987 to $11.0 million in 1988). It included an appropriation of $1.5 million for the purchase and refitting of a new research vessel.

Most of these resources were dedicated to monitoring and research, with a substantial emphasis on Federal-State cooperative efforts. For example, GLNPO allocated about $6.5 million to lake surveillance and assessment of pollutant loadings and about $2.5 million to remedial activities. Approximately one-half of this total funding was expended in joint Federal-State projects or as direct awards to States. GLNPO allocated about $1.5 million to general administration and the remainder of its budget to support international efforts under the GLWQA.

10.1.2 The 1989 Budget

In 1989, the budget for major Great Lakes research and management programs will increase by $1.9 million, reaching a total of $33.5 million. (This actually represents the addition of $3.4 million in new funding, accounting for the one-time appropriation of funds in 1988). Most of this increase is to be allocated to GLNPO to support its increased responsibilities under the CWA and the GLWQA. Specifically, the GLNPO budget will increase by $3.6 million, $600,000 of which is to support ten new staff positions and the remaining $3 million is to support the bilateral agreement with Canada and complete the outfitting of the research vessel.

The budget allocations for other major Federal Great Lakes research and management programs will remain fairly stable. However, increases for GLNPO activities are tending to equalize the distribution of funds for USEPA and NOAA research and management programs.

TABLE 10-1. FEDERAL FUNDING FOR SELECTED GREAT LAKES RESEARCH AND MANAGEMENT PROGRAMS ($ millions)

PROGRAM	FY 1980	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989
EPA GLNPO	6.5	6.0	5.4	4.7	4.0	6.5	4.8	5.3	11.0	13.0
Large Lakes Research Station	3.9	3.1	2.5	2.5	2.5	2.5	2.4	1.9	1.9	2.0
NOVA GLERL	3.3	3.4	3.6	3.6	3.6	3.6	3.8	4.1	4.4	4.6
Sea Grant (1)	5.3	3.8	4.9	5.2	5.2	5.4	5.6	5.6	5.6	5.6
Coastal Zone Management (2)	3.8	5.1	6.4	3.6	1.6	7.6	5.5	5.6	5.6	5.6
Fish and Wildlife Fishery Laboratory (3)	2.0	2.1	2.1	2.1	2.1	2.3	2.8	2.9	3.1	2.7
TOTAL	24.8	23.5	24.9	21.7	19	27.9	24.9	25.4	31.6	33.5

(1) Includes funds allocated to programs in Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin. The FY 1989 funding level is estimated.

(2) Comprises funding allocated to Great Lakes States with CZM programs: Michigan, New York, Pennsylvania, and Wisconsin. The FY 1989 funding level is estimated.

(3) Represents only those funds provided to the laboratory directly by Congressional appropriation. Does not include funds transferred from other agencies.

10.1.3 Funding History and Trends

Over the past 10 years, major Federal Great Lakes research and management programs have been funded at a level of about $25 million annually. Support declined in 1983 and 1984, with major reductions in funding for GLNPO and the Coastal Zone Management Program. More recently, funding levels have increased, reaching a new high of $33.5 million in 1989.

Expressed in real dollars, calculated using the Gross National Product (GNP) implicit price deflator and 1982 as a base year, budget reductions over the past decade were substantial. At its low point in 1984, the funding level was more than $11 million less than it was in 1980 (Figure 10-1). This represents a 39 percent reduction in support. Data collection and analysis programs were principal targets of funding decreases. Funding increases the following year fully offset the 1984 budget reductions, with the average of 1984 and 1985 total funding levels approximating those in 1983.

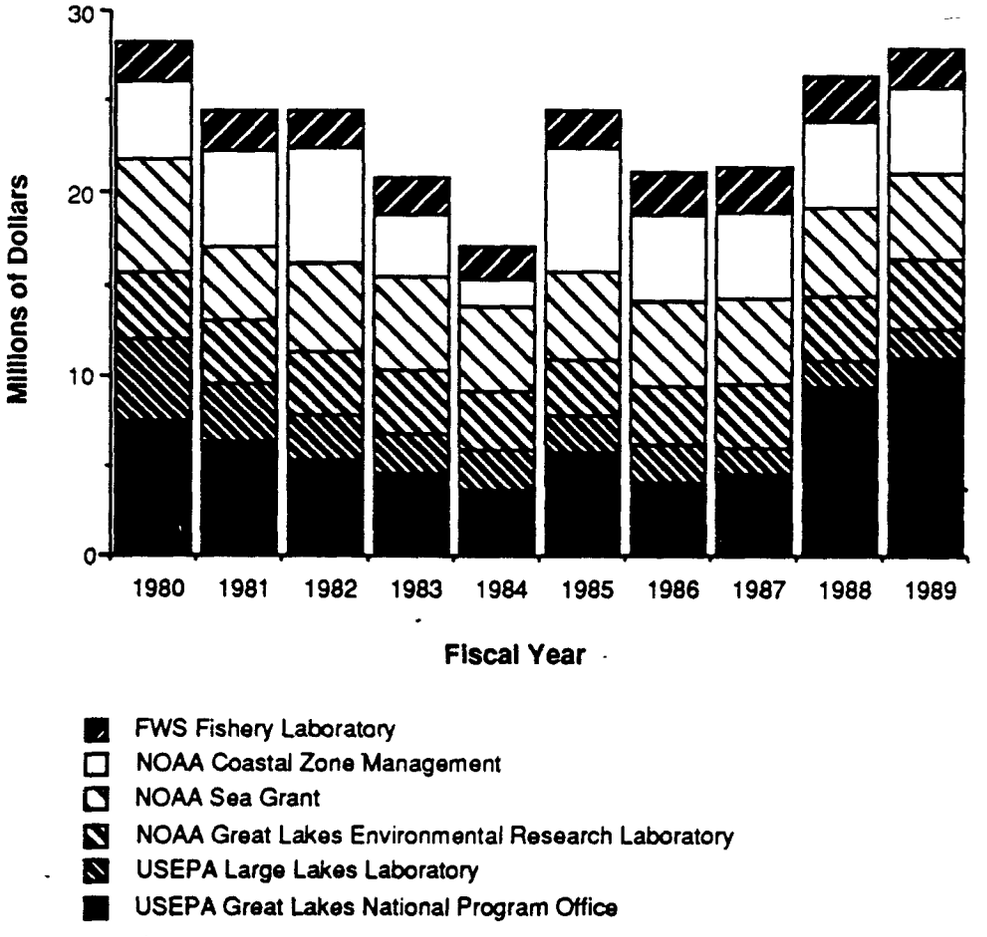
In terms of real dollars, funding increases in 1988 and 1989 have restored the total budget for research and management programs to the 1980 level of about $29 million. Comparing the 1989 budget to the 1980 budget, GLNPO is the only office that has registered a significant increase ($3.5 million in real dollars), while the budget for the USEPA's Large Lakes Research Station has declined by $2.8 million and the budget for NOAA's Sea Grant Program in the Great Lakes has declined by about $1.4 million. The other major programs are funded in 1989 at about the same level that they were in 1980.

10.2 FEDERAL POLLUTION ABATEMENT AND CONTROL PROGRAMS

As described in earlier chapters, the core of Federal activities for water pollution abatement and control are a set of programs administered by the USEPA's Office of Water (OW). These programs include activities related to:

- enforcement of regulatory provisions;
- overview of State administration of the National Pollutant Discharge Elimination System (NPDES) permit program;
- issuance of grants for State pollution control programs under Section 106 of the CWA;
- development of effluent standards and guidelines;
- water quality monitoring and analysis; and
- development of water quality standards and regulations.

Most of these activities are administered by the Regional Offices of the USEPA. The Great Lakes Basin is served by three such offices: Region V, which is the principal office, serving six Great Lakes States (i.e., Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin); Region II, which includes one Great Lakes State (i.e., New York), as well as New Jersey, Puerto Rico, and the Virgin Islands; and Region III, which includes only a small portion of the basin (i.e., one county in northwestern Pennsylvania), as well as Delaware, the District of Columbia, Maryland, West Virginia and Virginia.



* *Expressed in real dollars, calculated using the GNP implicit price deflator and FY 1982 as a base year. The FY 1987 index of 117.5 was used to estimate real dollar funding levels for FY 1988 and FY 1989.*

FIGURE 10-1. Trends in Federal Funding for Selected Great Lakes Research and Management Programs

Consequently, it is difficult to accurately determine the exact portion of USEPA water pollution abatement and control funding allocated to the Great Lakes Basin. However, since Region V incorporates most of the Great Lakes Basin, it is considered the best focus for a general budget analysis.

Within Region V, total obligations for USEPA water pollution abatement and control programs amounted to about $12.3 million in 1980 (Table 10-2). Total funding declined gradually until 1984, when it began increasing steadily, reaching a high of about $17.8 million in 1987. Obligations have declined again in the past two years, with a $2 million reduction being anticipated in 1989.

Most of the funding for these USEPA pollution and control programs is allocated to the States in the form of CWA Section 106 grants. These grants account for 55 to 80 percent of total Region V program resources over the past decade.

In addition to these major Federal pollution abatement and control programs, some portion of the USEPA's Region II and Region III water program resources are expended within the Great Lakes Basin. Further, a wide range of other contaminant control programs contribute directly to water quality improvements. These include the following:

- Superfund - Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 228 sites in USEPA's Region V have been included on the National Priorities List, and thus are eligible for up to $2 million each in funding for cleanup. Some of these hazardous waste cleanup efforts are certain to benefit water quality in the Great Lakes Basin.

- Confinement of Contaminated Sediments - The U.S. Army Corps of Engineers (COE) undertakes a range of environmental protection activities in association with its responsibility to maintain the nation's navigable waterways. Within the Great Lakes Basin, a portion of COE funding is allocated for issuing and enforcing dredge and fill permits under Section 404 of the CWA. In addition, more than $12 million was expended in the Basin in 1988 for activities related to the confinement of contaminated sediments, testing of sediment, water quality monitoring, construction of confined disposal facilities, and special studies.

- Nonpoint Source Controls for Agricultural Areas - The U.S. Department of Agriculture operates a number of national-scale programs to encourage appropriate consideration of soil erodibility and nonpoint source contaminant control. Some portion of the funds expended on this national program, including allocations for local extension services, directly benefit Great Lakes water quality.

- Spill Clean-Up - The U.S. Coast Guard works with the USEPA in responding to offshore spills of hazardous materials and oil. Generally, costs for cleanup are borne almost entirely by responsible parties, however, some costs are incurred by the Federal government (e.g., less than $100,000 annually).

TABLE 10-2 FEDERAL FUNDING FOR POLLUTION ABATEMENT AND CONTROL PROGRAMS IN SELECTED U.S. ENVIRONMENTAL PROTECTION AGENCY REGIONS

($ Millions Obligated)

PROGRAM	FY 1980	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989*
WATER QUALITY ENFORCEMENT										
REGION II			1.70	1.30	1.20	1.40	1 50	1.70	1 50	0.90
REGION III			2.90	1.70	1.70	2.30	1.50	1.60	1.70	0.90
REGION V	0.07	0.03	2.30	1.50	1.40	1.80	1.90	2 00	2 20	1.30
ALL REGIONS	2.20	3.60	17.20	13.60	13.20	16.00	17.30	18 60	19 80	11.10
WATER QUALITY PERMITS										
REGION II	0.20	0.20	0.70	0.70	0.90	1.10	1.10	0.90	1.00	0.50
REGION III			0.30	0.20	0.40	0.50	0.50	0.30	0 50	0.30
REGION V		0.03	0.60	0.60	0.70	1.00	1 20	1.20	1.60	0 80
ALL REGIONS	1.30	4.30	9.90	10.60	14.60	15.90	14.30	15 30	17 60	14.60
SECTION 106 GRANTS										
REGION II	5 40	5.80	5.70	6 00	6.00	6 50	6.70	7.80	6.60	6.50
REGION III	6.10	6.40	6.40	6.80	6.70	7.50	7.60	8 60	7 50	7.40
REGION V	8.80	9.10	9.30	4.60	9.50	10.70	10.90	12.60	10 50	11.10
ALL REGIONS	48.90	51.20	51.30	54.10	53.90	61.30	62.10	71.10	60.90	61.70
EFFLUENT STANDARDS AND GUIDELINES										
ALL REGIONS	26.50	23.70	13.00	13.00	16.70	9.20	7.70	7.50	6 40	5.60
WATER QUALITY MONITORING AND ANALYSIS										
REGION II	1.20	0.20	0.70	0.80	1.00	0.90	1.00	0.80	1.30	0.05
REGION III	0.20	0.05	0.30	0.50	0.60	0 60	0.90	1.00	0.80	0.00
REGION V	0.80	0.09	0.70	0.70	1.00	1.10	0.90	0.90	0.80	0 00
ALL REGIONS	10.70	3.30	8.20	8.30	13.10	12.80	11.10	12 40	12.40	5.90
WATER QUALITY STANDARDS AND REGULATIONS										
REGION II	0.01		0.07	0.09	0.20	0.20	0.20	0 10	0.20	0.09
REGION III	0.01		0.08	0.10	0.30	0.30	0.20	0.30	0.30	0.10
REGION V	0.03	0.01	0.20	0.20	0.30	0.30	0.40	0.40	0.40	0.20
ALL REGIONS	1.20	1.00	3.00	2.90	4.60	6.50	6.70	7.00	6.50	5.60
REGION V TOTAL (includes 10% of Effluent Standards and Guidelines)	12.30	11.60	14.40	8.40	14.60	15.80	16.10	17.80	16.10	14.00

* Authorized funds

10.3 FEDERAL CONSTRUCTION GRANTS FOR WASTEWATER TREATMENT WORKS

The largest Federal program directly affecting Great Lakes water quality is the USEPA's Construction Grants program, which is mainly intended to help local governments build or upgrade sewage treatment plants. As noted earlier in this report, cumulatively, more than $7.9 billion in Federal and State support has been expended on sewage treatment facility construction. In 1988, over $500 million was obligated to Great Lakes States under the Construction Grants program.

Almost all funding under this program is expended for facility development and implementation under Section 201 of the CWA (Table 10-3). State allotments under Sections 205(g) and 205(j) represent much smaller program components.

Construction grants funding within Region V of the USEPA reached high points in 1981, 1983, and 1988, when more than $500 million were obligated annually. A reduction in spending is anticipated in 1989, with obligated funding expected to be less than one-half the level in 1988.

Still, funding has been sufficient to support numerous important projects. This includes one of the largest municipal wastewater construction projects in the Region under way in Milwaukee, Wisconsin. Overall, the USEPA has contributed $414 million toward this $1.7 billion water pollution abatement effort. When completed in the mid-1990s, the facility will provide a highly reliable secondary wastewater treatment and will eliminate the discharge of combined sewer overflows to Lake Michigan.

The CWA envisions the Construction Grants program phasing out by 1990. Still, the USEPA will continue to help finance municipal sewage treatment facilities through a new State revolving-fund system. Great Lakes States within Region V are authorized to receive over $1.8 billion through 1994 under this State-managed system.

TABLE 10-3 FEDERAL CONSTRUCTION GRANTS FOR WASTEWATER TREATMENT WORKS IN SELECTED U S ENVIRONMENTAL PROTECTION AGENCY REGIONS

($ Millions Obligated)

PROGRAM	FY 1980	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989*
201 CONSTRUCTION GRANTS										
REGION II	39.9	531.7	273.3	474.4	390 0	387 6	254.3	368.6	288.8	156 8
REGION III	154.4	247.7	197.7	333 6	381.4	206.5	181.5	189.7	270.2	102.4
REGION V	276 2	560.4	343.1	577.2	742.0	483.6	304.4	357 0	564.5	199 9
ALL REGIONS	1161.6	2866.0	1614.0	2803.0	2956.5	2112.1	1605.7	1801 7	2119.7	970.2
205(G) GRANTS										
REGION II	12.7	14.2	1.2	29 4	12.1	16.1	14.9	14.9	4.0	NA
REGION III	2.5	1.7	9.8	8.1	9.5	9.0	11 0	6.5	8 2	
REGION V	3.2	7.6		21 2	25.2	25.8	24.2	16 0	19 1	
ALL REGIONS	32.6	84.8	21 4	125.0	83 0	98.1	107.6	81.5	73 7	
SECTION 205(J)(5) GRANTS										
REGION II				7.7	2.9	1.4	4.1	6.8	0 6	NA
REGION III				3.6	2.3	2.5	2.9	3.4	1.7	
REGION V				5.8	5.7	6.6	3.7	6 2	7.2	
ALL REGIONS			0.4	34.3	23.0	25.4	20.1	29 0	20.0	
CONSTRUCTION GRANTS										
NEW YORK (022)	11.2	403.8	248.1	261.5	270.6	263.0	176.9	248.3	231.4	103.0
PENNSYLVANIA (034)	71.4	99.7	33.2	159.6	142.0	82.0	65.5	45.1	103.6	37.0
ILLINOIS (051)	54.4	205.0	61.2	113.7	160.4	86.7	88 9	664.9	183.8	42.2
INDIANA (052)	51.8	23.6	54.4	55.2	72.9	64.9	45.2	28 0	47.4	22.5
MICHIGAN (053)	113.8	79.1	5.2	112.7	197.0	99.4	12.2	76 0	134.5	40.4
MINNESOTA (054)	25.6	36.6	21 7	78.1	43.0	43.0	17.5	32.5	46.5	17.1
OHIO (055)		165.6	173.2	155 2	184.3	134.6	102.5	67.4	117.2	52.5
WISCONSIN (056)	30 6	50.5	16.1	62.2	84.5	1.9	28.3	64.7	35 1	25.2
SECTION 205(G) GRANTS										
NEW YORK (022)	8.8	10.6		20.9	10.8	10.9	10.9	10 9		NA
PENNSYLVANIA (034)			4.3	4.2	3.9	3.9	3.9	3 9	3.9	
ILLINOIS (051)		5 9		4.9	4.4	4.4	4.4	3 3	4 3	
INDIANA (052)				2.6	2.4	4.7	2.4		2.4	
MICHIGAN (053)		4.8		3.9	8.0	4.6	4.2	4.2	4.8	
MINNESOTA (054)		2.1		1.8	1 8	1.8	3.6		1.8	
OHIO (055)	1.6	12.9		6 1	5.5	5.5	6 9	5 2	3.2	
WISCONSIN (056)		2 3		1.8	3.1	4 7	2.7	3 4	2 6	
SECTION 205(J)(5) GRANTS										
NEW YORK (022)				5.2	2.7	0 3	2 7	4.7		NA
PENNSYLVANIA (034)				1 0	1.0	1.0	1 0	1 7	0.2	
ILLINOIS (051)				1.2	1.1	1.4	0 8	1 1	1.9	
INDIANA (052)				0.7	0 6	1 0	0 2	0 9	0 7	
MICHIGAN (053)				1.5	1.1	1 0	1.1	1.0	1 7	
MINNESOTA (054)				0 4	0.7	0 6	0 2	0 3	0 6	
OHIO (055)				1 5	1.4	1.4	1 4	2 0	1.7	
WISCONSIN (056)				0 5	0.9	1.1	0 2	1 0	0.6	

* Authorized funds

11. GLOSSARY OF TERMS

Ammonia - a reduced form of nitrogen, is an important plant nutrient often measured as an indicator of biological productivity or enrichment, i.e., eutrophication. Un-ionized ammonia, is the principal toxic form of ammonia. Ammonia can be acutely toxic to freshwater organisms, depending upon prevalent pH and temperature.

Areas of Concern (AOCs) - a geographic area that fails to meet the General or Specific Objectives of the 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.

Best Management Practices (BMPs) - schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the United States. BMPs also include treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

Bioaccumulation - the rate at which a compound is accumulated and distributed in an organism.

Boundary Waters - the Great Lakes Basin waters forming the common border between the United States and Canada including their bays, arms, and inlets.

Cladophora - a genus of branched filamentous septate green algae, usually firmly attached to solid substrates, as on Great Lakes shores, where nutrient levels trigger growth; occasionally washed loose by storms to accumulate as a "nuisance" on beaches; or indication of eutrophication.

Contaminated Ground Water - subsurface water contained in soils, sediments, and/or fractured rocks which contains toxic levels of environmental pollutants derived from shallow waste-disposal sites (i.e., landfills, dumpsites, and lagoons); deep and shallow well injection of liquid waste; and leachate of persistent pesticides or other chemical residues from agriculture and of radionuclides from nuclear refineries.

Contaminated Sediments - sediments containing pollutants in potentially harmful concentrations and which may be released by physical or biological processes. In the Great lakes context, concentrations of contaminated sediments in harbor and river mouth areas are the primary concern.

Conventional Pollutants - chemicals such as various forms of nitrogen, phosphorus, and carbon, which cause oxygen depletion or excessive enrichment and eutrophication of the aquatic environment.

Critical Pollutants - substances that persist at levels that, singly or in synergistic or additive combination, are causing, or are likely to cause, impairment of beneficial uses despite past application of regulatory controls due to their presence in open lake waters, ability to cause or contribute to a failure to meet Agreement Objectives through their recognized threat to human health and aquatic life, or ability to bioaccumulate.

Cyanide - Cyanide can be present in many forms in the environment. The transport, fate, and toxicity of the chemical is quite dependent on the specific form. Hydrogen cyanide and its salts are highly toxic following acute exposure by humans, experimental animals, and both aquatic and terrestrial wildlife.

DDT - DDT and its metabolites, DDD and DDE, are very persistent in the environment and have been shown 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 waterbirds, raptors, and passerines significantly.

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 hydrocarbons. Both pesticides, and especially dieldrin, have been associated with large-scale bird and mammal kills in treated areas.

Dioxin (TCDD) - is a particularly hazardous group of 75 chemicals of the chlorinated dioxin family. 2,3,7,8 - TCCD or 2,3,7,8- tetrachlorodibenzo-para-dioxin is a particularly dangerous member of this group.

Ecosystem Approach - a comprehensive consideration of the variables (e.g., water, chemicals, toxic substance, and biota) making up the basic ecological system. When applied to a large regional system, the ecosystem approach requires considerations of three major interacting subsystems: physical, chemical, and biological phenomena; responsible institutions and their interactions and the socioeconomic system that utilizes the resources and receives the benefits or bears the burden of the result of management actions. This approach carries with it an expectation of management and criteria for taking management actions implicitly beyond the scope of conventional scientific inquiry in that they incorporate societal values, relationships to increasingly scarce resources, and evolving life styles in the basin.

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 or condition of individual organisms. For example, the objectives for Lake Superior call for the lake to be a stable oligotrophic ecosystem with lake trout as the top aquatic predator of a cold-water community and with Pontoporeia hoyi as a key organism in the food chain.

Effluent - the discharge of treated wastewater from municipal and industrial facilities.

Estuary - in regards to the Great Lakes, the estuary (or the estuary's environment) is defined as that portion of the inflowing river in which river water is measurably diluted with lake water. A compositional gradient between the two water masses is often evident associated with freshwater dilution.

Eutrophication - the overproduction of microscopic plant life stimulated by unnaturally abundant nutrient inputs. Problems associated with cultural input include turbidity, aesthetic nuisances, changes in algal species, filter clogging, taste and odor problems in water supplies, and oxygen depletion in lake water.

Fish Consumption Advisories - an advisory issued by the jurisdiction to protect human health against exposure to toxic chemicals concentrated in fish tissue.

Furans (Polychlorinated Dibenzofurous - PCDFs) - were noted in lake trout, common carp, and large mouth bass, and frequently occur as trace contaminant of polychlorinated biphenyls. Referred to as an "emerging problem" by the International Joint Commission.

Great Lakes Basin Ecosystem - the interacting components of air, land, water, and living organisms, including humans, within the drainage basin of the St. Lawrence River at or upstream from the point at which this river becomes the international boundary between Canada and the United States.

Great Lakes Water Quality Agreement (GLWQA) - an international agreement revised in November 1987 between the United States and Canada to restore and enhance the quality of the Great Lakes system and strengthen their commitment to solving the most critical problems on the lakes. It emphasizes the concept of ecosystem management for the Great Lakes Basin and recognizes that resource management issues in the Basin should be addressed within the context of the entire ecosystem, taking into consideration the relationships between environmental media and media-specific environmental programs.

Habitat - the physical, chemical, and biotic components of the environment, including water quality. Recognition of other components of habitat other than water quality determines the composition and well-being of the Great Lakes biological community. Quality of habitat is particularly significant for successful spawning, growth, and recruitment of fish and for determining the quality and quantity of food available at all levels of 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 can be bioaccumulated. HCB is readily sorped 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.

In-Place Pollutant - pollutants that have accumulated, usually in the river or lake sediments, from which they may be released by physical or biological processes.

International Joint Commission (IJC) - established by the 1909 Boundary Waters Treaty. A binational Commission with responsibility for decisions regarding obstruction or diversion of U.S./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.

Loadings (Phosphorous; Pollutant) - total quantity entering the Lakes, often recognized as the volume-weighted concentration of one or several pollutants discharged from either a point source or nonpoint source of pollution.

Mass Balance Approach and Models - a framework for management of persistent toxic substances requiring information about the quantity of a substance entering the ecosystem; the quantity stored, transferred or degraded within the ecosystem; and the quantity leaving. The difference between inputs and outputs is the quantity that remains to be recycled or lost to the sediment and the atmosphere.

Mercury - both organic and inorganic forms of mercury are reported to be teratogenic and embryotoxic in experimental animals. In humans, prenatal exposure to methylmercury has been associated with brain damage. Atmospheric transport is the major environmental distribution pathway for mercury. Adsorption onto suspended and submerged sediments is the most important process determining the fate of mercury in the aquatic environment. Mercury is strongly bioaccumulated by numerous mechanisms. Methylmercury is the most readily accumulated and retained form of mercury in aquatic biota, and once it enters a biological system it is very difficult to eliminate.

Mirex - Mirex, which has been used as a fire retardant and pest control agent, at one time was produced in the Lake Ontario Basin. Its continued presence in the Lake Ontario system has caused some concern. Bioaccumulation is well known for a variety of organisms but the effect of this bioaccmulation on the aquatic ecosystem is unknown. There is evidence that mirex is very persistent in bird tissue.

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 sites) into waters of the United States.

Nearshore Waters - the waters adjacent to the lakeshore directly affected by discharges from onshore and that interact with land by wave and wind actions.

Nitrate Plus Nitrite - an oxidized form of nitrogen, nitrate plus nitrite (often in conjunction with ammonia), is measured in aquatic systems as an indicator of biological productivity or enrichment (i.e., eutrophication) Excessive nitrate plus nitrite may also indicate the presence of agricultural fertilizer originating from nonpoint source runoff from adjacent land or point source discharges of sewage treatment plants.

Nonpoint Sources - polluted land runoff derived from numerous diffuse sources rather than one (or several) discrete discharge point(s).

Oligotrophic Ecosystem - those lakes poorly provided with the basic nutrients required for plant and animal production; poorly nourished in contrast to a eutrophic ecosystem.

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

Polychlorinated Biphenyls (PCBs) - highly persistent, highly bioaccumulative, and highly toxic pollutants that, due to presently high levels in some commercial and sport fish species are believed to constitute a threat to public health. PCBs are still in use for electrical purposes pending replacement. There appears to be recycling of the pollutant in the Great Lakes from contaminated sediments (both rivers and lakes) and the atmosphere.

Phosphorus - present as a constituent of various organic and inorganic complexes and compounds; the initial limiting nutrient in most freshwater systems; when phosphate phosphorus is abundant, other chemical substances may become limiting to growth of aquatic plants.

Point Source - any discernible, confirmed, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, vessel, or other floating craft from which pollutants are or may be discharged.

Publicly-Owned Treatment Work (POTW) - any device or system used in the treatment (including recycling and reclamation) of municipal sewage or industrial wastes of a liquid nature that is owned by a "State" or "municipality". This definition includes sewers, pipes, or other conveyances which convey wastewater to the treatment works.

Remedial Action Plans (RAPs) - plans prepared by the jurisdictions, following guidelines developed by the Great Lakes Water Quality Board, aimed at restoring all beneficial uses to Areas of Concern. These goals are to be accomplished through implementation of programs and measures to control sources and remediate environmental problems. The restoration effected under this initiative would also remove the threat posed by Areas of Concern to the adjacent nearshore and open lake water quality.

Specific Objectives - the concentration or quantity of a substance or level of effect that the Parties agree, after investigation, to recognize as a maximum or minimum desired limit for a defined body of water or portion thereof, taking into account the beneficial uses or level of environmental quality which the Parties desire to secure and protect

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. Bioaccumulation in birds and mammals may result in exposure to excessive concentrations. Bird kills due to toxaphene have been reported. Presence in the Great Lakes is suspected to be primarily due to atmospheric deposition.

Toxic Pollutants - substances that can cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological or reproductive malfunctions, or physical deformities in any organism or its offspring or that can become poisonous after concentrations in the food chain or in combination with other substances.

Trophic Status - the degree of nutrient enrichment and resultant biotic productivity in a lake resulting from geologic, climatologic, biologic, factors or influences, as well as from humans.