THE SHEBOYGAN RIVER

REMEDIAL ACTION PLAN

Wisconsin Department of Natural Resources
Southeast District Headquarters

Milwaukee, Wisconsin

July 1, 1989

PUBL-WR-211-88

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July 31, 1989

IN REPLY REFER TO: 8250

To the Citizens of the Sheboygan Area:

I am pleased to approve the Sheboygan River Remedial Action Plan as part of Wisconsin's Water Quality Management Plan. The plan is an important contribution to Great Lakes cleanup. It is also an important step in the long-term effort of the communities, industries, and citizens of the area to restore and protect this valuable state resource.

The Wisconsin Department of Natural Resources in conjunction with the International Joint Commission and the United States Environmental Protection Agency have targeted the Lower Sheboygan River and Harbor and nearshore Lake Michigan as one of 42 Great Lakes Areas of Concern.

Within the Area of Concern, impairment of the beneficial uses of the water resources has occurred as a consequence of the introduction of pollutants. These pollutants include polychlorinated biphenyls (PCB's) and other chlorinated organic compounds, heavy metals, phosphorus, nitrogen, suspended solids, and fecal coliform.

Examples of impaired uses that have resulted include waterfowl and fish assumption advisories, degradation and loss of habitat, dredging restrictions, reduced swimming opportunities, and accelerated eutrophication.

The International Joint Commission requested the Wisconsin Department of Natural Resources to prepare a Remedial Action Plan which would identify specific management strategies to control existing sources of pollution, abate environmental contamination already present, and restore the beneficial uses in the Area of Concern.

The Remedial Action Plan is one of several efforts underway to correct water quality problems in the Sheboygan Basin. Other projects include the Sheboygan River Basin Water Quality Management Plan, Nonpoint Source Priority Watershed Projects on both the Onion and Sheboygan Rivers, and two Superfund projects.

During the past two years, the Wisconsin Department of Natural Resources worked cooperatively with other agencies, researchers, and the citizens of the Sheboygan area to develop a remedial action plan for the Sheboygan River and

Harbor. All of these groups worked together to identify management goals for the harbor and river for the year 2000. The plan's goals call for: 1) Providing a fishery and ecosystem that is free from the effects of toxic contamination, 2) maintaining diverse communities of aquatic and terrestrial life, 3) controlling eutrophication, and 4) enhancing recreational uses of the harbor. The attainment of these goals is a worthwhile endeavor.

Judging by the response at the public hearing and the commitment of those that contributed to the preparation of the plan, there is great opportunity to achieve the water quality goals laid out in the plan. The plan incorporates the updating requirements of Public Law 92-500 as amended by Public Law 95-217 and as outlined in Federal Regulations 40 CFR, Part 35. This planning document is governed by the process for adoption of areawide water quality management plans as set forth in NR 121.08(1)(a) and (b).

Sincerely,

C. D. Besadny
Secretary

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ACKNOWLEDGEMENTS

Many people have contributed information and comments in the development of this Remedial Action Plan. Among those that have contributed to this effort are the Sheboygan Water Quality Task Force, the Sheboygan River and Harbor Interagency Technical Advisory Committee, and the WDNR Workgroup for the Sheboygan River Project. We appreciate their contribution on the plan and welcome further input from these and other groups during the implementation phase of the plan.

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Review comments and information were also provided for the draft Plan by Tecumseh Products, Inc.; Foley and Lardner; Lake Michigan Federation; the Kohler Company; and the following WDNR staff: Jim Bachhuber, Lee Kernen, Julian Chazin, Linda Talbot, Jack Sullivan, Chuck Ledin, Steve Skavroneck, Scott Hausmann, Carl Blabaum, Patty Hanz.

Other Contributions: Special thanks to Diane Barman and Maureen Spaeni for final typing of the document.

II. INTRODUCTION

BACKGROUND

The State of Wisconsin's Department of Natural Resources (WDNR) in conjunction with the International Joint Commission (IJC) and the United States Environmental Protection Agency (U.S. EPA) have targeted the Lower Sheboygan River and Harbor as an Area of Concern (AOC) for remedial action (Figure II.1). Through the IJC, Canada and the United States cooperatively resolve problems associated with the Great Lakes. Areas of Concern include major urban and industrial centers on Great Lakes rivers, harbors and connecting channels where beneficial uses are impaired. Toxic contamination is often a major problem in these areas. Sheboygan is one of the 42 Great Lakes AOCs and one of four AOCs in Wisconsin.

The Remedial Action Plan is one of several efforts underway which are working to correct water quality problems in the Sheboygan Basin. Other concurrent efforts include the Onion and Sheboygan River Priority Watershed Projects and the Water Quality Management Plan for the Sheboygan River Basin being developed by the WDNR (Meyer 1988), and Remedial Investigations and Feasibility Studies being conducted for the Kohler Co. landfill and the Sheboygan River and Harbor under guidance of U.S. EPA's Superfund Program.

The Sheboygan River Basin Water Quality Management Plan identifies water quality goals, problems, improvements, and management needs for the lakes and streams in the entire basin. This plan also examines existing and future wastewater treatment facility management needs. The Remedial Action Plan will be a site specific refinement of the Water Quality Management Plan that addresses problems of the Sheboygan Area of Concern.

Two projects focus on nonpoint source problems in the basin. The Sheboygan River watershed, one of three watersheds in the Sheboygan River Basin, was designated as a Priority Watershed under the Wisconsin Nonpoint Source Water Pollution Abatement Program in 1985. This program was created by the State Legislature in 1978 as a means to reduce surface and ground water pollution caused by nonpoint sources of pollution. As part of the priority watershed project, nonpoint sources are inventoried, a management plan is developed, and cost sharing is provided for best management practices in critical areas of the watershed. A priority watershed project has been underway in the Onion River since 1980 and is near completion.

In 1985, the Sheboygan Harbor and River Superfund site was proposed for inclusion on the National Priorities List. This is U.S. EPA's nationwide list of contaminated sites that are eligible for investigation and clean-up under the federal Superfund program. In April 1986, U.S. EPA and WDNR signed a Consent Order with Tecumseh Products Co., one of three potentially responsible parties identified for the site. Tecumseh Products Co. agreed to conduct the Remedial Investigation/Feasibility Study (RI/FS) for the Sheboygan site. The contractor for Tecumseh Products Co., Blasland and Bouck Engineers, P.C., began the RI/FS in the spring of 1986. Remedial investigation activities entailed the collection of sediment, soil, and water samples from the river and harbor over a period spanning May 1987 to June 1988.

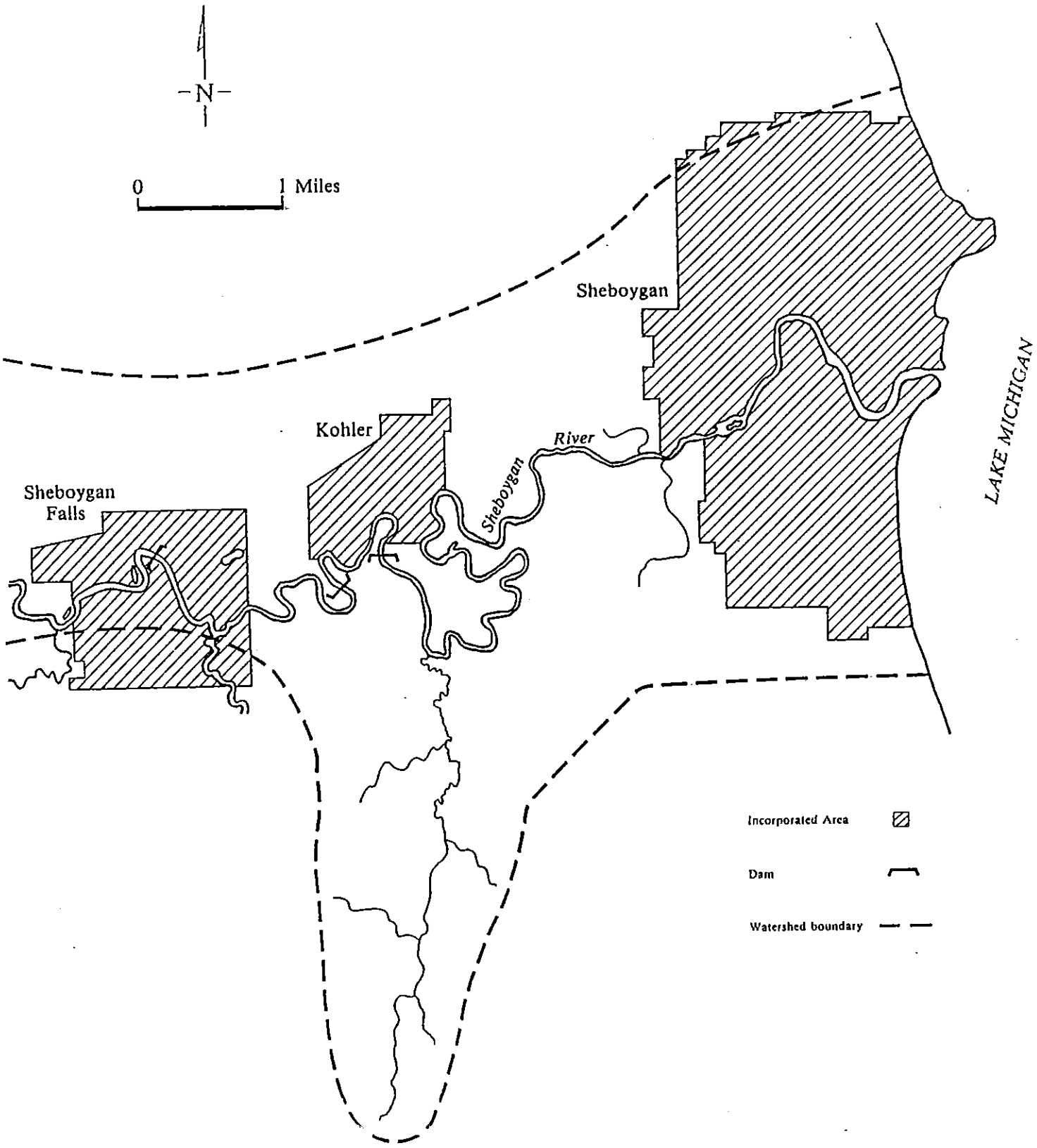


Figure II.1 The Sheboygan River Area of Concern

The Kohler Company landfill was proposed for inclusion in the Superfund National Priorities List in September 1983 and it was placed on the list in September 1984. Kohler Company is currently conducting a Remedial Investigation and Feasibility Study at this site.

The public is also aware of the Sheboygan River and harbor contamination. In 1984, the Sheboygan County Water Quality Task Force was created by citizens who were concerned about the effects of pollution on recreational and economic development in the AOC. The Task Force is composed of members from industry, government, fishing and conservation groups, and others. The WDNR selected the Task Force to be the citizens advisory committee for development of the Sheboygan River Remedial Action Plan (RAP).

The Task Force has facilitated informational exchange sessions between environmental agencies and the public. Results from a questionnaire which was distributed by the Sheboygan County Water Quality Task Force to the local community indicated that fishing, swimming, and canoeing would be more desirable if the Sheboygan AOC were cleaned up. A marina in the harbor is also desired whether the area is cleaned up or not. (See Appendix F for more information on public participation.)

PURPOSE

The IJC requested the WDNR to prepare a Remedial Action Plan (RAP) which will identify specific management strategies to control existing sources of pollution, abate environmental contamination already present, and restore beneficial uses in the AOC. As defined in the Water Quality Agreement between the United States and Canada, an impairment of beneficial use(s) means a change in the chemical, physical or biological integrity of the Great Lakes system. The RAP will address the following specific points:

* define the environmental problem, including geographic extent of the area affected, using detailed maps;
* identify beneficial uses that are impaired;
* describe the causes of the problems and sources of pollutants;
* identify remedial measures proposed to resolve the problems and restore beneficial uses;
* provide a schedule for implementing and completing remedial measures;
* identify agencies and jurisdictions responsible for implementing and regulating remedial measures;
* describe the process for evaluating remedial program implementation and effectiveness and;
* describe surveillance and monitoring activities that will be used to track effectiveness of the programs and eventually confirm that uses have been restored.

Water quality problems in the Sheboygan AOC are causing fish and waterfowl consumption advisories, dredging restrictions, eutrophication, and habitat loss and degradation. Restoration of impaired uses will be guided by an ecosystem perspective which emphasizes the protection of the entire Great Lakes system. Goals for the Sheboygan AOC are:

I. *Protect the ecosystem (including humans, wildlife, fish and other organisms) from the adverse effects (reproduction, survival, and health of individuals and the integrity of interspecies relationships) of toxic substances.*

II. *Maintain diverse communities of aquatic and terrestrial life.*

III. *Control eutrophication (nutrient enrichment of water) for the protection of Lake Michigan.*

IV. *Enhance recreational uses of the harbor.*

Specific Objectives of this plan are:

1. Describe the existence and extent of contamination due to chlorinated organic compounds, heavy metals, and others in the AOC (the emphasis will be on in-place pollutants, specifically polychlorinated biphenyls);

2. Describe the problems the contaminants pose to ecosystem health, public health, recreational uses, and economic development in the AOC;

3. Discuss alternatives for remediation; and

4. Provide a timetable and identify programs and agencies for implementation and remediation.

INTENDED USE OF THE REMEDIAL ACTION PLAN

Since there are several remedial efforts underway in the Sheboygan area, the RAP references those efforts when appropriate. The reader may obtain more detailed information in the specific reports. This initial RAP will be updated when more information becomes available.

It is recognized that the entire process of developing and implementing a RAP and confirming that the uses have been restored may take several decades. This endeavor can only be successful if concerned citizenry are involved in the development and implementation of the RAP. The Sheboygan County Water Quality Task Force, as well as other concerned parties, such as Lake Michigan Federation, will continue to participate in the RAP process.

This plan is intended to be utilized by the public as well as environmental agencies for restoring and protecting a desired quality of life.

III. ENVIRONMENTAL SETTING

LOCATION

The Area of Concern (AOC) (and impacted area, as defined by IJC) encompasses the lower Sheboygan River downstream from the Sheboygan Falls Dam including the entire harbor and nearshore Lake Michigan (Figure II.1). The Sheboygan harbor consists of an outer harbor formed by two breakwalls and an inner harbor which extends from the Coast Guard station upstream to Jefferson Avenue. The source area, which is the area from which pollutants are generated, is the entire Sheboygan River Basin which includes three watersheds: the Sheboygan River mainstem, Mullet River, and Onion River (Figure III.1). The Onion and Mullet Rivers are direct tributaries to the Sheboygan River mainstem and contribute some point, but principally nonpoint sources of pollution to the AOC. Pollutants to the Sheboygan River mainstem watershed, above the Sheboygan Falls Dam, are also mainly from nonpoint sources.

Communities along the AOC in Sheboygan County include the City of Sheboygan, the Village of Kohler and the City of Sheboygan Falls with 1986 populations of approximately 48000, 2000, and 6000 respectively.

NATURAL FEATURES

Drainage Basin Size

The 13.9 stream miles of the Sheboygan River in the AOC from Sheboygan Falls at the Sheboygan Falls Dam (also known as the Roller Mills Dam) to the harbor, drain approximately 22 square miles of land. The Sheboygan River mainstem totals 173 stream miles and drains 104.8 square miles from west to east into Lake Michigan. The Onion and Mullet Rivers discharge to the Sheboygan River 13 and 17 stream miles upstream from its mouth and drain 98 and 78 square miles, respectively. The total drainage area of all three watersheds is 300 square miles (Meyer 1988).

Topography

The direct drainage area of the river is slightly rolling, becoming flat near Lake Michigan at an elevation of 600 feet above sea level with a gradient approaching 8 feet per mile. The river water velocity is relatively slow.

Hydrology

The Sheboygan River has a mean annual discharge of 258 cubic feet per second at the United States Geological Survey (USGS) gaging station located 4.2 stream miles upstream from the harbor. This value was calculated from data spanning the last 44 years up to and including 1986. The extremes for the period of record were in March, 1975 with 7680 cubic feet per second (cfs) and in August 1922 with 1 cfs. Extremes for 1985/1986 were in November, 1985 with 4000 cfs and in August, 1986 with 49 cfs. The mean annual precipitation from 1978 to 1986 was 30 inches (Holstrom et al. 1986).

Sheboygan River Basin (with watersheds)

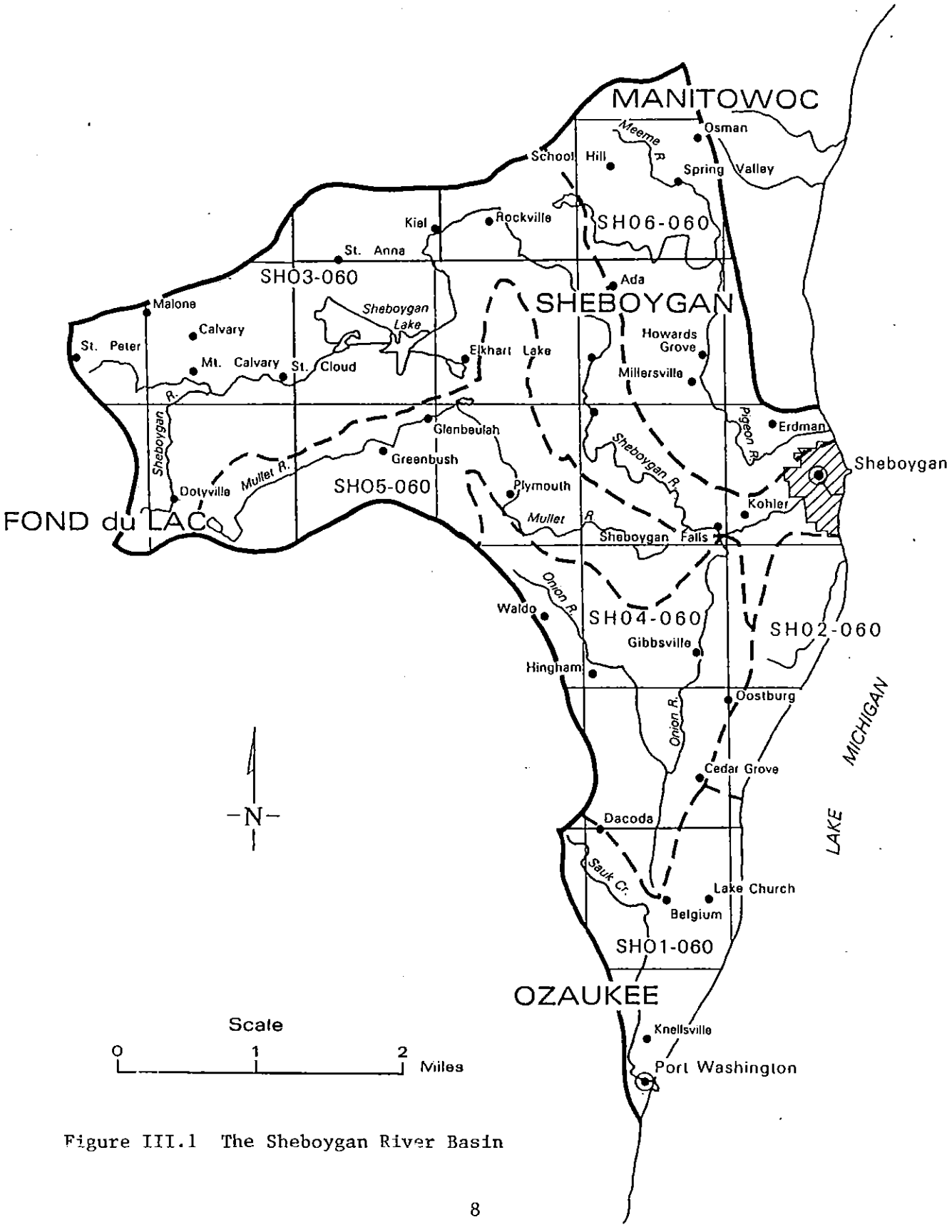


Figure III.1 The Sheboygan River Basin

Back water (seiche) effects of Lake Michigan can occur in the harbor and cause rapid rises in water levels and temporarily reverse river flow.

Soil types, runoff, erosion

Soils in the eastern third of the Sheboygan River Basin are primarily heavy clay soils intermixed with sands, silts, and gravels. Agricultural and urban runoff is fostered by these soil types. A more detailed discussion of erosion problems and erosion control techniques will be provided in the Sheboygan River Nonpoint Source Control plan which will be available in 1990. Erosion problems are also identified in all County Erosion Control Plans.

Navigational Channels and Structures

The harbor has an area of 96 acres contained by two breakwalls. Federal navigation channels within the harbor (Figure III.2) are:

1. an entrance to the harbor 25 feet deep decreasing to 21 feet deep;

2. a turning basin 20 feet deep; and

3. a channel in the Sheboygan River 21 feet deep extending from the turning basin to Maryland Avenue and then 15 feet deep upstream to Jefferson Avenue.

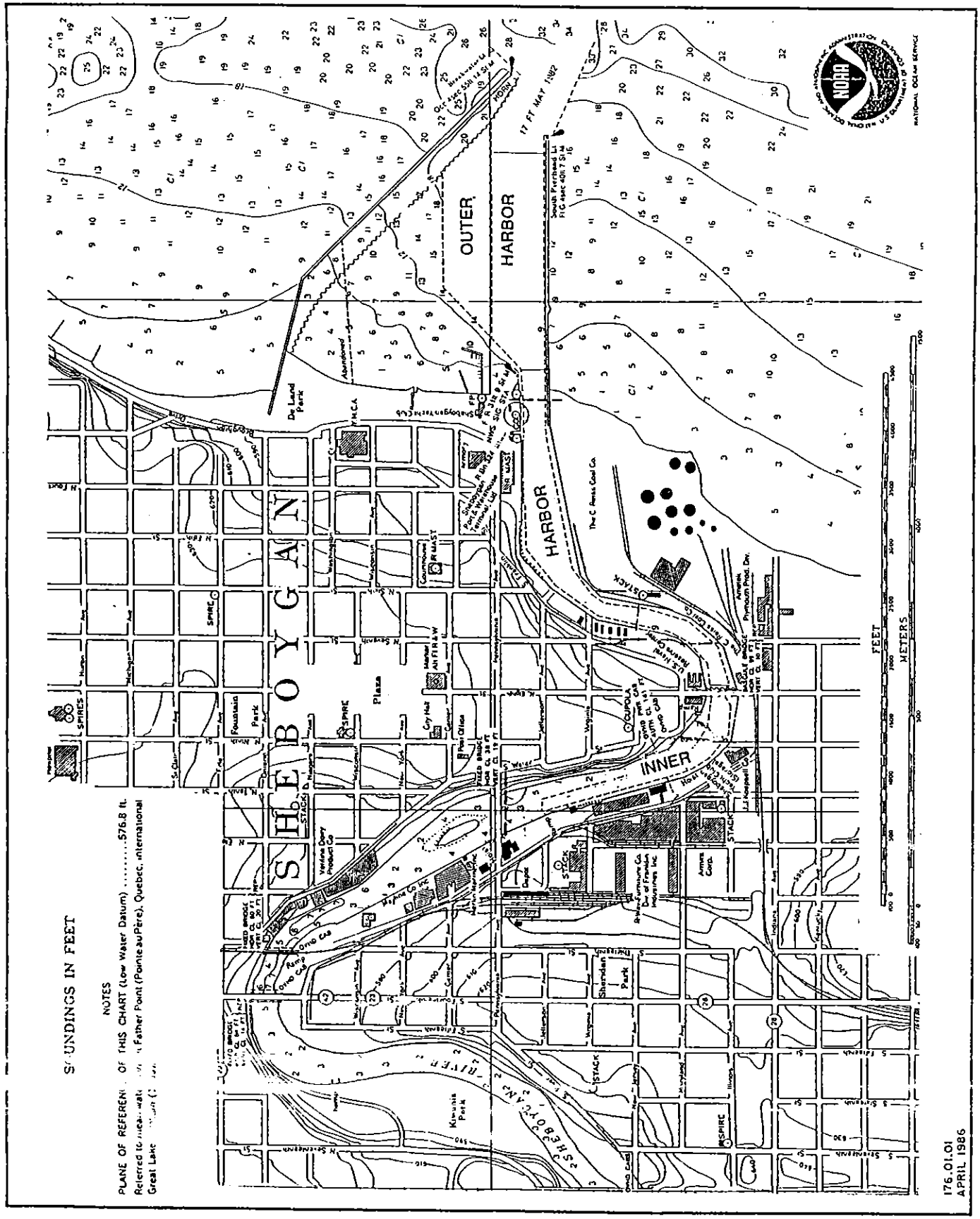
Navigation channel bottom elevations are now several feet above the project design navigation depth due to sedimentation and a lack of dredging. The sediment input to the harbor is estimated to be 30,000 cubic yards per year. In 1981, 1984, 1985, and 1987, 28556, 25596, 12026, and 24303 cubic yards of sediment, respectively, were removed from the harbor mouth and used for beach nourishment and industrial fill. This sediment was reported to be of good quality. (see "Chapter VII. Historical Record"). The entire harbor has not been dredged since 1969.

A limited dredge project to maintain navigation channels is pending. The limited dredge project is designed to provide an access channel to the C. Reiss Coal Co. docks in the Sheboygan Harbor. Approximately 46,000 cubic yards of sediment would need to be dredged initially. The U.S. Army Corps of Engineers entered into a contract with a consulting firm (Owen-Ayers) in 1987 to evaluate upland and in-water disposal sites for Sheboygan harbor sediment resulting from the proposed limited dredge project.

The project identified 19 disposal sites within a ten mile radius of the harbor and ranked them according to a set of criteria which included engineering, environmental, social, and economic factors. The 19 sites were reduced to 4 upland sites based on the criteria. The evaluation of disposal sites also identified the need to design for a 100,000 cubic yard capacity to allow continued maintenance dredging once the original project is completed.

The City of Sheboygan desires marina development. The in-water designs and sites evaluated did not rank highly, although they would be compatible with marina development. Concerns identified included cost, liner composition, structure height, and effects of wave action. The entire report on the evaluation of the 19 sites was completed in April, 1989.

Figure III.2 The Sheboygan Harbor



Funding has been requested by the Corps to review these 4 upland sites and to begin consultation with WDNR, the U.S. EPA, and U.S. Fish and Wildlife Service to obtain input on the potential use of these sites.

Other hydraulic restrictions, excluding the breakwaters, are two dams located in the Village of Kohler and one dam in the City of Sheboygan Falls, as shown in Figure II.1. The impounded water behind the dam in Kohler is used as an emergency source of cooling water for Kohler Co. and the Sheboygan Falls Dam is used for power generation.

Air Quality

Ambient air quality must meet the standards set in Wisconsin's Administrative Code NR 404, which are the same as the federal standards mandated by the Clean Air Act (Table III.1). Air quality monitoring is conducted at several sites near Sheboygan (Baggott et al. 1986). The Wisconsin Power and Light Co. (WP&L), located in the city of Sheboygan, is certified by the Wisconsin DNR to monitor sulfur dioxide, total suspended particulates, and ozone. Other WDNR monitoring sites in the Sheboygan area are located in the cities of Kewaunee and Manitowoc.

Ozone is the primary air quality problem in the Sheboygan area. Sheboygan County is a nonattainment area for ozone because it does not meet ambient air quality standards. Levels of sulfur dioxide and total suspended particulates do not exceed the primary ambient air quality standards in the Sheboygan area.

Monitoring of nitrogen dioxide, lead, and carbon monoxide elsewhere in the state, indicates these pollutants do not exceed the air quality standards.

There is no state monitoring data available to assess levels of PCBs or other potentially toxic compounds in the Sheboygan area.

LAND USES

Approximately 36 percent of the land along the Sheboygan River in the AOC is in residential, 14 percent in natural, and 11 percent in industrial uses. The remaining 39% is in transportation, agricultural, and commercial uses (WDNR 1980). Table III.2 illustrates the acreage for various uses in Sheboygan Township, an area which is representative of the land surrounding the river in the AOC.

The Kiel Marsh and Sheboygan Marsh, northwest of the AOC, approximately 60 stream miles from the river mouth, contain the closest public wildlife areas. The largest open space along the AOC is Kohler Company's River Wildlife Reserve. Approximately 800 acres are operated as a private recreational area. Approximately 200 acres of the River Wildlife Reserve are operated as a shooting game farm for pheasant, quail, waterfowl, wild turkey, and partridge. Farming activities are conducted within the game farm area to provide wildlife cover. A recently developed golf course and Kohler Farms are adjacent to River Wildlife, Reserve.

There are many public parks in the Cities of Sheboygan and Sheboygan Falls. River Park and Rochester Park are located along the river in Sheboygan Falls.

Table III.1 Wisconsin Air Pollution Standards

WISCONSIN AMBIENT AIR QUALITY STANDARDS
NR 404.03, WISCONSIN ADMINISTRATIVE CODE
ADOPTED FROM NOVEMBER 25, 1971 NATIONAL AMBIENT AIR QUALITY STANDARDS,
LAST REVISED SEPTEMBER, 1981
40 CFR 50.4 TO 50.11

Pollutant	Time of Average	Primary Standard**	Secondary Standard**	Method of Determination
Particulate Matter	Annual (Geometric Mean) 24 hour	75 ug 260 ug*	60 ug@ 150 ug*	High Volume Sampler
Sulfur Oxides (SO_x) (Measured as SO_2)	Annual (Arithmetic Mean) 24 hour 3 hour	80 ug (0.03 ppm) 365 ug (0.14 ppm)* ----------	 1300 ug (0.5 ppm)*	Pulsed and Continuous Fluorescence
Carbon Monoxide (CO)	8 hour 1 hour	10 mg (9 ppm)* 40 mg (35 ppm)*	Same as primary Same as primary	Nondispersive Infrared
Nitrogen Dioxide (NO_2)	Annual (Arithmetic Mean)	100 ug (0.05 ppm)	Same as primary	Chemiluminescence
Ozone (O_3)	1 hour	0.12 ppm (235 ug)*	Same as primary	Ultraviolet absorption, and Chemiluminescence
Lead (Pb)	Calendar Quarter (Arithmetic Mean)	1.5 ug		Atomic Absorption***

* Concentration not to be exceeded more than once (separate days for ozone) per year.

** Concentration in weight per cubic meter (all except ozone corrected to 25°C and 760 mm of Hg).

*** Analysis is conducted on acid extract of high-volume filter particulate.

@ Under the National Standards this is a guideline standard to be used in assessing implementation plans in achieving the 24-hour standard.

Source: Baggott et al. 1986

Table III.2 Land Uses in Sheboygan Township (1980)

Type	% of Total Acreage	Acreage
Natural	14.6	1255
Residential	35.6	3059
Industrial	11.3	970
Commercial	5.73	493
Agricultural	11.3	968
Transportation	21.6	1854
Total	100	8599

Source: WDNR, 1980b

In Sheboygan, Kiwanis and Franklin Parks provide public boat access with camping facilities being developed at Franklin Park. There are two public beaches located along Lake Michigan, General King Park south of the harbor and Deland Park north of the harbor.

Land uses adjacent to the harbor consist mainly of small boat facilities, parks, recreation areas, and industrial transportation. The City of Sheboygan's central business district and some industrial businesses are located in the vicinity of the harbor. The city actively participates in the development of a commercial area along the north bank of the river in the harbor area. The area is developed around the old commercial fish shanties. Currently, there are plans for continued riverfront development on a five acre site north of the old shanty area (Sheboygan County Water Quality Task Force 1987).

A sewer service area plan for the Sheboygan area will be developed by the Bay Lake Regional Planning Commission on contract with the WDNR. This plan will include the entire Sheboygan AOC and is scheduled for completion in the 4th quarter of 1989.

WATER USES

Wildlife Habitat along the Sheboygan River

The wildlife habitat within and along the Sheboygan River AOC is of good quality considering its proximity to an urban area and the resulting impacts

(Dale Katsma, WDNR Wildlife Manager, pers. comm. 1988). River banks provide habitat for belted kingfishers. Sandpipers and herons forage in shallow areas and mudflats. Raccoons and muskrats are common mammals associated with the river.

The nearshore area of the harbor and Lake Michigan provides foraging habitat for gulls, terns, shorebirds and ducks. Diving ducks have historically stopped in this area during their migration. In recent years, lesser scaup have used the area for 2 to 4 weeks during the fall (Dale Katsma, WDNR Wildlife Manager, pers. comm. 1988).

Appendix A (Tables 1-4) lists mammals and birds present in the AOC. Mink are rare in the AOC. The common tern, which is a seasonal resident only, is included on Wisconsin's Endangered Species List and has been reported in the harbor. The bald eagle and the piping plover are on the Federal Endangered Species List. While neither species have been reported to reside in the AOC, they have been reported in the AOC during migration.

Recreational Activities

Noncontact recreation such as walking, jogging and bicycling occurs in Sheboygan and Sheboygan Falls parks along the river. Much of the land near the river in Kohler is privately owned. Thus, public access is limited in the Village of Kohler, but not in Sheboygan and Sheboygan Falls.

The City of Sheboygan operates two public beaches for wading and swimming. They are located on Lake Michigan, north and south of the Sheboygan Harbor. Swimming, though, is popular at a quarry in Jaycee Park, which is not located near the river. There are no public beaches located on the lower Sheboygan River or harbor.

The lower Sheboygan River is navigable, but river traffic is partially restricted by the dams in Kohler and Sheboygan Falls. The Sheboygan Yacht Club is a private recreational resource in the harbor. Public boat access is available at many sites in Sheboygan. While sport and charter fishing occurs in the AOC, commercial fishing occurs outside the AOC in the open waters of Lake Michigan. Open water duck hunting also occurs in the harbor during the fall.

Commercial Shipping

The harbor supports commercial shipping vessels and is categorized as a diversified cargo port by the Wisconsin Department of Transportation. This means that the port receives more than one or two types of freight for use within the vicinity of the port. The C. Reiss Coal Co. is the major handler of commercial cargo in the harbor.

Fishing

Species Diversity/Balance

Major fish species collected in the Sheboygan River and harbor are alewife, gizzard shad, american smelt, carp, common shiner, white sucker, black bullhead, channel catfish, yellow perch, smallmouth bass, rock bass, walleye, northern pike, black crappie, white crappie, lake whitefish, round whitefish,

coho salmon, chinook salmon, and lake, brook, brown, and rainbow trout. Interestingly, smallmouth bass populations downstream of the Sheboygan Falls Dam have increased dramatically since 1980. They are now occasionally seen above the dam as well. The reason for this sudden increase is unknown. At any rate, it has enhanced the recreational fishery. Generally, there is a diversity of sport fish in the river between the dams. The impoundments are inhabited mainly by carp as habitat is limited for the more desirable sport and forage species.

Sport/Charter Fishing

Sheboygan harbor has periodic runs of Great Lake trout and salmon. Sport fishing begins in the spring for rainbow, brook, and brown trout. The summer months of June through August produce catches of brook and brown trout with coho and chinook salmon catches increasing during August. Catches of resident species such as yellow perch and whitefish are also prevalent. Rough fish such as carp and sucker are also fished. September marks the beginning of the fall salmon run when coho and chinook begin to ascend the Sheboygan River to spawn. Thus, the fall months are very productive for catches of coho and especially chinook salmon. Rainbow and brown trout catches also increase during the fall period. Late winter and spring produce runs of rainbow trout.

Stocking release sites are located within and outside of the Sheboygan harbor. Annual stocking of coho and chinook salmon and rainbow trout has been done in the fall and spring within Sheboygan harbor. Brook, brown, and lake trout are stocked at Lake Michigan sites in the spring and fall.

In 1969, the WDNR began annual creel surveys of Lake Michigan sport anglers at boat ramps and on piers, shores, and tributary streams all along the Wisconsin coast of the lake. Large scale trout and salmon stocking had begun just a few years earlier, setting the stage for an unprecedented Great Lakes sport fishery. Between 1969 and 1984 there has been more than a tenfold increase in fish caught in Lake Michigan (Appendix A, Table 5).

Lake Michigan is divided into several zones along the Wisconsin coast: Marinette/Green Bay; Door; Algoma/Kewaunee; Three Rivers/Manitowoc; Sheboygan; Port Washington; Milwaukee; and Racine/Kenosha. The Sheboygan River in 1984 was second to Three Rivers/Manitowoc with respect to angler effort (Appendix A, Figure 6). Other 1984 WDNR survey results indicate that anglers in the Sheboygan River vicinity caught 2673 lake trout and 2109 rainbow trout, which was more of each of these species than were caught in any other zone.

Trout and salmon also comprise the majority of the charter anglers' catch. Appendix A, (Table 7) indicates angler effort hours and catch numbers and composition for the years between 1976 and 1984. The angler hours increased from approximately 6000 hours to 68000 hours, as well as an increase in catch from 1500 to 21000 per year.

Commercial fishing

Lake whitefish are a valuable commercial fish and appear to be rebuilding their populations from an extreme low during the pre-lamprey control years (~1965). Offshore waters of Lake Michigan near Door County provide a spawning area for whitefish. The Sheboygan Harbor provides a nursery for these fish. Commercial fishing occurs just south of the harbor.

Commercial perch fishing has seen a significant increase approximately one half mile from the harbor mouth. Perch do not spawn in the harbor, but principally near offshore reefs and similar structures in 20 to 30 feet of water. Whitefish and perch catches near Sheboygan harbor were productive in 1987. Chubs are also commercially fished, but well off shore and outside of the AOC.

Public Water Supply

The municipal water supply for the City of Sheboygan Falls, the Village of Kohler, and the City of Sheboygan is from Lake Michigan with an intake located north of the harbor approximately one mile out into the lake. The Sheboygan Water Commission provides 4.8 billion gallons per year to these communities. The amounts provided for industrial, residential, commercial and public uses are provided in Table III.3.

Table III.3 Public Water Supply - 1986 Uses and Amounts (gallons x 10^3)

Cities of Sheboygan, Sheboygan Falls, and the Village of Kohler

Use	Sheboygan	Sheboygan Falls	Kohler
Residential	1,016,830	96,331	37,894
Commercial	429,6261	18,590	21,717
Industrial	2,033,181	725,443	29,170
Public	209,305	847,798	99,555
Total	3,688,942	847,798	99,555

Source: D. Stage, Sheboygan Water Utility, pers. comm. 1987

Standards and treatment requirements for human consumption are contained in ch. NR 109 and 111, Wis. Adm. Codes for safe drinking water. Maximum contaminant levels are established for some inorganic and organic compounds, microorganisms, radioactivity, and turbidity. All concentrations were below these levels on the last sampling date (February 2, 1988). The DNR monitors inorganics yearly, organics (including pesticides and volatiles) every three years and radioactivity once every four years. The Sheboygan Water Commission is responsible for sampling bacteria and turbidity daily.

Lead is a potentially toxic metal which is of increasing concern to public health when present in drinking water. In 1987, the City of Sheboygan municipal water supply contained only 3 ug/l of lead, which is well below the current standard of 50 ug/l.

Waste Disposal

The AOC also receives point (industrial and municipal effluent) and nonpoint (agricultural and urban runoff) sources of pollution. This information is presented in "Chapter V. Sources of Pollution".

WATER QUALITY OBJECTIVES

The Clean Water Act of 1986 mandates that the quality of state waters be sufficiently high to support aquatic life and recreational uses. The classification of this AOC is Full Fish and Aquatic Life capable of supporting a Warm Water Sport Fishery. This area also supports coldwater migrant fish from Lake Michigan. The AOC has suitable habitat to support a variety of warmwater and coldwater sport and forage fish species. Supporting water quality criteria are assigned according to this classification. Table III.4 summarizes the water quality criteria for the Full Fish and Aquatic Life and recreational use classification for the lower Sheboygan River.

Administrative Code NR 105 contains water quality standards for toxic substances. The standards are intended to protect the public interest including the protection of: 1) the public health and welfare, 2) the present and prospective uses of all waters of the state for public and private water supplies, 3) propagation of fish, other aquatic life, and wild and domestic animals, 4) domestic and recreational purposes, and 5) agricultural, commercial, industrial and other legitimate uses. The water quality standards for various organic and inorganic compounds that apply to Sheboygan are illustrated in Tables III.5 through III.7 and are based on NR 105.

Table IV-4 Water Quality Criteria for Full Fish and Aquatic Life and Recreational Use Classifications

APPLICABLE WATER USE OBJECTIVES AND WATER QUALITY STANDARDS FOR LAKES AND STREAMS WITHIN THE SOUTHEASTERN WISCONSIN REGION: 1977

Water Quality Parameters	Individual Water Use Objectives[a,b,c]								Combinations of Water Use Objectives Adopted for Southeastern Wisconsin Inland Lakes and Streams					
				Fish and Aquatic Life										
	Recreational Use	Restricted Use[q]	Public Water Supply	Warmwater Fishery	Trout Fishery	Salmon Spawning Fishery	Limited Fishery[w,x] (Intermediate Aquatic Life)	Marginal Aquatic Life[d,w]	Restricted Use and Minimum Standards[b]	Marginal Aquatic Life Recreational Use, and Minimum Standards[b]	Limited Fishery (Intermediate Aquatic Life), Recreational Use, and Minimum Standards[b]	Warmwater Fishery and Aquatic Life, Recreational Use, and Minimum Standards[b]	Trout Fishery and Aquatic Life, Recreational Use, and Minimum Standards[b]	Salmon Spawning Fishery and Aquatic Life, Recreational Use, and Minimum Standards[b]
Maximum Temperature (°F)	..[e]	..[e]	..[e]	89[e,h]	..[e,f]	..[e,f]	89[e]	89[e]	..[e]	..[e]	89[e]	89[e]	..[e,f]	..[e,f]
pH Range (S.U.)	..	6.0-9.0[g]	6.0-9.0[g]	6.0-9.0[g]	6.0-9.0[g]	6.0-9.0[g]	6.0-9.0[g]	6.0-9.0[g]	6.0-9.0[g]	6.0-9.0[g]	6.0-9.0[g]	6.0-9.0[g]	6.0-9.0[g]	6.0-9.0[g]
Minimum Dissolved Oxygen (mg/l)	..	2.0	..	5.0[h]	6.0[i]	5.0[i]	3.0	2.0	2.0	2.0	3.0	5.0[h]	6.0[i]	5.0[i]
Maximum Fecal Coliform (counts per 100 ml)	200-400[k]	1,000-2,000[l]	200-400[k]	..	..	..	..	200-400[k]	1,000-2,000[l]	200-400[k]	200-400[k]	200-400[k]	200-400[k]	200-400[k]
Maximum Total Residual Chlorine (mg/l)	..	..	..	0.5	0.002[y]	0.002[y]	0.5	0.5	..	0.5	0.5	0.002[y]	0.002[y]	0.002[y]
Maximum Unionized Ammonia-Nitrogen (mg/l)	..	..	..	0.02[u]	0.02[u]	0.02[u]	0.2[v]	..	..	..	0.2[v]	0.02[u]	0.02[u]	0.02[u]
Maximum Nitrate Nitrogen (mg/l)	..	..	10	..	..	..	..	..	..	..	..	..	..	..
Maximum Total Dissolved Solids (mg/l)	..	..	500-750[m]	..	..	..	..	..	..	..	..	..	..	..
Other[r,s,t]	..	..	..[n]	..[p]	..[o,p]	..[p]	..[p]	..	..[q]	..	..[p]	..[p]	..[o,p]	..[p]

[a] *Includes SEWRPC interpretations of all basic water use categories established by the Wisconsin Department of Natural Resources plus those combinations of water use categories applicable to the Southeastern Wisconsin Region. It is recognized that, under both extremely high and extremely low flow conditions, instream water quality levels can be expected to violate the established water quality standards for a reasonable length of time without damaging the overall health of the stream. It is important to note the critical differences between the official state and federally adopted water quality standards—composed of "use designations" and "water quality criteria"—and the water use objectives and supporting standards of the Regional Planning Commission. The U. S. Environmental Protection Agency and the Wisconsin Department of Natural Resources, being regulatory agencies, utilize water quality standards as a basis for enforcement actions and compliance monitoring. This requires that the standards have a rigid basis in research findings and in field experience. The Commission, by contrast, must forecast regulations and technology far into the future, documenting the assumptions used to analyze conditions and problems which may not currently exist anywhere, much less in or near southeastern Wisconsin. As a result, more recent—and some times more controversial—study findings must sometimes be applied. This results from the Commission's use of the water quality standards as criteria to measure the relative merits of alternative plans.*

[b] *All waters shall meet the following minimum standards at all times and under all flow conditions: substances that will cause objectionable deposits on the shore or in the bed of a body of water shall not be present in such amounts as to interfere with public rights in waters of the State. Floating or submerged debris, oil, scum, or other material shall not be present in such amounts as to interfere with public rights in the waters of the State. Materials producing color, odor, taste, or unsightliness shall not be present in amounts found to be of public health significance, nor shall substances be present in amounts which are acutely harmful to animal, plant, or aquatic life.*

[c] *Standards presented in the table are applicable to lakes over 50 acres in surface area and to major streams of the Region.*

[d] *Includes all effluent channels used predominantly for waste carriage and assimilation, wetlands, and diffuse surface waters and includes selected continuous and noncontinuous streams as specified by the DNR on the basis of field surveys and identified as "marginal surface waters." (See Wisconsin Administrative Code, Chapter NR 104.02(3)(b).)*

[e] *There shall be no temperature changes that may adversely affect aquatic life. Natural daily and seasonal temperature fluctuations shall be maintained. The maximum temperature rise at the edge of the mixing zone above the existing natural temperature shall not exceed 5°F for streams and 3°F for lakes.*

[f] *There shall be no significant artificial increases in temperature where natural trout or stocked salmon reproduction is to be protected.*

[g] *The pH shall be within the range of 6.0 to 9.0 standard units with no change greater than 0.5 units outside the estimated natural seasonal maximum and minimum.*

[h] *Dissolved oxygen and temperature standards apply to continuous streams and the epilimnion of stratified lakes and to the unstratified lakes; the dissolved oxygen standard does not apply to the hypolimnion of stratified inlake lakes. Trends in the period of anaerobic conditions in the hypolimnion of deep inland lakes should be considered important to the maintenance of their natural water quality, however.*

Table III.4 (cont.)

[i] Dissolved oxygen shall not be lowered to less than 7.0 mg/l during the trout spawning season.

[j] The dissolved oxygen in the Great Lakes tributaries used by stocked salmonids for spawning runs shall not be lowered below natural background during the period of habitation.

[k] Shall not exceed a monthly geometric mean of 200 per 100 ml based on not less than five samples per month nor a monthly geometric mean of 400 per 100 ml in more than 10 percent of all samples during any month.

[l] Shall not exceed a monthly geometric mean of 1,000 per 100 ml based on not less than five samples per month nor a monthly geometric mean of 2,000 per 100 ml in more than 10 percent of all samples during any month.

[m] Not to exceed 500 mg/l as a monthly average nor 750 mg/l at any time.

[n] The intake water supply shall be such that by appropriate treatment and adequate safeguards it will meet the established Drinking Water Standards.

[o] Streams classified as trout waters by the DNR (Wisconsin Trout Streams, publication 213-72) shall not be altered from natural background by effluents that influence the stream environment to such an extent that trout populations are adversely affected.

[p] Unauthorized concentrations of substances are not permitted that alone or in combination with other materials present are toxic to fish or other aquatic life. The determination of the toxicity of a substance shall be based upon the available scientific data base. References to be used in determining the toxicity of a substance shall include, but not be limited to, Quality Criteria for Water, EPA-440/9-76-003, U. S. Environmental Protection Agency, Washington, D. C., 1976, and Water Quality Criteria 1972, EPA-R3-73-003, National Academy of Sciences, National Academy of Engineering, U. S. Government Printing Office, Washington, D. C., 1974. Questions concerning the permissible levels, or changes in the same, of a substance, or combination of substances, or undefined toxicity to fish and other biota shall be resolved in accordance with the methods specified in Water Quality Criteria 1972 and Standard Methods for the Examination of Water and Wastewater, 14th Edition, American Public Health Association, New York, 1975, or other methods approved by the Department of Natural Resources.

[q] The parametric values presented are those typically assigned; although the term "restricted" best describes the intended use, the specific chemical parameters may vary from one such reach of stream to another, since these criteria are established by the Wisconsin Department of Natural Resources on a case-by-case basis, as noted in Wisconsin Administrative Code Chapter NR 104.

[r] Waters important to overall environmental integrity including trout streams, scientific areas, wild and scenic areas, endangered species habitat, and waters of high recreational potential all are subject to further pollution analysis and special standards and effluent criteria. See Wisconsin Administrative Code Chapter NR 104.02(4)(a), whereby this is to be determined by the Wisconsin Department of Natural Resources on a case-by-case basis. No waters in southeastern Wisconsin are designated under this category as of 1977.

[s] Lake Michigan thermal discharge standards, which are intended to minimize the effects on aquatic biota, apply to facilities discharging heated water directly to Lake Michigan, excluding that from municipal waste and water treatment plants and vessels or ships. Such discharges shall not raise the temperature of Lake Michigan at the boundary of the mixing zone established by the Wisconsin Department of Natural Resources by more than $3^{\circ}F$ and, except for the Milwaukee and Port Washington Harbors, thermal discharges shall not increase the temperature of Lake Michigan at the boundary of the established mixing zones during the following months above the following limits:

January, February, March	$45^{\circ}F$	July, August, September	$80^{\circ}F$
April	$55^{\circ}F$	October	$65^{\circ}F$
May	$60^{\circ}F$	November	$60^{\circ}F$
June	$70^{\circ}F$	December	$50^{\circ}F$

After a review of the ecological and environmental impact of thermal discharges in excess of a daily average of 500 million BTU per hour, mixing zones are established by the Department of Natural Resources. Any plant or facility, the construction of which is commenced on or after August 1, 1974, shall be so designed that the thermal discharges therefrom to Lake Michigan comply with mixing zones established by the Department. In establishing a mixing zone, the Department will consider ecological and environmental information obtained from studies conducted subsequent to February 1, 1974, and any requirements of the Federal Water Pollution Control Act Amendments of 1972, or regulations promulgated thereto.

[u] This level of un-ionized ammonia is assumed to be present at the temperature range of $70\text{-}75^{\circ}F$ and pH of 8.0 standard units, which are generally the critical conditions in the Region, and at ammonia-nitrogen concentrations of about [illegible] greater, and has been recommended by the USEPA as a water quality standard for the protection of fish and other aquatic life of the types found in the natural waters of the Region.

[v] This level of un-ionized ammonia is assumed to be present at the temperature range of $70\text{-}75^{\circ}F$ and pH of 8.0 standard units, which are generally the critical conditions in the Region, and at ammonia-nitrogen concentrations of about 3.[illegible] greater, and has been identified by the USEPA as a maximum concentration for the protection of tolerant species of insect life and forage minnows and other aquatic life of the types found in the Region.

[w] May include explicitly designated agricultural drainage ditches.

[x] Includes selected continuous and noncontinuous streams as specified by the DNR on the basis of field surveys and identified as "surface waters not supporting a balanced aquatic community (intermediate aquatic life)."

[y] Based on the level recommended in Quality Criteria for Water EPA-440/9-76-003, U. S. Environmental Protection Agency, Washington, D.C., 1976.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table III.5 Water Quality Criteria for Toxic Substances: Wild and Domestic Animal Criteria and Acute and Chronic Toxicity Criteria

Wild and Domestic Animal Criteria

Substance	Criteria (ng/L)
DDT and Metabolites	0.15
Mercury	2.0
Polychlorinated Biphenyls	
Aroclor 1248, 1254, 1260	3.0
Aroclor 1221, 1232, 1242	47.0
Aroclor 1016	233.0

Acute and Chronic Toxicity Criteria
(hardness of 140 ppm $CaCO_3$)

Substance	Criteria (ug/L)	
	Acute	Chronic
Arsenic (+3)	364	153
Cadmium (total)	5.7	0.79
Chromium (+3)	2,465	71.2
Chromium (+6)	14.2	9.7
Copper (total)	22.8	15.8
Lead (total)	259	15.5
Mercury (+2)	1.53	none
Nickel (total)	1,432	87.9
Selenium (+4)	58	7.07
Silver (total)	2.95	2.95
Zinc (total)	137	66
Cyanide (total)	22.4	5.2

Source: WDNR 1988

Table III.6 Water Quality Criteria for Toxic Substances: Human Cancer Criteria

Human Cancer Criteria

Substance	Criteria (ug/L unless specified otherwise)
Acrylonitrile	0.44
Aldrin (ng/L)	0.17
Arsenic[2]	50
alpha-BHC	0.034
beta-BHC	0.06
gamma-BHC (lindane)	0.068
BHC, technical grade	0.045
Benzene[3]	5
Benzidine (ng/L)	0.65
Benzo(a)pyrene	0.023
Beryllium	0.033
Bis(2-chloroethyl) ether	0.28
Bis(chloromethyl) ether (ng/L)	0.037
Carbon tetrachloride	2.1
Chlordane (ng/L)	1.3
Chloroethene (vinyl chloride)	0.15
Chloroform (trichloromethane)	1.8
4,4'-DDT (ng/L)	0.043
1,4-Dichlorobenzene	11
3,3'-Dichlorobenzidine	0.039
1,2-Dichloroethane	3.7
1,1-Dichloroethene	2.1
Dichloromethane (methylene chloride)	47
Dieldrin (ng/L)	0.17
2,4-Dinitrotoluene	8.6
1,2-Diphenylhydrazine	0.28
Halomethanes[3]	1.8
Heptachlor (ng/L)	0.42
Hexachlorobenzene (ng/L)	1.6
Hexachlorobutadiene	4.2
Hexachloroethane	11
N-Nitrosodiethylamine (ng/L)	8
N-Nitrosodimethylamine	0.013
N-Nitrosodi-n-butylamine	0.059
N-Nitrosodiphenylamine	24
N-Nitrosopyrrolidine	0.16
Polychlorinated biphenyls (ng/L)[5]	0.15
Polynuclear Aromatic Hydrocarbons[6]	0.023
2,3,7,8-Tetrachlorodibenzo-p-dioxin (pg/L)	0.03
1,1,2,2-Tetrachloroethane	1.6
Tetrachloroethene	4.6
Toxaphene (ng/L)	1.7

Table III.6 Water Quality Criteria for Toxic Substances: Human Cancer Criteria (con't)

Substance	Criteria (mg/L unless specified otherwise)
1,1,2-Trichloroethane	5.3
Trichloroethene[3]	5
2,4,6-Trichlorophenol	4.2

[1] A human cancer criterion expressed in micrograms per liter (ug/L), nanograms per liter (ng/L) or picograms per liter (pg/L) can be converted to milligrams per liter (mg/L) by dividing the criterion by 1000, 1,000,000 or 1,000,000,000, respectively.

[2] Human cancer criteria for arsenic equal the maximum contaminant level.

[3] For this substance the human cancer criteria for public water supply receiving water classifications equal the maximum contaminant level pursuant to s. NR 105.09(4)(b).

[4] Human cancer criteria for halomethanes are applicable to any combination of the following chemicals: bromomethane (methyl bromide), chloromethane (methyl chloride), triboromomethane (bromoform), bromodichloromethane (dichloromethyl bromide), dichlorodifluoromethane (fluorocarbon 12) and trichlorofluoromethane (fluorocarbon 11).

[5] For purposes of regulating the discharge of polychlorinated biphenyls (PCB) under ch. NR 106, the human cancer criteria for PCB shall apply only to Aroclors 1254 and 1260. In determining for a discharge the Aroclor mixture present or the predominant Aroclor mixture, when more than one Aroclor is present, the department may take into account factors such as: source of the PCB Aroclor or Aroclor mixture, historical information, amount of quantitative chemical information, quality of available data, and variability of the data.

[6] Human cancer criteria for polynuclear aromatic hydrocarbons are applicable to any combination of the following chemicals: benzo(a)anthracene (1,2-benzanthracene), benzo(b)fluoranthene (3,4-benzofluoranthene), benzo(g,h,i)perylene (1,12-benzoperylene), benzo(k)fluoranthene (11,12-benzofluoranthene), chrysene, dibenzo(a,h)anthracene (1,2,5,6-dibenzanthracene), indeno(1,2 3-cd)pyrene, phenanthrene and pyrene.

Source: WDNR 1988

Table III.7 Water Quality Criteria for Toxic Substances: Human Threshold Criteria

Substance	Criteria (ug/L unless specified otherwise)
Acrolein	0.11
Antimony	0.12
Bis (2-chloroisopropyl) ether	0.026
Cadmium[2]	0.01
Chlorobenzene	0.95
Chromium (+3)	140
Chromium (+6)[2]	0.05
Cyanide, total	0.6
1,2-Dichlorobenzene	1.4
1,3-Dichlorobenzene	1.6
cis-1,2-Dichloroethene	0.27
trans-1,2-Dichloroethene	0.27
2,4-Dichlorophenol	1.4
Dichloropropenes[3]	0.066
Di-2-ethylhexyl phthalate	5.9
Diethyl phthalate	170
Dimethyl phthalate	190
Di-n-butyl phthalate	13
4,6-Dinitro-o-cresol	0.01
Dinitrophenols[3]	0.054
Endosulfan	0.023
Endrin (ug/L)	0.021
Ethylbenzene	1.4
Fluoranthene (ug/L)	9.3
Hexachlorocyclopentadiene	0.16
Isophorone	3.9
Lead[4]	0.05
Mercury (ug/L)	0.079
Nickel	0.17
Nitrobenzene	15
Pentachlorobenzene	0.015
Pentachlorophenol	0.76
Phenol	2.7
Selenium[2]	0.01
Silver (ug/L)	6.4
1,2,4,5-Tetrachlorobenzene (ug/L)	8.1
Thallium (ug/L)	6.5
Toluene	7.6
1,1,1-Trichloroethane[2]	0.2
2,4,5-Trichlorophenol	0.81

[1] A human threshold criterion expressed in micrograms per liter (ug/L) can be converted to milligrams per liter (mg/L) by dividing the criterion by 1000.

[2] For this substance the human threshold criteria for public water supply receiving water classifications equal the maximum contaminant level pursuant to s. NR 105.08(3)(b).

[3] The human threshold criteria for this chemical class are applicable to each isomer.

[4] The human threshold criteria for lead equal the maximum contaminant level.

Source: WDNR 1988

IV. DEFINITION OF THE PROBLEM

IMPAIRED USES

As defined in the Great Lakes Water Quality Agreement between the United States and Canada, an impairment of beneficial use(s) means a change in the chemical, physical or biological integrity of the Great Lakes system sufficient to cause any of the following:

1) restrictions on fish and wildlife consumption;
2) tainting of fish and wildlife flavor;
3) degradation of fish and wildlife populations;
4) fish tumors or other deformities;
5) bird or animal deformities or reproduction problems;
6) degradation of benthos;
7) restrictions on dredging activities;
8) eutrophication or undesirable algae;
9) restrictions on drinking water consumption or taste and odor problems;
10) beach closings;
11) degradation of aesthetics;
12) added costs to agriculture or industry;
13) degradation of phytoplankton and zooplankton populations; or
14) loss of fish and wildlife habitat.

Waterfowl and fish consumption advisories and dredging restrictions are of significant concern in the Sheboygan AOC. Other concerns include eutrophication, habitat loss and degradation, and aquatic and terrestrial life diversity. Limiting factors include toxic organic substances such as polychlorinated biphenyls (PCBs), and toxic inorganic substances such as heavy metals, sedimentation, turbidity, suspended solids, fecal coliforms, phosphorus (and possibly nitrogen levels). Table IV.1 quantifies several water quality parameters obtained from the river at the STH 28 USGS monitoring station during the 1985 and 1986 calendar years. The figures are compared to acceptable levels (based on national and state criteria) and the percentage of exceedances identified.

Restrictions on Fish and Wildlife Consumption

In 1987, waterfowl consumption advisories were established for the AOC (Appendix A, Table 18a) and they remain in effect to date. Mallard ducks and lesser scaup should not be eaten from this area due to PCB concentrations in their tissue greater than the U.S. Food and Drug Administration (FDA) tolerance level established for poultry of 3 ppm (fat basis) (see Appendix A, Tables 15-18, for wildlife contaminant data). It's not known if the Sheboygan River is the only source of the PCBs the waterfowl are accumulating. The WDNR plans to band mallards in the AOC to determine their movement patterns and harvest rates.

Table IV.1 A comparison between monitored data and water quality criteria for the Sheboygan AOC, 1985 and 1986 Calendar Years

Parameter	Observations	Minimum	Average	Maximum	Acceptable Level	% Parameter Exceedances
Dissolved Oxygen (mg/L)	23	7.20	11.96	18.50	5.00**	0
Temp. (°C)	23	0.10	10.78	25.10	30.0*	0
pH (low)	23	6.80	7.93	8.90	6.00**	0
pH (high)	23	6.80	7.93	8.90	9.00**	0
Phosphorus (mg/L)*	24	0.04	0.19	0.58	0.10*	67
Residue*	24	2.00	48.00	338.00	90.0*	13
Ammonia-NH_3 (mg/L)	22	0.000	0.001	0.007	0.040**	0
NO_2 + NO_3(mg/L)	24	0.02	1.10	2.30	1.00**	54
Fecal Coliform (100 mls)	24	10.00	585.00	7000.00	200.00**	33

* Based on national criterion.

** Based on state criterion.

Source: WDNR 1988b

Mallards are the most common waterfowl species bagged by sportsmen in Wisconsin. Fortunately, less than 0.3 percent of the total annual waterfowl harvest comes from the areas covered by the advisory, which includes portions of the lower Fox River, Milwaukee harbor, and the Sheboygan harbor upstream to the Sheboygan Falls Dam.

Fish consumption advisories for sport fishermen developed by the WDNR and Department of Health and Social Services have been in effect since 1978 for the AOC. The advisories recommend that certain species and length of fish should not be consumed due to PCB concentrations in the tissue greater than the FDA tolerance limit of 2 ppm. See Appendix A (Tables 8-14) for fish contamination data. The 1989 advisory recommends that bluegill, crappie, rock bass, smallmouth bass, carp, walleye, northern pike, catfish, trout and salmon should not be eaten (Appendix A, Table 19).

Fish consumption advisories for the Sheboygan River are negatively perceived and may have influenced the desirability of the fish. The Wisconsin Department of Health and Social Services (DHSS) and WDNR conducted a study in 1985 in which 801 people from 10 counties in Wisconsin completed surveys and 198 anglers donated blood samples. Twenty eight anglers from Sheboygan County submitted to blood sampling. A conclusion of the study was that PCB concentrations in the blood increased as the amount of fish consumed from Lake Michigan increased. Lake Michigan sport fishing for salmon and trout has been a continuing recreational use over the years, even though these species are included on the consumption advisories. Although many anglers may be following the fish consumption advisories, the possibility remains that some people may not be aware of the advisories.

Other concerns relating to PCBs and the fishery include the cessation of salmonid stocking within the harbor and the elimination of a proposed coho salmon egg collection facility.

Stocking of coho and chinook salmon and rainbow trout within the harbor ceased in 1987 due to PCB contamination of the Sheboygan River and harbor. A WDNR study (Masnado 1986) revealed that brook, brown, and rainbow trout yearlings, that had been stocked in the Sheboygan River two to three months prior to sampling attained PCB concentrations in their tissue ranging from 0.35 to 5.0 ppm. Since fish consumption advisories are posted for fish containing greater than 2 ppm of PCBs, continued stocking would not be beneficial to the fish or to fish consumers. The last run of mature coho up the Sheboygan River will be in the fall of 1988 and full-term (4 year) chinook in 1989. Rainbow trout will have runs through the fall of 1990 and will be reduced thereafter.

Tainting of Fish and Wildlife Flavor

While no formal studies have been conducted, there have been no recorded complaints of tainted fish or wildlife flavor.

Alteration of the Fishery

Fish populations and diversity in the Sheboygan River, harbor, and Lake Michigan have been altered by various factors including the effects of exotic species, sedimentation, and dams.

The native sport and commercial fish populations declined in Lake Michigan during the late 1950's primarily as a result of the introduction of exotic species (alewife and sea lamprey) and overfishing. Subsequent stocking of native and non-native salmonid species has contributed to increased native fish populations and a reduction in alewife populations. This revitalized fishery has also created a widely utilized recreational sport fishery.

Presently, the lower Sheboygan River supports a diverse population of fish and aquatic life. However, there is concern that sediment from upstream sources which has been deposited above the upper and lower Kohler Dams, along the river bank at bends in the river, and in the harbor may be negatively impacting the diversity and health of the local fishery. Excessive sedimentation can impact fish and aquatic life by:

1) acting directly on fish by either killing them or reducing their growth rate;
2) preventing the successful development of eggs and larvae;
3) modifying natural movement and migration;
4) reducing availability and abundance of food; and
5) degrading habitat.

The three dams in the AOC segregate the river and prevent natural migration of fish. Presently, cold water anadromous fish migrate from Lake Michigan to the lower Kohler Dam. If these dams were removed or modified to allow fish passage, a cold water anadromous fishery could be extended further up the river system, increasing recreational fishing opportunities.

Degradation of Wildlife Populations

The habitat in the Area of Concern is suitable for mink, kingfishers, and swallows, but they are thought to be below normal population levels for this type of habitat (Dale Katsma, WDNR, pers. comm. 1987). The reasons for these population levels remain unidentified.

Fish Tumors or other Deformities

There has not been a scientific study to determine if tumors or other deformities exist in fish from the Sheboygan Area of Concern. WDNR has not received citizen complaints or noticed problems during fish surveys that would indicate that fish tumors are a problem in the AOC.

Bird or Animal Deformities or Reproduction Problems

There has not been a scientific study to determine if deformities or reproduction problems exist in birds or animals in the Area of Concern.

Degradation of Benthos

Data is unavailable for determination.

Restrictions on Dredging Activities

The sediment input to the harbor has been estimated to be 30,000 cubic yards per year (U.S. Army Corps of Engineers 1979).

The sediment deposition associated with heavy metals and PCBs has impacted dredging activities within the harbor. Since 1969, dredging of the harbor (excluding the mouth) has been restricted, partially because of the lack of a disposal site for contaminated sediment due to costs, liability, and siting and the potential for resuspension and exposure of more highly contaminated materials (see "Chapter VII. Historical Record").

The U.S. Army Corps of Engineers is responsible for maintaining federal navigation channels within the harbor. Lake Michigan water levels have been high between 1970 and 1987 (Appendix D) which has facilitated navigation even though sediment has continued to be deposited in the harbor. The amount of materials shipped in and out of the port per ship has remained fairly constant from 1970 to 1987 (reference Appendix D). Water levels decreased in 1987 and were at average levels in June of 1988 based on means calculated between 1900 and 1987. The Corps and C. Reiss Coal Co. are concerned that decreasing water levels and sediment deposition in the harbor will cause inefficient navigation in the future, necessitating more vessel trips to move the present amount of commerce, thereby, increasing transportation costs (U.S. COE 1979; Bob Beiver, C. Reiss Coal Co., pers. comm. 1988).

The Sheboygan River Water Quality Task Force (reference Appendix F) prepared and distributed a questionnaire in 1988 to obtain public input to the Remedial Action Plan. The responses suggest that citizens desire the development of a marina in the harbor (and more shops) whether the area is "cleaned-up" or not. A marina is viewed as a desirable attraction for, among other reasons, the enhancement of recreational uses of the lake. While the harbor dredging restrictions have been an impediment to marina development in the past, authorization to dredge a portion of the harbor associated with the marina project was given in April, 1989. Recent sampling results indicated the sediment to be of good quality in this area. Approximately 20,000 cubic yards of sediment were dredged in May, 1989 and utilized as beach nourishment directly adjacent to the harbor.

The City of Sheboygan would like a confined disposal facility (CDF), in conjunction with marina development, to provide additional parking and recreational access for people that would use the proposed marina (Donohue and United Design Associates 1985). CDFs are in-water structures that have been designed and constructed in the past as long term sites for disposal of sediment within harbors. These facilities have been built and maintained by the U.S. Army Corps of Engineers. Structural features may be incorporated to serve marinas. WDNR is the state agency responsible for review and approval of CDFs. On the federal level, U.S. EPA and Fish and Wildlife Service also participate in the review and approval process.

The concept of a CDF has been proposed for the Sheboygan Harbor since the [illegible] the U.S. Army Corps of Engineers submitted a draft Environmental Impact Statement (EIS) for harbor dredging and construction of a CDF (U.S. ACOE 1979). A CDF was not constructed for various reasons, including WDNR and U.S. EPA concern about the degree of PCB and heavy metal contaminated sediment. A letter from WDNR Secretary Besadny to Wisconsin Governor Dreyfus in 1981 summarized agency concerns and responses to the draft EIS (Appendix C).

A Feasibility Study for a Sheboygan Marina was developed by Bellomo and Duffin Design Associates in 1985. The study recommended that the City of Sheboygan obtain the cooperation and assistance of other agencies in construction of a CDF.

Thus, CDF construction is considered by many members of the local community to be an important component of marina development, and hence, an enhancement of recreational uses. The City of Sheboygan, as sponsor of the CDF, would have long term liability and maintenance responsibility for the facility.

Eutrophication or Undesirable Algae

Eutrophication means an increase in algae and macrophyte production typically due to nutrient loadings, such as phosphorus and nitrogen, to the surface water. Phosphorus concentrations in the lower Sheboygan River routinely exceed the recommended U.S. EPA suggested water quality criteria of 0.1 mg/l (U.S. EPA 1976). Nitrogen concentrations are elevated and are typical of concentrations observed from other agricultural river basins located in southeast Wisconsin (WDNR 1980).

Eutrophication may negatively impact water supplies, recreational and aesthetic uses and water quality needed to sustain fish and other aquatic life communities. Table IV.2 describes potential water quality problems which may occur as a result of excessive primary producer growth (U.S. EPA 1983). Based on very limited data, none of these impacts have been identified as limiting water quality in the free-flowing reaches of the Sheboygan River. Occasional occurrences of undesirable algae have been observed in the harbor. With regard to potential impacts to Lake Michigan, the Sheboygan River is a source of nutrient loadings to the lake. Reducing nutrient loadings to the Great Lakes is a key federal, state and IJC management objective.

Restrictions on drinking water consumption or taste and odor problems

There have been no reports of drinking water problems regarding taste and odor. Drinking water monitoring has not documented any levels above state and federal drinking water standards.

Beach Closings

There are no swimming beaches in the lower Sheboygan River or harbor. There are two public swimming beaches located north and south of the harbor along Lake Michigan. There have been no beach closings to date.

Fecal coliform is an indicator bacteria used to evaluate the safety of surface waters for recreational use. The water quality of the lower Sheboygan River does not support full body contact, such as swimming, based on 1979 bacteria data, which exceeded Wisconsin's water recreational use standard. The present standard, which was applied in 1979, is based on a minimum of five samples taken over a thirty day period, in which the geometric mean fecal coliform bacteria counts should not exceed 200 counts per 100 mls, nor shall more than 10% of the total samples taken during a 30 day period exceed 400 counts per 100 mls. As presented in Table IV.1, there were exceedances of this standard 33% of the time in 1985. This average was calculated from one sample very thirty days instead of five per thirty days. The 1985 exceedance supports the

Table IV.2 Water Quality and Related Problems Associated with Eutrophication in the Sheboygan AOC

Type of Use Use Impairment	Comment on Sheboygan AOC
Water Supply	
Taste and odor impairments	Do not exist
Filter clogging	
Turbidity	
Increased chlorine demand	
Algal growth in distribution system	
Blockage of intake screens	
Aesthetics	
Floating mats	Do not exist
Surface scums	
Turbidity	
Rooted aquatic plans	
Swimming/Boating	
Excessive macrophyte and filamentous algae in shallow areas	Extensive periphytic growth (*Cladophora sp.*) covers coarse substrate along harbor shoreline
Ecology	
Low dissolved oxygen	These conditions have not been reported in the AOC, but further assessment is needed.
Reduced species abundance and diversity	
pH changes may enhance un-ionized ammonia toxicity	
Turbidity	
Modification of substrate	

Source: Youngyn WDNR, pers. comm. 1988

1979 data. Thus, the water quality of the lower Sheboygan River is classified, however, as capable of supporting full body contact recreational use based on physical conditions, such as depth, width and current. Results from the 1988 citizen's questionnaire show that approximately 70% of the respondents agreed that unspecified contaminants in the Sheboygan River and harbor pose a threat to human health and well being. However, approximately 60% swim or wade and approximately 50% engage in some kind of fishing.

Degradation of Aesthetics

Degradation of aesthetics is not known to be a problem in the AOC.

Added Cost to Agriculture or Industry

Information on added costs to agriculture or industry is not available.

Degradation of Phytoplankton and Zooplankton Populations

There is no information on phytoplankton or zooplankton populations in the AOC.

Loss and Degradation of Fish and Wildlife Habitat

Based on limited data, the AOC supports a variety of wildlife for being within and adjacent to an urban area (Appendix A, Tables 1-4). However, agricultural and urban development, such as landfills, golf courses, and shopping malls, has resulted in a loss of wildlife habitat. Existing wetlands have been inventoried by the Wisconsin Wetlands Inventory (WDNR 1983). There is now a greater importance placed on the habitat that remains.

Habitat necessary to maintain a diversity of aquatic life in the Sheboygan River is being degraded, primarily as a result of sediment from upland erosion. The dams also contribute to degraded habitat. The dams within the AOC influence sediment deposition and surface water quality by reducing velocities, increasing sedimentation rates, trapping particulate matter, and increasing water temperatures. As a result, the dams provide degraded habitat more suited for pollution-tolerant types of fish and aquatic life. The dams also inhibit fish passage, thereby limiting the recreational fishery potential of the Sheboygan River and its tributaries.

The Sheboygan River and harbor contribute to degraded habitat quality for fish and wildlife in the Lake Michigan ecosystem by contaminant transport. Contaminants are transported to the lake generally via biota migrating or passively drifting out of the river and harbor and with the outflow of water and sediment. Viewed as a system, the mass movement of contaminants constitutes an impairment of the beneficial uses of the Lake Michigan ecosystem that is evidenced by the effects of contamination in that ecosystem.

MAJOR POLLUTANTS OF CONCERN (CAUSING THE IMPAIRED USES)

The pollutants of potential concern include polychlorinated biphenyls (PCBs) and other chlorinated organic compounds, heavy metals, phosphorus, nitrogen, suspended solids and fecal coliform bacteria.

Toxic Substances

There are potentially toxic substances such as PCBs and heavy metals present in the AOC. A toxic substance can be defined as any substance causing an adverse effect on biological systems. To determine the toxicity of a specific compound, much information is needed, such as the dose, the bio-physical-chemical properties of the substance, the route, duration and frequency of exposure, the type of species exposed, and other factors.

Some of the possible toxic effects of heavy metals include the following: liver and kidney damage, tumors, birth defects from cadmium; hemorrhages of the gastrointestinal tract and lung and other respiratory cancers from chromium; brain, bone, and neurological damage, and learning disabilities from lead (U.S. EPA 1985).

Some of the possible toxic effects of PCBs include chloracne, dermal toxicity, thymic atrophy, immunotoxicity, reproductive toxicity, porphyria, organ/tissue-specific hypo- and hyperplastic responses, tumor promotion, body weight loss, and the induction of enzymes (Safe 1987a, Poland and Knutson 1982).

Furans and dioxins are highly toxic substances which are sometimes found with PCBs. 2,3,7,8 TCDF (tetrachloro dibenzo-p-furan) has been identified in various PCB mixtures (known as Aroclors in the United States) and is similar in toxicological effects to PCBs and 2,3,7,8-tetrachloro-dibenzo-p-dioxin (TCDD). TCDD is considered to be one of the most highly toxic compounds known. In general, with respect to dose, PCBs are less toxic than TCDF, which is less toxic than TCDD.

A quick review of PCB chemistry and terminology is provided prior to presenting data on biota, water, and sediment contamination. PCBs were produced in the U.S. under the trade name Aroclor by the Monsanto Chemical Co. There are 209 theoretically possible different types of PCBs. These different types of PCB are called congeners. PCB congeners differ in chemical and toxicological properties depending on the number and position of the chlorine atoms on the biphenyl molecule. Aroclors are mixtures of PCB congeners. A variety of Aroclors have been produced containing various proportions of approximately 80 to 100 of these congeners. Aroclors were used for various purposes, with the result that many congeners have been distributed throughout the environment.

Aroclors 1248 and 1254 were the PCB mixtures contained in hydraulic fluid used by Tecumseh Products Co. for manufacturing processes and were subsequently released to the Sheboygan River and harbor. The numbers 1248 and 1254 imply 48% and 54% chlorination (by weight) respectively, of the biphenyl molecule resulting primarily in tetra and penta chlorinated biphenyls.

PCBs in fish, sediment, water, and other matrices have typically been analyzed using Aroclor pattern recognition. Over time, patterns of PCBs in environmental samples do not resemble a specific Aroclor mixture due to processes such as biodegradation, biotransformation, bioaccumulation, weathering, vapor phase transport and others. So, a total PCB concentration is often reported as a combination of Aroclors to approximate the observed PCB pattern.

Biota Contamination

The following discussion provides information on levels of toxic contaminants present in fish and wildlife from the Sheboygan River and harbor. High levels of PCBs in various species of fish and waterfowl have resulted in fish and waterfowl consumption advisories for the Sheboygan Area of Concern. Mercury was found at low levels, below the fish consumption advisory guidelines. Furan (2,3,7,8-TCDF) has been found at low levels (ppt) in fish. There is no information on toxic contaminant levels in shellfish nor information on tumors or other abnormalities in fish or wildlife.

Fish Data

Polychlorinated biphenyls (PCBs): The majority of PCB data for fish in the Sheboygan River Basin is derived from annual sampling by the WDNR. Sampling sites within the AOC are at the Sheboygan Falls Dam, upper Kohler Dam, lower Kohler Dam, Kiwanis Park and Sheboygan Harbor.

Because of the variations in the numbers of species collected, location of sampling stations, and the methods used for analyses, it is difficult to draw definitive trends for PCB concentrations between and within species. In general, PCB concentrations in fish tissue have decreased between 1972 and 1984 within the AOC and in the Great Lakes (Baumann and Whittle 1988). In September, 1977, fish were collected for the first time in the Sheboygan River at Kiwanis Park in the City of Sheboygan (Appendix A, Table 8). Carp contained approximately 750 ppm of PCBs at that time. PCB levels now are much lower. For example, the lower Kohler Dam results for PCBs indicate approximately a 25 fold concentration decrease in carp between 1978 and 1984, a 5 fold decrease in rock bass between 1981 and 1984, and a 5 fold decrease in brook trout between 1978 and 1985 (Appendix A, Tables 9,10). PCB information for all species sampled within the AOC between 1978 and 1987 is provided in Appendix A (Table 11).

PCB levels are higher in tissue from fish in the Sheboygan River below Sheboygan Falls Dam than in those reaches above the dam and in the Onion and Mullet Rivers. In 1983, fish contained less than 1.0 ppm PCB in the Mullet River. In 1984, fish contained less than 1.5 ppm PCB in the Onion River. In 1987, fish contained less than 0.30 ppm PCB above the Sheboygan Falls Dam. Analyses from 1987 indicate some species of fish within the AOC still contain PCBs at levels greater than the FDA tolerance level of 2 ppm PCB (Appendix A, Table 12). Therefore, fish consumption advisories remain in effect for the AOC (Appendix A, Table 19).

Appendix A (Table 13) summarizes the available data on PCB Aroclor quantification in fish from the Sheboygan AOC. In 1981, Aroclors 1242, 1248, and 1254 were reported in fish, but in 1983 Aroclors 1248 and 1254 were used for quantification and were also reported in 1986 and 1987. These were

analyses conducted by a single laboratory under contract with the state. These data suggest that either transformation processes have occurred in the fish and/or the aquatic environment over the course of the monitoring years, or different reference standards were used depending on the judgement of the analyst (which is common within and between laboratories) and there are no real differences in Aroclors in the fish. A study on PCB congeners in Wisconsin fish (Maack and Sonzogni 1988) found that two trichlorinated congeners were prominent in coho salmon from the Sheboygan River. This pair is also present in Aroclor 1242 in the highest percentage relative to other Aroclor mixtures.

Three fish (smallmouth bass, rock bass, and bluegill) were collected from the Sheboygan River at Kiwanis Park by WDNR and analyzed in 1988 for PCB congeners by Dr. M. Mullin (U.S. EPA, Large Lakes Research Station, Grosse Ile, MI). Although the sample size was small and further sampling would be required to substantiate these results, they do provide useful information.

The length and weight, percent fat, and total PCB concentration varied among the three fish. The congener distribution was similar among all three species. Most levels of chlorination (di-nona) were observed in the fish with tetrachlorinated biphenyls comprising the greatest percentage of the total PCB concentration. Most of these congeners were also reported in fish from Wisconsin waters (Maack and Sonzogni 1988), except the trichlorinated pair were not the dominant congeners observed recently as they were in coho salmon, previously. Note that coho salmon are Lake Michigan migrants unlike bass and bluegill which are Sheboygan River residents.

Several studies have reported that the PCB congeners differ with respect to relative toxicity (Pellizzari et al. 1985; Safe et al. 1985). Approximately 8% of the total PCB concentration in the fish analyzed contained highly toxic congeners. Analysis of additional fish is necessary to determine the abundance of these particular congeners. The toxicological significance also needs further investigation.

Dioxins and Furans: As part of a statewide dioxin and furan study in 1983, the WDNR collected three carp and one snapping turtle from the lower Kohler Dam and collected three chinook salmon in Sheboygan. The results (Appendix A, Table 14) for 2,3,7,8-TCDF levels in tissue were: an average composited concentration of 54 ppt in carp, 24 ppt in chinook, and 234 ppt in the snapping turtle. The fish contained less than 10 ppt of 2,3,7,8-TCDD. No dioxin data were reported for the snapping turtle.

Pesticides and Metals: Pesticide residues (chlordane, DDT, dieldrin) in fish from the Sheboygan River AOC were not detected or were at very low levels between 1978 and 1982 based on WDNR monitoring data (WDNR 1987). There has been no monitoring of metals in fish from the Mullet and Onion Rivers. There has been limited monitoring for metals in fish from the Sheboygan River. The metals, arsenic, cadmium, chromium, copper, lead, and mercury were analyzed in various resident and migrant species between 1978 and 1982. Only mercury and copper were detected. The mercury levels were below fish advisory levels of 0.5 ppm. There is no fish consumption advisory criterion for copper.

Wildlife Data

Great blue herons, belted kingfishers, solitary sandpipers and spotted sandpipers were collected along the Sheboygan River in the AOC between 1976 and 1980 by the WDNR and U.S. Fish and Wildlife Service. PCB concentrations in these wild birds ranged from 23 to 218 ppm (wet weight) in the carcasses, 12 to 58 ppm in stomach contents, and 50 to 220 ppm in brains (Appendix A, Table 15). A DDT metabolite (p,p' DDE) ranged from 0.38 to 8.8 ppm in carcasses, 7.1-16 ppm in brains, and 0.10-0.55 ppm in stomach contents. Dieldrin ranged from nondetected to 0.92 ppm in carcasses, nondetectable to 2.8 ppm in brains, and nondetectable in stomach contents.

WDNR monitored wildlife contaminants again in 1985-1986. Five mallards, which were collected along the Sheboygan River between Sheboygan Falls Dam and Lake Michigan, contained a mean PCB concentration of 214 ppm on a fat basis and 10.3 on a wet weight basis (Appendix A, Table 16). Two lesser scaup samples (composites of 10 birds) from the Sheboygan Harbor contained a mean total PCB concentration of 25 ppm on a fat basis and 5.4 ppm on a wet weight basis (Appendix A, Table 17). These analyses resulted in consumption advisories for mallards and lesser scaup in the AOC (Appendix A, Table 18a). The WDNR and DHSS issued the advisory in 1987 to inform sportsmen of the potential health risks of consuming waterfowl where PCB concentrations exceeded the FDA tolerance level of 3 ppm (fat basis) in poultry.

An additional collection of ten mallards in the Kiwanis Park area in 1987 revealed a mean PCB concentration of 31.8 ppm on a fat basis and 2.6 ppm on a wet weight basis. Ten lesser scaup samples from the harbor area in 1987 yielded a mean PCB concentration of 25.1 ppm on a fat basis and 2.6 ppm on a wet weight basis. Two redheads, also collected in the harbor area in 1987, contained a mean PCB concentration of 36.2 ppm on a fat basis and 3.4 ppm on a wet weight basis. Although waterfowl samples collected in 1988 have not yet been fully analyzed, it does not appear that the consumption advisory will be lifted for the 1989 hunting season.

Over 480 wild animals were collected throughout the state and analyzed for contaminants. Two white-tailed deer from the Sheboygan area had detectable levels of cadmium in the kidneys, but no detectable levels in edible portions. Information on other species and locations can be obtained in the WDNR report entitled "Environmental Contaminant Monitoring of Wisconsin Wild Game 1985-1986" (Amundson 1987).

Water Contamination

Water quality data has been collected from the Lower Sheboygan River over the last 10 years. Results indicate that suspended solids, fecal coliform bacteria, and the nutrients phosphorus and nitrogen are elevated above acceptable levels. Toxic substances, such as PCBs and heavy metals, however, were either not detected or detected at low levels in the water column. Heavy metals concentrations were near laboratory detection limits and met IJC objective levels. PCBs were detected at two locations which is of concern because of the increased bioavailability of PCBs while in the water column.

Conventional Pollutants: Data collected by the WDNR between 1977 and 1987 for determining water quality is presented in Appendix B (Table 1). Suspended solid concentrations in the lower Sheboygan River (monitored between 1977 and

1987) ranged from zero to 75 mg/l approximately 90 percent of the time. Fecal coliform sampling has shown that the standard is routinely exceeded in the AOC (lower Sheboygan River at the U.S.G.S. gaging station at Interstate 43). As shown in Appendix B (Table 4), there were exceedances 38% of the time in 1985. Phosphorus and nitrogen concentrations routinely exceeded the U.S EPA suggested water quality criteria (Appendix B, Table 4).

Polychlorinated biphenyls (PCBs): WDNR sampled river water in the Sheboygan, Mullet, and Onion Rivers in April of 1978 and analyzed for PCBs. All samples contained less than 0.5 ppb PCBs, except for a Sheboygan River (at the junction of Hwy 28) flood stage sample which contained 3.0 ppb. The reported results are shown in Appendix B (Table 2). (Note in Table 2, the concentration unit of ug/L does not correspond to ppm; it should be ppb.)

As part of the Remedial Investigation activities at the Sheboygan Harbor and River Superfund site, water samples were collected from five river and one harbor location over the period May 31-June 2, 1987. These samples were collected during moderate flow conditions. They were analyzed for PCBs and eight metals (Appendix B, Table 3). Three additional rounds of water samples (at high, moderate, and low flow conditions) were collected during the next phase of the Superfund project, during the spring and summer, 1988. They are currently being analyzed for PCBs and eight metals. The low flow samples will also be analyzed for volatile organic compounds. The results will be available in the Remedial Investigation/Enhanced Screening Report. Refer to the Quality Assurance Project Plan and Sampling Analysis Plan for the Sheboygan River and Harbor Remedial Investigation and Feasibility Study for collection methods, analytical techniques, and detection limits (Blasland and Bouck 1986, 1987).

PCBs were not found in the water column above the Sheboygan Falls Dam, but were detected in the AOC. Available data indicates that the background sample from above the Sheboygan Falls Dam and the harbor sample had PCBs less than the detection limit of 0.05 ppb. In the remaining samples, unfiltered PCB concentrations ranging from 0.094 to 0.267 ppb, and filtered from 0.059 to 0.118 ppb, were reported as Aroclor 1242. By comparison, Swackhamer and Armstrong (1987) reported an average total unfiltered PCB concentration in open Lake Michigan of 0.0012 ppb (std. dev. of 0.0005 ppb).

Heavy Metals: Monitored heavy metal concentrations in the water column from one of the five rounds of sampling were near detection limits and below IJC objectives. (Blasland and Bouck 1988) The metals mercury (Hg), nickel (Ni) and cadmium (Cd) were not detected at the detection limits of 0.2, 1.0, and 1.0 ppb, respectively, in any sample, filtered or unfiltered. Copper (Cu), chromium (Cr), lead (Pb), and arsenic (As) were detected in all samples. All sample sites contained 4 ppb of copper, unfiltered, except for the harbor site at 2 ppb. Chromium varied between 1 and 2 ppb, unfiltered, between all sites. Lead in unfiltered samples ranged from less than 1 to 3 ppb, unfiltered. Arsenic concentrations were approximately 1 ppb for all sites. The IJC objectives for Cu, Cr, Pb, and As in unfiltered water samples are 5, 50, 25, and 50, ppb respectively for the protection of aquatic life (IJC 1988). The Remedial Investigation/Enhanced Screening Report presents results from all five rounds of sampling.

Sediment Contamination

The following information presents the historical sediment sampling results for the Sheboygan River and harbor since 1969 prior to presenting more recent Superfund sampling results. Currently, there are no criteria available for comparisons in order to present a sense of contaminant severity.

Historical Sediment Data

In 1969, Sheboygan harbor sediment sampling was conducted by the Federal Water Pollution Control Administration and the U.S. Army Corps of Engineers (FWPCA 1969). The conclusions of the study were that the bottom sediments within the federal navigation channel between Jefferson Avenue and station Sheb 69-5 and 69-6 were "heavily polluted" and the sediments in the outer harbor near the breakwater lights were "lightly polluted" due to heavy metals (Appendix C, Figure 1).

The sediment analysis included chemical and physical parameters (Appendix C, Tables 1,2). It was reported that three sampling locations contained high concentrations of nitrogen, chemical oxygen demand, oil and grease and heavy metals. Heavy metal concentrations were highest at site 16 (Eighth St.) and decreased to the river's confluence with Lake Michigan. Copper, lead, and chromium concentrations ranged between 45 to 175 ppm, 80 to 335 ppm, and 170 to 1400 ppm, respectively.

In 1974, U.S. EPA collected harbor sediment samples and analyzed them for chemical and physical parameters similar to the 1969 study (U.S. EPA 1974). The study reported that a comparison of the two studies indicated no change in pollution levels (Appendix C, Tables 3,4). Lead and chromium concentrations ranged from 50 to 220 ppm and 68 to 350 ppm, respectively.

In 1978, the WDNR (Kleinert) sampled sediment at 13 locations within the Sheboygan River Basin (Appendix C, Table 5). Physical characteristics of the sediment are presented in Appendix C (Table 6). The highest concentration of PCBs, 190 ppm, was detected immediately downstream from Tecumseh Products Diecasting Plant in Sheboygan Falls. There were levels upstream of the Lower Kohler Dam in Kohler ranging between 27 and 81 ppm. Sediment samples from the Sheboygan River upstream from the Sheboygan Falls Dam and the Mullet and Onion Rivers contained no detectable levels of PCBs.

In 1978, WDNR (1980) collected additional samples from the Sheboygan River (Appendix C). The conclusions of the study were that the Sheboygan River bottom from Sheboygan Falls to the City of Sheboygan was generally scoured, with areas of deposition above the lower Kohler Dam, near Kiwanis Park, along the island near Pennsylvania Ave., above Eighth St., and near the U.S. Geological Survey gaging station. The average rate of deposition was calculated to be 10 cm/yr. A general pattern of increasing PCB concentrations downstream corresponded closely with the decreased particle size downstream. PCB concentrations ranged from 1.6 to 76 ppm (Appendix C, Table 9).

The finer grained sediments, composed of primarily silt, clay and organic material, revealed higher concentrations of PCBs than those in sand and silt substrates deposited in the same time period. Deposits rich in organic matter had the highest PCB concentrations. Segmented core samples indicated increased PCB concentrations at increased bottom sediment depth, suggesting

that partial dredging would expose aquatic organisms to higher PCB concentrations. Thus, as reported in the WDNR report, if dredging were necessary, a total dredging of all contaminated bottom sediment may be environmentally warranted.

In 1979, U.S. Army Corps of Engineers conducted sampling at 11 sites within the Sheboygan harbor (Appendix C, Table 9). Analyses were performed on heavy metals (Pb, Zn, Cu, Cr) and PCBs. The May 1979 results, presented in Appendix C (Tables 12 and 13), indicated that sites between Jefferson Ave. and the outer harbor (a through f) were heavily contaminated with Pb, Cu, and PCBs and moderately to heavily contaminated with Cr and Zn. Samples from sites in the harbor mouth area (g through i) were nonpolluted for all parameters sampled. These assessments were based on U.S. EPA Great Lakes harbor sediment guidelines of 1977 in which sediment concentrations greater than 10 ppm for PCBs, 60 ppm for Pb, 200 ppm for Zn, 50 ppm for Cu, and 75 ppm for Cr were defined as heavily contaminated.

Based on the 1972 Clean Water Act and the early sediment sample results (1969-1974), it was concluded that Sheboygan harbor sediment should not be disposed in open water due to heavy metal contamination. 1978 PCB analyses of the sediment in the AOC stemmed from observations that PCB concentrations were at significant levels in fish from the Sheboygan River. Harbor maintenance dredging did not occur in 1979 because study results indicated that the proposed project depth would expose a sediment surface layer in which concentrations of heavy metals and PCBs would exceed those in the existing surface layer. Also, a suitable disposal site for dredged material was unavailable.

Sheboygan River and Harbor Superfund Data: Phase I

As part of the 1987 Remedial Investigation activities at the Sheboygan River and Harbor Superfund site, river sediment was collected from 10 locations between the Sheboygan Falls Dam and Pennsylvania Avenue bridge. The sediment samples were analyzed for U.S. EPA's Contract Lab Program Hazardous Substance List of compounds (Appendix C, Table 14). The following discussion is based on a portion of the Sheboygan RI data from May 1987.

Polychlorinated biphenyls (PCBs): PCB concentrations ranged from 0.07 to 110 ppm (dry weight). The highest concentrations was reported at the sampling location behind the lower Kohler Dam. This value was reported as Aroclor 1242. The sampling depth was 1.7 feet. Aroclors 1242, 1248, 1254 and various combinations were reported for the other sites.

Dioxins and Furans: A sample was also analyzed for 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and 2,3,7,8-tetrachlorodibenzo-p-furan (TCDF). Neither compound was detected with generally high detection limits (Jack Cu[illegible], WDNR, pers. comm. 1988; John Olson, Wisconsin Department of [illegible] Services, pers. comm. 1988) of 0.12 ppb for TCDD and 0.07 ppb for TCDF (wet weight).

Heavy Metals: The highest concentrations of As, Cd, Cr, Cu, Pb, Hg, Ni, and Zn were observed at the sampling location between 14th St. and Pennsylvania Ave. Arsenic was reported at 6.5 ppm, Cd at 1.7 ppm, Cr at 52 ppm, Cu at 55 ppm, Pb at 158 ppm, Hg at 0.153 ppm, Ni at 34 ppm, and Zn at 112 ppm.

Data for other compounds are also presented in Appendix C (Table 14).

Sheboygan River and Harbor Superfund Data: Phase II

The second phase of the Superfund (river and harbor) investigation occurred in September 1987 and consisted of collecting river and harbor sediment and river bank soil samples. Ninety six river sediment cores (which translates to 104 samples), twenty harbor sediment cores, and twenty soil samples along the river bank and islands were collected. The U.S. Army Corps of Engineers extensively sampled the C. Reiss Coal area of the harbor in 1982 and 1984. Consequently, the Superfund Project did not sample that area to a significant degree. The Corps data is presented in Appendix C; maps will be provided when available. The following is a summary of preliminary results for chemical and physical analyses which were available at the time of preparing this report.

Polychlorinated biphenyls (PCBs)/River Sediment: The sediment depth in the river ranged from approximately 0.4 feet, about two thirds of a mile downstream of the Upper Kohler Dam to over 12 feet near the Pennsylvania Avenue bridge. At each river sample location, the core segments were composited by the laboratory prior to analysis for total PCBs, except for two cores near the island upstream of the Pennsylvania Avenue bridge. Both of these cores (R98 and R100) were analyzed by depth such as was done with the harbor sediment cores.

There were a wide range of total PCB concentrations in the sediments. The site above the Sheboygan Falls Dam contained 0.07 ppm, two sites downstream of Tecumseh contained 4500 and 4300 ppm. One site below the upper Kohler Dam contained 890 ppm. Approximately 70% of the samples contained less than 20 ppm, and some sites contained relatively low concentrations of approximately 0.1 ppm or detectable levels of 0.025 ppm. The core segments were reported as total PCBs, Aroclors 1242, 1248, 1254 and combinations of these Aroclors. Aroclor 1242 was used as the primary Aroclor for quantitation. (Approximately 24 samples were reported as Aroclor 1242, 5 samples as Aroclor 1248, 1 sample as Aroclor 1254, 6 samples as a combination of Aroclors 1248 and 1254, and 47 samples as a combination of Aroclor 1242 and 1254. For the Aroclor 1242/1254 samples, Aroclor 1242 was the prominent Aroclor used for quantitation; the ratio for 1242/1254 ranged from 0.62 to 6.4 with a mean of 1.9 and deviation of 1.1.)

The sediment below the lower Kohler Dam contains much lower PCB concentrations (<20 ppm) than sediment in reaches above the dam. The sites sampled between Pennsylvania Avenue and the lower Kohler Dam (R42-R101, n=50) contained a mean concentration of 2.80 ppm, a standard deviation of 3.81 ppm, a median of 1.05 ppm, a range of 0.025-16.6 ppm, and an inter-quartile range (IQR) of 3.22 ppm. The sites between the two Kohler dams (R23-R41, n=14) contained a mean concentration of 103 ppm, a standard deviation of 228 ppm, a median of 11.8 ppm, a range of 0.1-890 ppm, and an IQR of 123 ppm. The sties above the upper Kohler Dam to the Sheboygan Falls Dam (R1-R22, n=19) contained a mean concentration of 543 ppm, a standard deviation of 1370 ppm, a median of 15.5 ppm, a range of 0.025-4500 ppm, and an IQR of 230 ppm.

Polychlorinated biphenyls (PCBs)/Harbor Sediment: The harbor is defined as the area encompassed by the Pennsylvania Avenue bridge, the harbor mouth, and the two breakwalls. Harbor sediment was collected from 20 locations and analyzed by depth for PCBs (reported as Aroclors 1242, 1248, 1254 and total

PCBs). The sediment cores were segmented in the following way: 0-0.5, 0.5-2, 2-4, 4-6, 6-8, 8-12, 12-16, and 16-20 feet. The cores ended when native lake sediments were encountered.

The study found that the entire harbor (sites H1-H20) contains less than 6 ppm of PCBs in the top one half foot of sediment. The highest total PCB concentrations are observed within the inner harbor (H11-20) and generally increased with depth. The maximum observed concentration is 220 ppm in the 8-12 ft segment at site H15 (above Eighth St.). The outer harbor (H1-9) contains less than 8 ppm at all depths.

All samples, except one, collected in the outer harbor (sites H1-H9, relative to the inner harbor sites H11-H20) contained less than 3 ppm total PCBs, with many segments containing less than the detection limit of 0.025 ppm. The one exception contained 8 ppm. Combinations of Aroclors 1242, 1248, and 1254 were reported in these samples. All of the samples in the northern portion of the outer harbor (sites H4-H9) contained less than 0.2 ppm.

The inner harbor (sites H11-H20, between Pennsylvania Avenue and the turning basin, n=10) contained less than 6.0 ppm (a mean concentration of 3.4 ppm, and a standard deviation of 1.2) for the segment at 0-0.5 ft, which is in direct contact with the water. The top two feet contained less than 12.5 ppm. Total PCB concentrations were higher at greater depths. For example, six samples from depths below 0.5 feet had total PCB concentrations greater than 50 ppm. Appendix C, Table 16 illustrates the mean concentration for each segment at sites H11-H20. The standard deviations are high and similar segments do not necessarily contain the maximum observed PCB concentrations. For example, the segment at 6-8 ft, from site H12 contains 180 ppm and corresponds to the maximum PCB concentration for that site. However, samples from sites H13, 14, and 15 at the 6-8 ft segment contain PCB concentrations of 12.3, 3.2, and 88 ppm, respectively, which do not correspond to the maximum observed PCB concentrations at these sites of 55 ppm, 11.7 ppm, and 220 ppm. There does appear to be a trend of increasing concentration with increasing depth until an undefined, variable depth is reached and then there is a decrease in concentration. Sites H11, H12, H13, and H15 all contain greater than 30 ppm PCBs at their bottom depths (H11 at 20 feet had 40 ppm, H12 at 16 feet had 37 ppm, H13 at 20 feet had 32 ppm, H15 at 16 feet had 80 ppm). The remaining sites have less than 1.1 ppm at their bottom depths which ranged from 12 to 20 feet.

H10 is a transition site between the outer harbor with low PCB concentrations and the inner harbor with higher concentrations. The 0-0.5 ft segment contains 0.17 ppm and a maximum concentration of 38 ppm in the 2-4 ft segment. PCB concentrations then decrease to 0.05 ppm in the 4-6 ft segment.

The segment samples containing the highest concentration (from sites H11-H20) were quantitated mainly as Aroclor 1242, i.e. 82% of the total PCB concentration was quantitated as Aroclor 1242. For the upper-most segment, 0-0.5 ft, Aroclors 1242 and 1254 (approximately 50:50) were used for quantitation. Aroclor 1248 was not detected. Note, that there is greater confidence in data from more highly concentrated samples in chromatographic analyses.

Polychlorinated biphenyls (PCBs)/Soils: The 20 soil samples collected along the river bank contained between 0.025 and 71 ppm of total PCBs. An island

site (S2) downstream of Rochester Park in Sheboygan Falls, contained [illegible]. A river bank site (S3) downstream of the upper Kohler Dam, contained 30 ppm. The remaining samples contained less than 10 ppm.

Relationship of Particle Size to PCB Levels/River Sediment: Sediment particle sizing was conducted on 10 river samples to evaluate the relationship of particle size to contamination distribution (R56, R49, R76, R79, R73, R97, R83, R3, R11, R18). The samples were collected at various sites between the Pennsylvania Avenue bridge and the Sheboygan Falls Dam. Some of the samples support the general tendency of higher PCB concentrations to be associated with smaller particle sizes. Exceptions are samples R97 (upstream of the Pennsylvania Ave. bridge) and R76 (upstream of Kiwanis Park) which contain a large percentage of relatively small particles and low PCB concentrations and the R11 sample (downstream of Tecumseh Products) which contains a large percentage of relatively large particles with a high PCB concentration (Appendix C, Table 2).

Relationship of Particle Size to PCB Levels/Harbor Sediment: Sediment particle sizing was also conducted on the 20 harbor cores. Two different segments per core were analyzed (2-4 ft, and a deeper segment which varied with each core, Appendix C, Table 3).

For the outer harbor sites (H1-H9), total PCB concentrations were low (less than 1 ppm) regardless of particle size.

Sites between the inner and outer harbors (H10 and H11), for the 2-4 ft segment, contained a similar particle size distribution, yet a large difference in PCB concentration, 38 vs. 3.5 ppm, respectively. Sites in the inner harbor (H11, H12, H13, H15, and H17) are similar in that higher PCB concentrations correspond to smaller particle size. Sites H10 and H14 contained a greater percentage of larger particles, yet higher concentrations when compared to the above five sites. Site H18 contained a much higher concentration than the above five sites, yet approximately the same particle distribution. Site H19 did not have particle sizing conducted in the 2-4 ft segment, thus a comparison cannot be made. Site H20 contained less than 1 ppm and a fairly even distribution of particle sizes.

At greater depths, sites H11-H20 contained lower PCB concentrations with larger particles.

Relationship of Total Organic Carbon to PCB Levels/Harbor: Total organic carbon (TOC) was determined for 20 harbor sites (H1-H20) and also for 10 river samples from Phase I collections, (Appendix C, Tables 3,4). TOC ranged from approximately 0.2-5% for all sites. There does not appear to be a correlation between TOC and PCB concentrations. In a 1984/85 study performed by the Corps on Sheboygan harbor sediment, it was reported that total organic carbon was constant in all sediment and that the fine grained mineral fraction of the soil appeared to be a better correlate of PCB than organic carbon content (Blasland and Bouck 1988).

Relationship of Physical Characteristics to PCB Levels: Appendix C (Table 15) presents subjective physical descriptions of the harbor and river sediment by RI investigators. Generally, the river sediment is fairly well mixed with silt, sand, gravel, and organic matter. There is limited information on the harbor, however.

There does not appear to be an association between high PCB concentrations and black organic matter (or strong organic odor). Some samples from various river sites, such as R4 and R7 (downstream of Tecumseh Products Co.), were described as containing black organic matter and the R4 sample had a strong organic odor. These samples contained 4300 and 4500 ppm of PCBs, respectively. Other samples with a similar physical description with relatively high PCB concentrations were from sites R5, R12, R22, R23, R33, R36, and R10 with concentrations of 59, 156, 93, 890, 110, 230, and 280 ppm, respectively. However, there were 12 other sites with a similar physical description and PCB concentrations less than 11 ppm. There were three other sites, R17, R19, and R25, without that description containing relatively high PCB concentrations of 50, 250, and 140 ppm, respectively.

Dioxins and Furans: One harbor sediment sample, H12, was analyzed for tetrachlorinated dioxins and tetrachlorinated furans in the 6-8 ft segment. None of these compounds were detected at detection levels of 0.16 ppb for total tetrachlorinated dioxins and 0.25 ppb for total tetrachlorinated furans. Note, this segment contained 180 ppm of PCBs.

Heavy Metals: The sediment samples analyzed for metals (As, Cd, Cr, Cu, Pb, Ni, Zn, and Hg) showed relatively low concentrations upstream and increased concentrations downstream to the harbor. The inner harbor contains Cd, Cr, Cu, Pb, Ni, and Zn. Hg was detected at relatively low levels and As was not detected in most samples. If detected, arsenic levels were close to the detection limit. Levels of all metals in the outer harbor were low or undetectable. All of the metals data has not been reported to date. Inductively-coupled Plasma Arc Spectroscopy (ICP) was used for analyzing the metals arsenic, lead, cadmium, zinc, chromium, copper, and nickel with detection limits (ppm) of 2.5, 10, 1.0, 1.0, 2.5, 1.6, and 3.5, respectively. Atomic Absorption was used for mercury analyses with a detection limit of 0.05 ppm.

More information on the Sheboygan River and Harbor Superfund Project will be provided in the Remedial Investigation/Enhanced Screening report which is expected to be available in late 1988.

Comparison between 1979 and 1987 PCB Sediment Data

In May and October of 1979, the U.S. Army Corps of Engineers collected samples in the inner harbor (between Pennsylvania Avenue bridge east to the turning basin) at sites located near the 1987 sampling. A comparison of total PCB concentrations found in 1979 with those found during the Superfund study has shown no significant change.

An analysis of total PCBs as a function of depth within the sediment for each year reveals that the vertical distribution pattern consistently exhibits higher PCB concentrations at greater depths and lower concentrations within the first two to three feet.

An analysis of total PCBs within the 0-2 ft segment for each year indicated there is not an obvious change in total PCB values. The 0-2 ft segment had a mean concentration of 5.0 ppm in 1987 and approximately 7.0 ppm in 1979 (Appendix C, Table A).

The outer harbor PCB results for 1987 are similar to those obtained from past sampling; i.e., PCB concentrations less than 8 ppm.

Inner harbor samples were quantitated as a combination of Aroclors 1242 and 1254 for all depths in 1979 (a ratio was not reported). 1987 samples were quantitated with Aroclor 1242 for those samples containing high concentrations of PCBs and Aroclors 1242 and 1254 were used for lower concentrated samples (i.e. those near the sediment water interface). It is not clear from these Aroclor analyses if there has been a change in PCB distributions in the inner harbor sediment.

PCB Congener Analyses

In 1988, Sheboygan River sediment from two different sites (Lower Kohler Dam and Kiwanis Park) were analyzed for PCB congeners by Dr. M. Mullin (U.S. EPA, Large Lakes Research Station, Grosse Ile, MI, unpublished data). Since there were only two samples, the results are not definitive.

The Lower Kohler Dam sample had a total PCB concentration of 110 ppm. Approximately 50% of the total concentration was comprised of di and tri chlorinated congeners. The Kiwanis Park sample had a total PCB concentration of 8 ppm. Approximately 60% of the total concentration was comprised of di and tri chlorinated congeners. Additional samples would be required to confirm the abundance of these lower chlorinated congeners; the toxicological findings could be of practical importance in development of remedial actions. The relationship between congeners present in fish and in sediment also merits further investigation.

V. SOURCES OF POLLUTION

PRIMARY SOURCES

Primary sources are those which manufacture, use, or produce the materials which subsequently become pollutants. Sources of pollution include municipal treatment plants, industries, and agricultural and urban runoff.

Heavy metal contamination is also present in the AOC and sources will be identified by the Sheboygan River and Harbor Superfund Project. Data is presented in "Chapter IV. Definition of the Problem".

Wisconsin is initiating a program to develop and enforce toxic effluent limits for dischargers to surface waters. Administrative codes NR 105 and 106 contain the procedures for determining water quality criteria for toxic substances and incorporating these criteria into effluent limits.

Conventional pollutants of concern in the Sheboygan area are suspended solids, phosphorus, nitrogen and fecal coliform. They are routinely monitored in private and public wastewater discharges in the AOC. They are also transported to the AOC via urban and rural sources.

The following narrative will list the pollution sources and their current characteristics.

Municipal Sources

City of Sheboygan Wastewater Treatment Plant

Since 1979 the city of Sheboygan has operated a wastewater treatment plant for the Cities of Sheboygan, Sheboygan Falls, the Village of Kohler, the Town of Sheboygan, and portions of the Towns of Sheboygan Falls, Lima, and Wilson. Prior to that date, Sheboygan Falls and Kohler discharged directly to the Sheboygan River via their own wastewater treatment plants. The City of Sheboygan treatment plant discharges to Lake Michigan south of the harbor. It retains a permit under the Wisconsin Pollution Discharge Elimination System (WPDES). Effluent limits were not violated between August 1986 and September 1987. Metals (Cd, Cr, Cu, Pb, Ni, Zn, As, Hg), cyanide, chlorine, total phosphorus, suspended solids, BOD and pH are routinely monitored. The type of treatment used is activated sludge with phosphorus removal. Twenty seven industries discharge to this plant. Pollutants of potential concern for many of the industries are chromium, zinc, copper, and lead.

It has been reported that an important source of PCB pollution to the Great Lakes is from wastewater treatment plans (Simmons 1984). However, 1975 and 1978 investigations (Appendix E, Table 2) indicated treatment plants were not a source of PCBs in the Sheboygan AOC. Sampling of the Sheboygan, Sheboygan Falls, Kohler, Belgium, and Kiel treatment plants did not disclose PCBs greater than 1.0 ppb (Kleinert 1978). The Plymouth treatment plant which discharged to the Mullet River did not indicate PCBs greater than 0.2 ppb during normal flow conditions, but showed 9.0 ppb during a flood stage.

City of Sheboygan Incinerator

The City of Sheboygan Incinerator's cooling water discharge has also been in compliance with its WPDES permit for flow, BOD, suspended solids, pH and temperature. PCBs were monitored in 1978 and reported to be at levels less than 1.0 ppb.

Industrial Sources

Potential industrial pollutants of concern originating from both upstream areas and within the AOC include cyanide, cadmium, chromium, copper, lead, mercury, nickel, zinc, silver, and phenols. The Sheboygan River Basin Water Quality Management Plan (Meyer 1988) contains specific point source information for the Sheboygan River mainstem and the entire Sheboygan River Basin. Individual industries are identified by name, permit type, receiving water, industrial activities and other pertinent information.

Polychlorinated biphenyls (PCBs) contained in the sediment are the most widespread and environmentally significant contaminant in the AOC. PCBs were present in the hydraulic fluids used in manufacturing processes by Tecumseh Products Company Diecast Division between 1966 and 1971. Tecumseh is located adjacent to the Sheboygan River in Sheboygan Falls. Prior to the issuance of regulations governing PCBs, PCB contaminated material was inadvertently used to construct a dike located along the river downstream of the Sheboygan Falls Dam. Following EPA's issuance of regulations governing PCB use, Tecumseh Products Co. voluntarily excavated and replaced 72,300 cubic feet of PCB containing material (up to 120,000 ppm) from the dike in September of 1979.

Although clean-up actions were undertaken by Tecumseh, PCBs escaped to the Sheboygan River. Because of their persistence in the environment they remain a contaminant of concern in the AOC. Other historical sources of PCBs are being investigated by the Sheboygan River and Harbor Superfund Project.

In 1975 and 1976, the WDNR analyzed several industrial outfalls in the state for PCBs. Two sanitary sewer discharges from Thomas Industries, a diecasting industry, contained PCBs on four different dates. Samples obtained by the DNR revealed a level of 125 ppb PCBs on June 13, 1975 and 88 ppb on August 19, 1975. Additional sampling on December 3, 1975 and March 25, 1976 identified levels of 35 ppb and 1000 ppb respectively. All samples except the March 25, 1976 sample were determined to be Aroclor 1248 (Kleinert 1976).

In 1978, Kleinert reported that 10 industries in the AOC were not significant contributors of PCBs (Appendix E, Table 1). Thomas Industries had a concentration of 140 ppb in its noncontact cooling water effluent before transport to the treatment plant. Relative to the other industries sampled, this was a high concentration. A surface water discharge was also sampled in 1978 and contained a very low concentration of 0.2 ppb PCB.

On January 24, 1986 DNR personnel again sampled Thomas Industries for PCB contamination (Appendix E, Figure 1). The following information was obtained:

Sample #	Material Sampled	Sample Location	Approximate PCB Level (ppb)
1	cooling water	east outfall to storm sewer	<0.50
2	ponded material	base of east loading dock	150
*3	sediment	east loading dock catch basin	940
*3	liquid	east loading dock catch basin	30
4	oily tar-like substance	small hole in base of south wall	4600

*Sample #3 contained both liquid and sediment portions which were analyzed separately.

A March 1986 follow-up investigation by the U.S. EPA and DNR reported no violations of the federal PCB regulations by Thomas Industries.

Kohler Co., a bathroom fixture manufacturer, is the only industry with known WPDES permit violations (suspended solids, chromium, nickel, and pH) which occurred periodically between 1982 and 1987. The suspended solids violations occurred at the discharge to the Sheboygan River. The chromium, nickel, and pH violations occurred at an internal sample point for determining compliance with categorical metal finishing effluent limits applicable to the brass building wastewater (not at the lagoon which then discharges to the Sheboygan River). Kohler Co. was referred to the Wisconsin Attorney General's office for enforcement actions March 23, 1987.

Discharge monitoring data between 1982 and 1988 for Kohler Company's combined discharge (through the lagoon to the Sheboygan River) indicates that levels of chromium and nickel did not exceed EPA water quality standards. EPA water quality limits were not in effect for Kohler Co. between 1982 and 1987.

A September 1988 draft WPDES permit for Kohler Company contains water quality related limits based primarily on EPA water quality criteria for antimony, zinc, beryllium, cadmium, copper, lead, silver and cyanide (amenable to chlorination) for the combined discharge to the Sheboygan River through the lagoons. After the Department assures that the requirements of NR 105 and 106 are met, a final WPDES permit will be issued. Compliance with any water quality related limits which are contained in a final permit would be required under a compliance schedule.

Agricultural Nonpoint Sources of Pollution

Agricultural land use is not predominant in the AOC, but there is nonpoint source pollution from agricultural runoff upstream of the AOC.

Runoff and erosion of the clay soils in the eastern third of the Sheboygan River Basin results in turbid water, sedimentation, and elevated nutrient levels. Runoff from feedlots and manure spreading sites carry bacteria and nutrients into the water. When cattle have unrestricted access to the river they increase land streambank and streambed erosion and sediment deposition downstream. The Mullet and Onion Rivers, direct tributaries to the Sheboygan River, carry pollution from nonpoint sources in addition to the Sheboygan River mainstem. These three river systems contribute significant nutrient and bacteria loads to the AOC and Lake Michigan (USGS and WDNR 1984). It should also be noted that between 1957 and 1967, 7620 pounds of sodium arsenite were applied directly to the Sheboygan River for purposes of aquatic plant control (Lueschow 1972).

The Nonpoint Source Water Pollution Abatement Program has designated the Sheboygan River as a Priority Watershed and is currently gathering information on nonpoint sources and critical areas that will be available in late 1989. The Onion River is also a Priority Watershed. This watershed project will complete implementation of nonpoint source control measures in late 1988. The Sheboygan River Basin Water Quality Management Plan (WDNR 1988) contains information on how nonpoint and point source pollution affect water quality.

Since 1986, C. Reiss Coal Company has been storing fertilizer in tanks located near Lake Michigan. The Department of Agriculture, Trade, and Consumer Protection (DATCP) is responsible for reviewing the C. Reiss Coal Company's performance and compliance with Wisconsin Administrative Code Ag 162, which contains procedures for storing fertilizer. IN May, 1988 C. Reiss Coal Company completed a discharge response plan (referring to the storage tanks) as required by Ag 162 and DATCP has reported that they are close to being in compliance (Paul Morrison, DATCP, pers. comm. 1988).

The U.S. Coast Guard also has responsibility for responding to spills if they should occur from the shipping vessels.

Urban Nonpoint Sources of Pollution

Urban runoff may contain nutrients, bacteria and potentially toxic substances including lead. The full effect of urban stormwater runoff on water quality has not been determined for the AOC. The Sheboygan River Watershed Nonpoint Source plan will assess and quantify urban stormwater loadings to the river. Inventory results will be available in late 1989.

SECONDARY SOURCES

Land Disposal Areas

In the communities of Sheboygan, Kohler, and Sheboygan Falls, there are 9 landfills. The Town of Sheboygan, and two Wisconsin Power and Light Company (WP&L) landfills are closed. Active landfills include the City of Sheboygan, City of Sheboygan Falls, Town of Wilson, Town of Sheboygan Falls, Spielvogel (privately owned and operated), and the Kohler Company. The Kohler Company's landfill became a Superfund site in 1984.

With respect to the closed landfills, the Town of Sheboygan and one of the WP&L sites are not located near the Sheboygan River. Due to the groundwater pollution from the Town of Sheboygan landfill, people living in the area switched from private water supplies to Sheboygan's municipal water supply. The WP&L landfill associated with the AOC is south of the harbor adjacent to Lake Michigan. This contains fly ash and bottom ash generated from the burning of coal. Groundwater is monitored on a quarterly basis for the parameters contained in Wisconsin's Administrative Code NR 140, and also for boron.

The City of Sheboygan and the Kohler Co. landfills are the only two active facilities in close proximity to the river.

The Kohler Co. landfill Superfund site occupies approximately 82 acres of land in the Village of Kohler. It is bounded on three sides by the Sheboygan River and to the north by State Highway 28. Kohler Co. landfill is approximately 300 feet north of the river (Appendix E, Figure 2). It has been in operation since the 1950's, primarily for the disposal of foundry and manufacturing wastes for Kohler Company. Certain waste streams disposed of in the landfill, such as chrome plating wastes and enamel powder, contained heavy metals such as chromium, cadmium, and lead. Eight metals, including chromium, cadmium, and lead, have been identified as contaminants of concern in the Sheboygan Harbor and River Superfund site's RI/FS. The Kohler Superfund site's RI/FS has also included the metals portion of the U.S. EPA's Hazardous Substance List as contaminants of concern. In 1978, a dredging project within the Sheboygan River produced approximately 75 to 85 cubic yards of PCB-contaminated sediments (1.3 to 37.5 ppm PCBs) which were subsequently disposed in the Kohler Co. landfill following approval by the WDNR.

In 1984, the landfill was placed by the U.S. EPA on the National Priorities List due to the potential for groundwater and surface water contamination. The Kohler Co. landfill Superfund project is extensively investigating this site.

The pollutants from the City of Sheboygan landfill, which is located approximately 500 feet from the river, are unquantified. As with many municipal landfills, there is the potential for surface water and groundwater contamination. If PCBs are present in the landfill due to scrapped capacitors, transformers, or other sources, they would probably not be transported via groundwater because of the physicochemical properties of PCBs, which result in strong sorption by soil solids and, accordingly, immobilization.

There are currently no sites accepting hazardous waste for disposal in the AOC or in Wisconsin. There are also no in-water confined disposal facilities in the AOC.

Air Deposition

As previously stated in "Chapter III. Environmental Setting", ozone, sulfur dioxide, particulates and other parameters such as lead, carbon monoxide and nitrogen dioxide are monitored in Sheboygan County to determine ambient air quality. Ozone is the only parameter that exceeds air quality standards. There has been no quantitative assessment of the effects of these airborne contaminants to the Sheboygan River.

Wet and dry deposition monitoring for toxins in air has, however, been initiated in Door County (Peninsula State Park) and is expected to be initiated in Milwaukee County in 1990. This monitoring should provide some information on deposition of these substances in Sheboygan harbor as well. A mass balance study as part of the Lower Green Bay Remedial Action Plan is currently underway in the city of Green Bay. It includes intensive monitoring of both wet and dry toxics deposition.

PCBs can enter the air through combustion processes. Either incomplete combustion of PCBs or the generation of PCBs from chloroalkanes** (and possibly chlorinated organics, in general) at an incinerator can result in PCBs entering the atmosphere. Atmospheric emissions of PCBs have not been monitored at the City of Sheboygan Incinerator.

Air toxics administrative code NR 445 was adopted by the Natural Resources Board in September, 1988. The "DNR Report of Recommendations--Hazardous Emissions Task Force, July 1985" and administrative code NR 445 contain additional information.

**Chloroalkanes are chlorinated aliphatic hydrocarbons such as, carbon tetrachloride, trichloroethane, and dichloropropane, used as solvents and degreasers.

VI. POLLUTANT TRANSPORT MECHANISMS AND LOADINGS

TRANSPORT MECHANISMS

In general, the contaminants of concern, primarily PCBs, are transported to the Sheboygan River and harbor and Lake Michigan via sediment, biota, water, and air.

PCBs are adsorbed to the sediments because of their physicochemical properties, such as hydrophobicity. Levels of PCBs in the sediment are much higher than those in water or fish. "Chapter IV. Definition of the Problem" contains information on the levels of contamination in sediment, water, and biota.

The PCBs are available from the water, sediment, and particulate matter to benthic invertebrates which are consumed by forage fish and in turn piscivorous fish. PCBs are also available to fish via water, phytoplankton, suspended particulates, zooplankton and macroinvertebrates. This availability also extends to those birds and mammals that consume insects and fish. Species at the top of the food chain contain higher concentrations than species at lower trophic levels because PCBs bioaccumulate. It has been reported that food chain transfer accounts for more than 99% of the body burden of adult trout (Thomann and Connolly 1984).

A 1984/1985 study by the U.S. Army Corps of Engineers (McFarland et al. 1985) on Sheboygan harbor sediment reported that transport of PCBs from the sediment to aquatic organisms may be facilitated by organic material that arises from sediment surfaces. This study suggests that the capacity of the transport mechanisms is the limiting factor in bioaccumulation, not the concentration of PCBs in the sediment.

Disturbance of the sediment by biological or physical processes would lead to an increased concentration of PCBs in the water column. Water is then a medium for PCB transport to aquatic organisms, i.e. fish could then ingest the PCBs. Physical turbation of the sediment occurs during flood flows, dredging activities or propwash from large vessels in the harbor. The increased availability of contaminants to aquatic life has been a concern with regard to dredging of the AOC.

Because of the concern for the contribution of contaminants (loadings) from the Sheboygan River to Lake Michigan, the IJC designated this area as an AOC.

POLLUTANT LOADS

Industrial and municipal loadings to the Sheboygan River within the AOC are reported in Appendix E (Table 3). There are no combined or sanitary sewer overflows within the AOC. Nonpoint source loadings of pollutants to the Sheboygan River from agricultural and urban runoff will be provided by the Nonpoint Source Water Pollution Abatement Program for the Sheboygan River Priority Watershed.

Total Phosphorus: Total phosphorus loadings from the Sheboygan River to Lake Michigan for 1980, 1981, and 1982 were estimated at 74.9, 58.4, and 97.6 tons, respectively (Bannerman et al. 1984).

Suspended Solids: Bannerman and coworkers (1984) also estimated sediment suspended solids loadings of 21815, 16278, and 27280 tons to Lake Michigan from the Sheboygan River in 1980, 1981, and 1982, respectively.

Polychlorinated Biphenyls (PCBs): Marti (1984) reported a PCB loading to Lake Michigan from the Sheboygan River between 14.4 and 29.9 kg/yr (Appendix B, Table 4). This is a relatively low loading rate due primarily to the low flow rate. The Sheboygan River had the highest PCB concentration (~ 100 ng/L) among the tributaries listed in Appendix B (Table 4). It was further reported that the loading rate could vary by an order of magnitude.

VII. HISTORICAL RECORD OF MANAGEMENT ACTIONS

Table VII.1 lists the historical record of remedial actions directed at reducing and managing environmental pollution. This chapter briefly describes each of these actions between the years of 1969 and 1987 in the AOC.

Table VII.1 Management Actions in the Sheboygan AOC: 1969-1987

Date	Action	Impaired Use Affecting
1969	Dredging of Sheboygan harbor halted.	Navigation
1977	PCBs banned.	
1978	City of Sheboygan wastewater treatment plant upgraded, providing service for Kohler, Sheboygan Falls and Sheboygan.	Fish and Wildlife, Recreation Use
1978	Fish consumption advisories established for AOC.	Recreational Use
1979	Tecumseh dike evacuated and replaced.	Fish and Wildlife, Navigation
1980	Onion River watershed designated as a Priority Watershed by Wisconsin's Nonpoint Source Water Pollution Abatement Program.	Fish and Wildlife, Recreational Use
1984	Sheboygan River Task Force formed.	--
1984	The Kohler Co. Landfill designated as a federal Superfund site, and consent order signed by Kohler Products Co.	Fish and Wildlife, Recreational Use, Navigation
1985	Sheboygan River and Harbor designated as a federal Superfund site, and consent order signed by Tecumseh Products Co.	Fish and Wildlife, Recreational Use, Consumption Advisory, Navigation
1985	WDNR commits to develop a Remedial Action Plan for the Sheboygan Area of Concern.	--
1985	Sheboygan River Watershed designated as a priority watershed under Wisconsin's Nonpoint Source Water Pollution Abatement Program.	Fish and Wildlife, Recreation, Navigation
1987	Waterfowl consumption advisory established for AOC.	Recreational Use
1987	Sheboygan harbor proposed for EPA's Inplace Pollution Demonstration Project.	--

HARBOR SEDIMENT MANAGEMENT

The existing Federal navigation project at Sheboygan was authorized by the Rivers and Harbors Acts of 1866, 1907, 1927, 1954 and subsequent acts (U.S. ACOE 1979). The first harbor improvements, constructed in 1852, consisted of parallel piers at the mouth of the Sheboygan River. The first dredging occurred in 1867, providing a channel with a project depth of 12 feet and length of 320 feet. Minor construction and dredging continued through the 19th century. The south pier was completed in 1904. Construction of the north breakwater commenced in October 1913 and was completed in October 1931. Dredging of the existing turning basin was completed in 1931. Dredging of the entrance channel to current project depth was completed in July 1938. The authorized project which includes present navigation features (see "Chapter III. Environmental Setting"), was completed in December of 1956 (Figure III.1).

The Sheboygan harbor, from Lake Michigan to Eighth Street, was dredged to project navigation depths (25 and 21 ft) by the U.S. Army Corps of Engineers between 1956 and 1969. The sediments were removed annually and disposed of in the off shore waters of Lake Michigan. Dredging of the harbor (excluding the mouth) was halted in 1969 due to U.S. EPA and WDNR's decision prohibiting open water disposal of contaminated sediments. The Corps' sediment sampling revealed heavy metal contamination at that time.

In 1979, the Corps (Chicago District) produced a draft Environmental Impact Statement (EIS) relating to the operation and maintenance of Sheboygan harbor including the construction of a confined disposal facility (CDF) within the outer harbor (U.S. ACOE 1979). Contaminated sediments were a factor in the prohibition of the project development.

In 1981, approximately 28,500 cubic yards of lake sand was removed from the harbor mouth and was used as fill for the industrial park in the City of Sheboygan. In 1984, approximately 25,600 cubic yards of lake sand was removed from the mouth and transported to the docks of C. Reiss Coal Co. In 1985 and 1987, approximately 12,000 and 24,000 cubic yards of lake sand, respectively, were removed from the harbor mouth and used for beach nourishment south of the harbor (Bob Mundelius, U.S. ACOE, pers. comm. 1987). These dredgings were conducted with WDNR approval.

The Corps has proposed a limited dredge project to initially remove approximately 45000 cubic yards of PCB contaminated sediment along the south pier encompassing an area 200 feet wide and 2,600 feet long. This project would extend from the Corps 0+00 station to within the turning basin 400 feet upstream of the U.S. Coast Guard station at the Corps 30+00 station (correspondence between DNR and Corps). A report completed in April, 1989, identified and evaluated 19 disposal sites within a ten mile radius of the harbor.

In summary, dredging of the harbor, excluding the mouth, has not occurred since 1969 due to polluted sediments. There has also been no open water disposal of contaminated sediment since that time.

PCB REGULATION

The U.S. Food and Drug Administration (FDA) became involved in the regulation of PCBs in 1969 when the chemical was first discovered in food items (Sonzongni and Swain 1984). In 1973, temporary tolerance limits were established to protect the consumer from food products indirectly contaminated with PCBs. A 5 ppm tolerance level in fish for human consumption was also established in 1973 (Federal Register 38 FR 18096). The manufacture of PCBs and the purchase for use in the U.S. was prohibited as of July 1, 1977 (Federal Register 42 FR 6531 and 44 FR 31514). As a result of increased concern over PCB toxicity, the federal FDA lowered the tolerance levels for several food categories in 1979. The 5 ppm tolerance level for fish was lowered to 2 ppm in 1984 (Federal Register 49 FR 21514). In 1985, a tolerance level of 3 ppm (fat basis) was established by the federal FDA for poultry consumption.

The ban of PCBs and the establishment of fish and poultry consumption tolerance levels by regulatory agencies constitutes wildlife and human health risk management.

DEVELOPMENT OF REGIONAL AND WASTEWATER TREATMENT FACILITIES IN SHEBOYGAN

The 1978 upgrading and expansion of the City of Sheboygan wastewater treatment plant to provide regional treatment services for Sheboygan Falls, Kohler and nearby areas was a major step for improved water quality in the Sheboygan AOC. The City of Sheboygan first constructed a wastewater treatment plant on the present site in 1937. This original plant provided primary treatment, which essentially consisted of large suspended solids removal. In 1957, the plant was upgraded to provide secondary treatment through the removal of additional suspended solids and soluble organic material.

By 1970, Sheboygan had outgrown the upgraded treatment facilities, and the city authorized an engineering study to assess the community's wastewater treatment needs. Before design and construction of a plant addition began, however, Congress enacted the Federal Water Pollution Control Act Amendments of 1972. In response to these new requirements, a feasibility study was conducted which indicated that a single wastewater treatment plant would be the most cost effective and environmentally sound method of treating wastewater produced in the region. The facility would serve the Cities of Sheboygan Falls and Sheboygan, the Village of kohler, the Town of Sheboygan, and portions of the Towns of Sheboygan Falls, Lima, and Wilson.

The sanitary sewer system analysis and the wastewater treatment facilities plan were completed in 1975 and 1976, respectively. The facilities plan called for expansion of the existing Sheboygan wastewater treatment facilities and the abandonment of the treatment facilities in Kohler and Sheboygan Falls. Many components of the previous Sheboygan treatment plant were incorporated into the new facilities, which resulted in lower construction costs. This plan also included construction within the City of Sheboygan of the west interceptor to convey wastewater from Sheboygan Falls and Kohler, a sanitary sewer rehabilitation and combined sewer elimination program, and an upgrading

of Sheboygan's two major wastewater pumping stations located at North Avenue and N. 3rd Street and at Kentucky Avenue and S. 7th Street.

Following the 1977 approval by the WDNR of the plans and specifications for the regional wastewater treatment facilities, the City of Sheboygan received federal funding for 75 percent of the project cost. The WDNR provided approximately five percent of the project cost, with the remainder being funded locally.

In January 1978, construction of the $23.9 million regional treatment facilities commenced. The liquid handling portion became operational in December 1979 and the solids handling portion in the fall of 1981. Construction of the $1.04 million west interceptor, $810,000 sanitary sewer rehabilitation, and $1.55 million upgrading of the North America and Kentucky Avenue pump stations was concurrent with construction of the treatment facilities (Unpublished data, WDNR Southeast District Wastewater files). The construction of these facilities was a positive action taken to improve the quality of the effluent discharged to the surface water.

CONSUMPTION ADVISORIES

On April 20, 1978, the WDNR and Department of Health and Social Services recommended that the public not eat the fish from the Sheboygan River between the Sheboygan Falls Dam and the Coast Guard Station in Sheboygan because the fish tissue contained PCBs in excess of the FDA tolerance limit of 5 ppm. Initially, signs were posted by the WDNR indicating this warning, but were removed when the warning was added to the state's fish consumption advisory which is published twice yearly. The fish consumption advisories remain in effect. Appendix A, Table 19 illustrates the advisories posted for Wisconsin waters.

In 1987, the WDNR posted waterfowl advisories for the Sheboygan River from Sheboygan Falls downstream to the river's mouth at Lake Michigan because of high PCB levels. Mallard duck and lesser scaup tissue had PCB levels in excess of the FDA tolerance level for poultry of 3 ppm (fat basis). This river segment retains the health advisory to date (Appendix A, Table 18a).

DISCOVERY OF PCB CONTAMINATION IN THE AOC

In 1978, the WDNR reported sediment PCB concentrations of 190 ppm downstream of Tecumseh Products Diecasting Plant in Sheboygan Falls (Appendix C, Table 5). Soil samples obtained from Tecumseh property contained up to 120,000 ppm PCBs (Appendix C, Table 8). Subsequent to these discoveries, the WDNR issued an order on May 12, 1978 banning further disposal of solid waste on Tecumseh property. PCB usage stopped in 1971 by Tecumseh. On June 21, 1978 the WDNR issued a second order requiring the excavation, collection and proper storage of all materials likely to contain PCBs from the dike on the Sheboygan River behind the Tecumseh plant. Materials containing PCBs included oil absorbent substances, scrap pressure hose, and oil soaked debris.

In September 1979, Tecumseh Products Co. voluntarily removed 72,300 cubic feet of PCB contaminated material (up to 120,000 ppm) from the dike to a concrete

block house located near the Sheboygan Falls landfill. This was scheduled to be an eighteen month storage site until a permanent site was located. In July, 1982 Tecumseh arranged to have the material transported to a federally licensed disposal site near Cincinnati, Ohio. The disposal cost was $1.0 million. The temporary storage facility was cleaned and it presently used by the city as a garage.

ONION RIVER PRIORITY WATERSHED

In 1980 the Onion River watershed was designated as a Priority Watershed under Wisconsin Nonpoint Source Pollution Abatement Program. Implementation of nonpoint source control measures began in 1981 and will be completed in late 1989. See the "Sheboygan River Priority Watershed" discussion for information on priority watersheds and Wisconsin's Nonpoint Source Pollution Abatement Program.

SHEBOYGAN COUNTY WATER QUALITY TASK FORCE

The Sheboygan County Water Quality Task FOrce was self created in late 1984 to explore possible cleanup solutions and to coordinate restoration efforts for the Sheboygan River and harbor. Task Force members include representatives from industry, government, fishing and conservation groups, and the general public (Appendix F, Figure 1). Among the Task Force's accomplishments and/or projects underway are:

* Establishment of an administrative facility to manage the affairs for the Task Force and provide a base of operations for interfacing with the numerous agencies involved with the cleanup program (The Task Force rents office space from the Sheboygan County Chamber of Commerce and retains the part-time services of experienced technical engineering staff.);

* Identification of involved agencies and definition of their responsibilities/policies/requirements as they relate to the Sheboygan harbor and river cleanup;

* Promotion of the Sheboygan River as a Priority Watershed and the Sheboygan AOC as a Superfund site;

* Promotion of agencies plan for clean sediment dredging, limited sediment dredging, and cleanup of the harbor and river;

* Preparation of a library of pertinent data;

* Continuation of community information programs through regular Task Force meetings, news media briefings, and presentations to local groups; and

* Development and distribution of a questionnaire for the public (Appendix F);

The WDNR has recognized the Task Force as the citizens advisory committee for the RAP. The WDNR selected the Task Force because of their past

accomplishments and interest in the project. The role of the Task Force in development of the RAP is the following:

* Review and comment on draft chapters of the Remedial Action Plan;

* Assist the DNR in the preparation of a popular summary of the final plan;

* Maintain a mailing list of interested individuals; and

* Sponsor three informational meetings for the public.

DESIGNATION OF TWO SUPERFUND PROJECTS

The Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) responds to hazardous waste problems on a national level. The objectives of CERCLA are: 1) to develop a comprehensive program to set priorities for cleaning up hazardous waste sites; 2) to make responsible parties pay for these cleanups; 3) to set up a hazardous waste trust fund, popularly known as "Superfund" (for the twofold purpose of performing remedial cleanups in cases where responsible parties could not be found and responding to emergency situations involving hazardous substances); and 4) to advance scientific and technological capabilities in all aspects of hazardous waste management, treatment, and disposal. CERCLA's reauthorization in 1986, commonly referred to as Superfund Amendments and Reauthorization Act (SARA), provided funding over the next five years and "tightened" the Superfund regulations.

Kohler Company Landfill Site

The Kohler Company landfill was proposed for inclusion in the Super fund National Priorities List in September 1983 and it was finalized kin September 1984. Kohler Company agreed to conduct a Remedial Investigation and Feasibility Study at this site. It is currently underway.

Sheboygan River and Harbor

The Sheboygan AOC was nominated by the WDNR for the Superfund National Priorities List on May 24, 1985. It was designated as a federal Superfund site in September, 1985. U.S. EPA, WDNR, and Tecumseh Products finalized an agreement whereby Tecumseh would conduct an investigation of the area. The investigation is currently underway.

REMEDIAL ACTION PLAN (RAP)

As far back as 1912, the Governments of Canada and the United States asked the International Joint Commission to examine the extent and causes of pollution in the Great Lakes. The Commission identified specific locations, including the St. Marys, St. Clair, Detroit, Niagara, and St. Lawrence Rivers, which were polluted with raw sewage. This pollution resulted in nearby human populations contracting waterborne diseases like typhoid fever and cholera. The Commission identified sources and recommended specific remedial actions,

including water purification and treatment, to control the pollution. Such efforts eventually let to the elimination of waterborne disease epidemics in the Great Lakes Basin.

With the passage of time, other problems became evident, particularly eutrophication. Increasing concern for eutrophication of certain areas of the Great Lakes culminated in the signing of the 1972 Great Lakes Water Quality Agreement. The 1972 Agreement provided the focus for a coordinated effort to control phosphorus inputs and thus abate eutrophication problems. As scientific knowledge increased, the 1972 Agreement was expanded in 1978 to recognize the need to understand and effectively manage toxic substance loadings into the Great Lakes. An ecosystem approach, requiring a more integrated and holistic perspective to protect water quality and health of the entire Great lakes system, was also emphasized. That approach recognizes the complex interrelationships among water, land, air, plant and animal life, including humans.

Since 1973, in its annual assessments of Great Lakes water quality, the IJC's Water Quality Board has identified Problem Areas. There were designated as Areas of Concern in 1980. These are areas where Water Quality Agreement objectives or jurisdictional standards, criteria, or guidelines established to protect uses have been exceeded and remedial measures are necessary to restore all beneficial uses. Areas of Concern include the major municipal and industrial centers on Great Lakes rivers, harbors, and connecting channels.

The number of Areas of Concern has changed with time due to improvements in water quality, the emergence of new problems or, reinterpretation of the significance of previously reported problems based on more comprehensive data. The Board's 1985 Report contains a more complete discussion of the changes in numbers of reported Areas of Concern. The major identified problems have changed in relation to the evolution of scientific knowledge of water quality problems (i.e., from bacterial pollution to eutrophication to toxic substances contamination) and progress, particularly in abating bacterial pollution and eutrophication problems (including dissolved oxygen depletion), 41 of the 42 Areas of Concern have toxic substances problems. It should also be noted that there is growing concern for loss of fish and wildlife habitat and biological diversity in Areas of Concern.

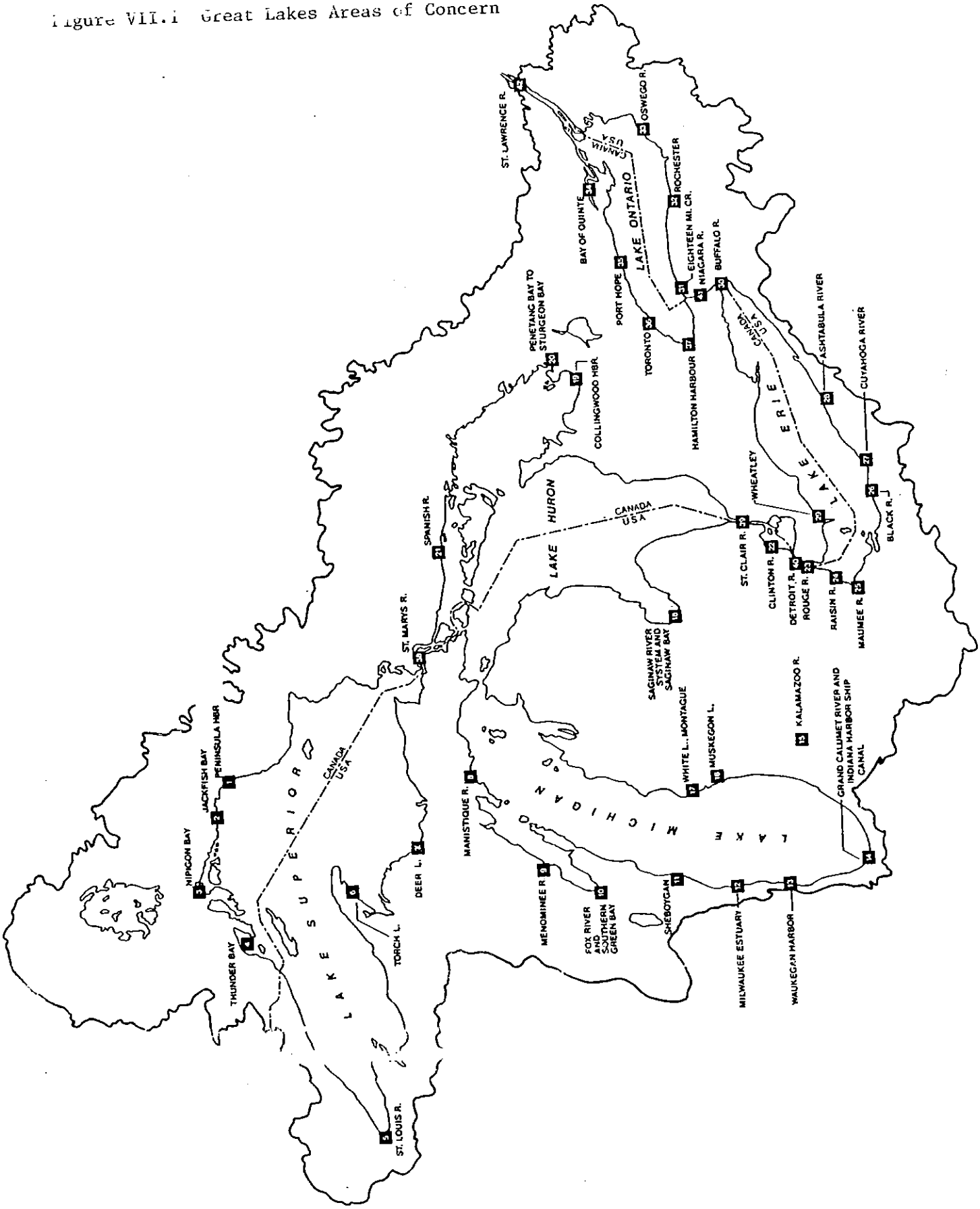
In 1985, the eight Great Lakes states and the Province of Ontario committed themselves to developing a RAP to restore beneficial uses in each Area of Concern within their political boundaries. Thus, Wisconsin committed to developing RAPs for four AOCs--lower Green Bay and Fox River, Sheboygan River and harbor, Milwaukee "estuary", and the Menominee River.

RAPs not only identify specific measures necessary to control existing sources of pollution, abate environmental contamination already present, and restore beneficial uses, but in order to measure progress, they also present timetables for implementation of remedial action. The Board recommended to the jurisdictions that each RAP address the following specific points:

* Define the environmental problem, including geographic extent of the area affected using detailed maps and surveillance information.

* Identify beneficial uses that are impaired.

Figure VII.1 Great Lakes Areas of Concern



* Describe the causes of the problems and identify all known sources of pollutants.

* Provide a schedule for implementing and completing remedial measures.

* Identify jurisdictions and agencies responsible for implementing and regulating remedial measures.

* Describe the process for evaluating remedial program implementation and effectiveness.

* Describe surveillance and monitoring activities that will be used to tract effectiveness.

* Describe surveillance and monitoring activities that will be used to track effectiveness of the program and eventually confirm that uses have been restored.

The development of RAPs represent a challenging departure from most historical pollution control efforts. Previously , separate programs for regulation of municipal and industrial discharge., urban runoff, and agricultural runoff were implemented without considering overlapping responsibilities or whether the programs would be adequate to restore all beneficial uses. This new process will call upon a wide array of government agencies at all levels. All programs, agencies, and communities affecting an Area of Concern must work together on common goals and objectives in the RAP to assure its successful implementation (IJC 1987a.)

SHEBOYGAN RIVER PRIORITY WATERSHED

In October, 1985, the Sheboygan River watershed was designated as a Priority Watershed under the Wisconsin Nonpoint Source Water Pollution Abatement Program. This program was created by the State Legislature in 1978 as a means to reduce surface and groundwater pollution caused by nonpoint sources of pollution. This program provides cost sharing for best management practices to correct nonpoint sources of pollution affecting water quality.

The project will extensively inventory and assess the various sources of urban and rural nonpoint pollution within the watershed by the end of 1989. Also, by the end of 1989, an appraisal of each water resource (stream, lake, and groundwater) within the watershed will be completed. This water resource appraisal will determine the current use the resource is supporting, what the potential use could be for each resource, and how much reduction of specific pollutants (including lead, copper, zinc, fecal coliform, and nutrients) must be attained to reach this potential use. This information is combined with the data on the sources of nonpoint pollution to come up with a management strategy to attain the objectives for each water resource through the control of nonpoint sources of pollution.

Upon completion of this plan (projected for late 1989), funding will be provided by the state to support the local units of governments in carrying

out the plan and installing the necessary nonpoint source control measures. The period of plan implementation will likely be eight years in length.

FIVE YEAR STUDY AND IN-PLACE POLLUTANT DEMONSTRATION PROJECT

The Federal Water Pollution Control Act of 1987 proposed the Sheboygan Harbor as a site for priority consideration for a five year study and demonstration project. The U.S. EPA Great Lakes National Program Office (GLNPO) will carry out the study and project relating to toxic pollutants in the Great Lakes. Chemical, biological, and physical data will be utilized for the development of a Sediment Action Index. This work will emphasize site specific toxicity and bioavailability of contaminants when assessing the problem and remedial options. The Sheboygan harbor investigation is expected to be initiated in the summer of 1989.

VIII. GOALS AND OBJECTIVES FOR THE SHEBOYGAN AOC ECOSYSTEM

The goals for the Sheboygan AOC were established with consideration for the goals and objectives of the Clean Water Act and Great Lakes Quality Agreement, state and federal water quality standards, and the concerns of the public and the Sheboygan County Water Quality Task Force. A public survey developed by the Task Force aided in the development of the goals and objectives. The following are Wisconsin's long term goals and objectives for achieving beneficial uses in the Sheboygan AOC by the year 2000.

ECOSYSTEM GOALS AND OBJECTIVES FOR RESTORATION OF IMPAIRED USES

I. PROTECT THE ECOSYSTEM (INCLUDING HUMANS, WILDLIFE, FISH, AND OTHER ORGANISMS) FROM THE ADVERSE EFFECTS (ON THE REPRODUCTION, SURVIVAL, AND HEALTH OF INDIVIDUALS, AND THE INTEGRITY OF INTERSPECIES RELATIONSHIPS) OF TOXIC SUBSTANCES;

II. MAINTAIN AND ENHANCE A DIVERSE COMMUNITY OF TERRESTRIAL AND AQUATIC LIFE AND THEIR NECESSARY HABITAT;

III. CONTROL EUTROPHICATION (NUTRIENT ENRICHMENT OF WATER) FOR THE PROTECTION OF LAKE MICHIGAN; AND

IV. ENHANCE RECREATIONAL USES.

In order to achieve these goals and restore beneficial uses (see Chapter IV), the following objectives must be met through the RAP process:

1. *Reduce sources of toxic substances and organism exposure to toxic substances to allow unrestricted consumption and unimpaired reproductive performance of resident fish and wildlife (Goals I and II)*

2. *Maintain a diverse resident fishery and, with attainment of the above toxic objective, establish seasonal runs of coho and chinook salmon and steelhead (Goal II)*

3. *Protect natural areas (green space) along the waterway and enhance habitat for aquatic and terrestrial communities (Goals II, III, and IV)*

4. *Continue to control nutrient inputs to the Sheboygan River and nearshore areas of Lake Michigan to meet the goals of the Great Lakes Water Quality Agreement and to reduce abnormal occurrence of undesirable algae in the marina (Goals II, III, and IV)*

5. *Reduce suspended solids concentrations in the Sheboygan River to meet a mean concentration of 25 mg/L during 90% of the time and reduce bedload (solids transported and deposited along the river bottom) by 50% to 75%.*

6. *Reduce bacteria levels in the Sheboygan, Onion, and Mullet Rivers to meet state recreational use standards (Goal IV)*

7. *Provide adequate public access and recreational facilities (Goal IV)*

8. *Enhance public understanding, education, and participation to support the ecosystem goals of this plan (Goals I, II, III, and IV)*

The Sheboygan AOC is a valued state resource. It is important from an economic and recreational standpoint. The Sheboygan area is utilized for sport and charter fishing, and commercial shipping and development. Sheboygan has taken a lead in charter fishing along Wisconsin's coast of Lake Michigan. The Sheboygan Harbor area experienced increases in catch and angler pressure between 1969 and 1984. Commercial shipping also occurs in the harbor for transport of coal and other materials. Shops have been developed around the old fish shanties and there are city plans for continued waterfront development, which includes a marina.

The plan's goals describe a desired ecosystem that is a compromise between the extremes of full restoration to presettlement conditions and continuing degradation. Environmental, economic and recreational concerns are reflected in these goals. Wisconsin expects these goals to be achieved by the year 2000.

WATER USE AND QUALITY OBJECTIVES

The Wisconsin Department of Natural Resources is responsible for: 1) designating the biological and recreational uses for which the waters of the state shall be maintained and protected, 2) prescribing the water quality required to maintain these designated uses, and 3) indicating the methods to implement, achieve and maintain the prescribed water quality conditions. Accordingly, an evaluation of the existing water quality and natural resource conditions was conducted for the Area of Concern as an essential precursor for determining water quality objectives (WDNR 1988b).

Biological Stream Use Classification

Biological stream uses describe the fish species or other aquatic organisms capable of being supported by a stream system. Designation of a particular use class is based on the ability of a stream to provide habitat and water quality conditions suitable for appropriate aquatic organisms. The entire lower Sheboygan River and the inner and outer harbor area are classified as "Fish and Aquatic Life - Warm Water Sport Fish." Under this use classification, these waters are capable of supporting a warm water sport fishery and serving as a spawning area for fish such as walleye, bluegill and smallmouth bass.

Recreational Stream Use Classification

The entire Sheboygan River and the inner and outer harbor area are classified as Full Body Contact waters. This means that this area should be suitable for human recreational uses such as swimming and waterskiing.

Water Quality Criteria

Water quality necessary to support the above biological and recreational uses are quantified by certain measurable criteria. These criteria are specified for critical water quality parameters which must be maintained to enable the waterway to continually meet its designated use. Water quality criteria for the lower Sheboygan River and the inner and outer harbor area are contained in Tables III.4 through III.7.

"HOW CLEAN IS CLEAN?" AND SEDIMENT QUALITY CRITERIA

The sediment in some areas of the Sheboygan River and harbor is contaminated with PCBs, heavy metals, and other compounds. (See Chapter IV. "Definition of the Problem" for data.) Potentially toxic substances, such as PCBs, have caused fish and waterfowl consumption advisories and dredging restrictions. In order to remediate these problems and protect the ecosystem from the adverse affects of toxic substances (as identified in Goal I), the determination of "How clean is clean?" is required.

Because the sediment is a major sink as well as a source of PCBs to aquatic organisms, a sediment PCB concentration which would produce a nontoxic PCB concentration in organisms is needed in order to make environmentally, socially, and economically sound management decisions regarding remediation. A nontoxic PCB concentration in organisms can be defined in various ways depending on who/what is being protected and the manner in which PCBs are defined.

Applicable IJC, Federal and State Guidelines

Fish Consumption Guidelines: The International Joint Commission (IJC) recommends that the total PCB concentration in fish tissue (whole fish, wet weight) should not exceed 0.1 ppm for the protection of birds and animals that consume fish. This 0.1 ppm objective originally appeared in the 1974 IJC Water Quality Report and is in the current Water Quality Agreement (IJC 1988).

The U.S. Food and Drug Administration (FDA) has established a total PCB concentration of 2 ppm in fish and 3 ppm in poultry as a tolerance level for the protection of human health (WDNR and DHSS 1988). These values apply to fish and fowl shipped in interstate commerce for human consumption. Although the FDA has no regulatory control over the individual states, the State of Wisconsin has followed FDA's guidelines for PCBs in the fish and wildlife consumption advisories. In contrast to the IJC objective, the FDA level is for the protection of humans, not birds or animals that eat the fish.

The eight Great Lakes states and the U.S. EPA are jointly involved in a continuing effort to develop consistent fish consumption advisories for the entire Great Lakes Basin. In May of 1986, the Governors of the eight states signed a Great Lakes Toxics Substance Control Agreement which authorized this action to proceed until there is a unified advisory. It is anticipated that there may be a change in the current fish consumption advisory for Wisconsin by 1990. It is important to note that PCB tolerance levels in fish may change, which can have implications for clean-up levels in the AOC.

Contaminated Sediment Disposal Guidelines: PCBs are toxic substances under the federal Toxic Substance Control Act (TSCA). Dredge spoils containing greater than 50 ppm total PCBs are required to be disposed of at a federally approved chemical waste facility.

Sites and facilities for the disposal of PCBs in Wisconsin require review under administrative rules NR 157, 181, 500-522, and 347. There are currently no state rules that identify acceptable PCB concentrations in dredge spoils for disposal in confined disposal facilities (CDFs) in water. Management decisions are made on a case by case basis.

Chapter NR 157, the State's PCB regulations, require that the disposal of any waste containing PCBs be in a state approved incinerator or hazardous waste landfill for PCBs. NR 157 also allows other methods of disposal as approved by the WDNR on a case-by-case basis.

WDNR considers dredge spoils containing less than 10 ppm PCBs as solid waste (subject to NR 500-520) and the provisions of NR 157 for an incinerator or hazardous waste landfill are not required. Dredge spoils containing greater than 50 ppm PCBs must be disposed in a facility approved under hazardous waste disposal regulations NR 181. Dredge spoils containing more than 10 ppm PCBs but less than 50 ppm PCBs may also be disposed in a solid waste landfill if approved by the WDNR.

The proposed Wisconsin Rule NR 522 sets technical standards for the construction of dredge spoil disposal facilities. Under WDNR guidance issued in February 1987, dredge spoils containing less than 10 ppm PCBs could be disposed in a landfill constructed to NR 522 standards. The standards may also be appropriate for dredge spoils containing between 10 and 50 ppm PCBs if specifically approved by the WDNR.

Site Specific Approach for Sediment Contaminant Criteria

As can be seen, there are no clearly established PCB concentrations for what constitutes clean sediment, in which sediment concentrations result in nontoxic levels in aquatic organisms. Site-specific studies offer the most promising approach for determining "How clean is clean".

Research on Sheboygan harbor sediment was conducted in 1985 by the U.S. Army Corps of Engineers' Waterways Research Station at Vicksburg (McFarland et. al. 1985). The objective of the study was to determine the influence of temperature and level of sediment contamination on the rate and amount of PCB bioaccumulation by aquatic organisms in laboratory exposures. (Bioaccumulation was defined as the degree to which PCBs could be accumulated in organism tissues from contaminated sediment or water. Bioaccumulation is typically defined with respect to the food chain, not water or sediment.) Total PCB concentrations of 0.45, 5.0, 25, and 50 ppm were tested on molluscs [illegible] fingerling fish which included rainbow trout yearlings. The following observations were reported:

-- all levels of chlorination bioaccumulated and most of the uptake was of tetra, penta, and hexa chlorinated biphenyls with congeners 138 and 153 prominent in sediment and organisms;

-- congener 77 (one of the more toxic congeners) is probably not present in Sheboygan sediments;

-- aquatic organism bioaccumulation is minimal at 4 C and greater at 20 C;

-- organisms' PCB concentration increased with increasing sediment PCB concentration, but at a decreasing rate (steady state concentrations were predicted for each organism at each PCB treatment level and temperature and for PCB homologs);

-- uptake occurred without direct sediment contact;

-- the degree of sediment contamination is much less a determinant of actual bioaccumulation than are physical, chemical, and biological processes affecting bioavailability;

-- bioavailability is enhanced by the suspension of contaminated sediment;

-- PCB transport from sediment to aquatic organisms is a function of organic carbon content; and

-- if dredging of the harbor is to occur, it should be done during the time of year when water temperature and biological activity are low and in such a way to minimize suspension of contaminated sediment.

Thus, two major conclusions of the Corps study were that high PCB concentrations in sediment did not result in proportionately high concentrations in the organisms' tissue and that the degree of sediment contamination is much less a determinant of actual bioaccumulation than are physical, chemical, and biological processes affecting bioavailability. The authors cited this latter conclusion as a commonality among studies done by other researchers.

The results of Tatem (1986) also suggest that high PCB concentrations in Sheboygan River sediment did not result in similarly high concentrations in prawns. Willford (1980) reported that the amount of bioaccumulation was not consistently related to the concentration of PCBs in sediment collected from five Great Lakes harbors.

Research conducted in Green Bay further indicates that there is not a direct relationship between concentrations in sediment and PCBs in fish. In a 1985 study (Mac et. al.), fathead minnows were exposed under field and laboratory conditions to sediment from the lower Green Bay. Sediment contained 2.03 ppm PCBs from Site 1 and 0.65 ppm PCBs from site 2. The fish accumulated PCBs, reported as Aroclor 1248, from both sediment sites. However, PCB concentrations were higher in fish that were exposed to the lesser contaminated sediment at Site 2. During field exposures, the bioaccumulation factor (the degree to which toxics may be accumulated in organism tissues from contaminated sediment or water) for fish ranged from 3.5 (suspended cage) to 6.2 (bottom cage) for Site 2 and 0.8 (suspended cage) to 1.3 (bottom cage) for Site 1. During laboratory exposures, the bioaccumulation factor for fish was 2.3 for Site 1 and 5.9 for Site 2. The study reported that differences in organic content, fine-grained materials, and oil concentrations in the sediment may be responsible for differences in bioaccumulation factors between the sites.

A study on Puget Sound, WA sediment was conducted by Chapman (1986) to derive sediment quality criteria for lead, polycyclic aromatic hydrocarbons (PAHs), and total PCBs. This was reported to be the first study in which sediment contaminant criteria were derived using sediment chemistry, in situ studies, and sediment bioassays in combination. Chapman dubbed the combination of these studies as the "Sediment Quality Triad". Thus, the study utilized toxicological data in addition to observed levels of contaminants in sediment and organisms in determining criteria.

The sediment concentration derived for total PCBs at which no or minimal biological effects were observed was 0.1 ppm. The derivation of this concentration ignored which of the contaminants may have caused the observed biological effects. However, synergistic or antagonistic interactions between the chemicals were possible, providing more of a real world system. Toxicological and biological effects were measured using three bioassays and fish histopathology. It was reported that biological effects increased with a corresponding increase in contaminant concentrations in the sediment.

Transfer or application of these criteria to the Sheboygan River is currently not possible. However, similar work is being done on areas of the Great Lakes by U.S. EPA. The U.S. EPA Great Lakes National Program Office in coordination with U.S. Army Corps of Engineers, U.S. EPA Large Lakes Research Lab, and others are developing a Sediment Action Index as part of a 5 year study and demonstration project as authorized by the Clean Water Act Amendment of 1987. In development of this index, chemical, physical, biological and bioassay data are being used to rank sediment quality for various Great Lakes areas. This approach is similar to the Chapman study described previously in that the site specific toxicity and bioavailability of contaminants are being determined. Two sites are currently being investigated (Green Bay, Wisconsin and Detroit River, Michigan) and it is anticipated that other Areas of Concern will be addressed in the near future.

Site Specific Toxicity of PCB

The site specific toxicity of PCBs can be assessed in various ways. For example, PCBs can be viewed as a family of compounds with the same level of toxicity (as in the Chapman study), or as Aroclors (Monsanto Chemical Co. trade name for PCB mixtures) with varying toxicities, or they can be viewed as individual compounds (congeners) with different toxicities.

There have been a plethora of studies performed on many organisms to determine the toxicological effects of PCBs, usually in the form of Aroclor mixtures. Various toxic effects were reported. Congeners refer to one or more of the 209 possible PCB compounds which differ depending on the number and position of the chlorine atoms on the biphenyl molecule. Some of the possible toxic (and biological) effects of PCB congeners at high concentrations with acute exposure include chloracne, dermal toxicity, thymic atrophy, immunotoxicity, reproductive toxicity, porphyria, organ/tissue-specific hypo- and hyperplastic responses tumor promotion (in a two stage model of rat hepatocarcinogenesis, i.e., initiation and promotion), body weight loss, and the induction of enzymes such as aryl hydrocarbon hydroxylase, ethoxyresorufin-o-deethylase, and specific cytochrome P-450 isozymes (Safe 1987a, Poland and Knutson 1982).

The most toxic congeners (of those for which toxicity data exists) have been reported to be the coplanar hexachlorinated (3,3',4,4',5,5'--no. 169) and pentachlorinated (3,4,4',5,5'--no. 126) biphenyls (Safe et al. 1985, Leece et al. 1985, McKinney and Singh 1981, Goldstein et al. 1977, Silkworth and Grabstein 1982, Yoshihara 1979). These congeners are present in Aroclors in very minute quantities (Duinker 1988). Congeners 118, 105, 156, 123, and 157 are mono-orthochloro-substituted isomers of the coplanar PCBs which have displayed toxic and biologic responses, but are much less potent than 169 and 126 and their potency is 3 to 4 orders of magnitude smaller than 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) (Safe et al. 1985, Safe 1987b)

The toxic responses and enzyme induction produced by the most toxic PCB congeners are similar to those produced by tetrachlorodibenzo-p-dioxin (TCDD). These compounds are also structurally similar. Thus, the research emphasis has been to study structure activity relationships between PCB congeners and TCDD. Not all of the PCB congeners have been studied in terms of laboratory toxicity testing, but there are general conclusions with respect to toxicity based on the structure activity relationships and from the congeners that have been tested. Since the toxicity of halogenated organic compounds is often compared to the highly potent TCDD, one might expect the coplanar 3,3'4,4'-tetrachlorobiphenyl (77) to be highly toxic, since it is most structurally similar to TCDD of all the congeners. However, the in vivo toxicity of 77 is significantly lower than 169 and 126 (Leece et al. 1985, Safe et al. 1985). It appears that congener 77 along with other lesser chlorinated congeners, particularly those with two adjacent unsubstituted carbon atoms, are rapidly metabolized in vivo, and, therefore detoxified (Safe 1987b, Birnbaum 1985). Note that metabolism does not always imply detoxification of chemicals, but with PCBs, this appears to be the general rule.

Other investigations on contaminated sediments, specifically due to PCBs, are occurring in the Hudson River. Brown et al. (1987) reported dechlorination of aquatic sediments from 6 PCB spill sites including the Hudson River. The PCB contamination in the Hudson River is reported to be among the worst in the U.S. in terms of concentration and quantity of total PCBs. Brown et al. (1987) reported that capacitor manufacturing operations in New York released primarily Aroclor 1242.

Brown and coworkers have concluded that PCB dechlorination, and thus detoxification, is occurring in the Hudson River sediments. They also reported that biodegradation may be occurring in Sheboygan River sediments.

Summary

Based on the conclusions from these various studies, answering the question of "How clean is clean?" becomes much more complex. The tendency to focus on bioaccumulation and bulk sediment chemistry may not be adequate when determining site specific sediment criteria. An assessment of the bioavailability of PCBs in the Sheboygan AOC and sediment toxicological data, which are necessary for developing site-specific sediment quality criteria, may be needed before remedial actions can be undertaken with any degree of certainty. This approach would be similar to the "Sediment Quality Triad". The sediment chemistry data are available, but the other two parts of the triad are lacking (see Chapter IV. Definition of the Problem and Chapter VI. Pollutant Transport Mechanisms and Loadings).

IX. RECOMMENDED REMEDIAL ACTIONS

In this chapter, the four ecosystem goals of this planning process will be discussed individually. It is essential that the RAP, the Superfund Project and other projects that are investigating the contaminated sediment problems and associated toxicity, coordinate their efforts to have a positive effect in Sheboygan. Ongoing work should continue in order to refine the definition of the problem and insure proper decisions are made regarding remediation of the contaminated sediment. Since the RAP is being completed prior to the other Sheboygan efforts, this RAP identifies informational needs for determining "How Clean is Clean?" for the Sheboygan AOC. Remedial alternatives for the contaminated sediment are discussed based on information currently available. There may be more options available to control toxics in sediment if the informational needs outlined below proceed. Thus, the RAP should be updated when additional information is available from the ongoing toxics control projects (~1991).

Remedial actions for enhancing fish and wildlife habitat, controlling eutrophication, and enhancing recreation (goals II, III, and IV) are available and the appropriate management actions are listed and discussed.

ECOSYSTEM GOAL I: PROTECT THE ECOSYSTEM (INCLUDING HUMANS, WILDLIFE, FISH, AND OTHER ORGANISMS) FROM THE ADVERSE EFFECTS (ON THE REPRODUCTION, SURVIVAL, AND HEALTH OF INDIVIDUALS, AND THE INTEGRITY OF INTERSPECIES RELATIONSHIPS) OF TOXIC SUBSTANCES

Objective: Reduce sources of toxic substances and organism exposure to toxic substances to allow unrestricted consumption and unimpaired reproduction of resident fish and wildlife

REMEDIAL ACTION #I. A: CLEAN-UP IN-PLACE POLLUTANTS

Remedial Action #I. A.1. Determine site-specific sediment criteria

A reduction of organism exposure to toxic substances, a reduction of toxic sources, and protection and enhancement of aquatic and terrestrial habitat in this ecosystem is desirable. In order to achieve these objectives, with respect to PCBs, a refined assessment of the degree of PCB toxicity at this site is needed. The following list of data collection activities are integral to determining "How Clean is Clean?". These studies must be completed within the next one to three years to allow management decisions to be made within the same time frame as the Sheboygan River and Harbor Superfund Project.

#I. A.1.a. Perform congener specific PCB analyses--sediment, fish, and other matrices to determine potential toxicity of congeners present and whether dechlorination and detoxification are occurring

Who's Responsible: University of Wisconsin, Wisconsin DNR
Estimated Cost: $200,000 (Wisconsin Coastal Management, Wisconsin Sea Grant), $1,000-$6,000 (WDNR)
Target Completion Date: Oct 1988-1990

The proposed Wisconsin Sea Grant / Coastal Management study (Appendix G) to be initiated in the fall of 1988 will assess the types and levels of PCB congeners in several sediment samples from the Sheboygan AOC and determine whether dechlorination and detoxification have occurred. Congener toxicity information available from the scientific literature will be utilized to determine the potential toxicity of the congeners present. The results of this study could have major environmental and economic implications if it were found that toxic congeners were not present in significant concentrations. If it were found that toxic congeners were present, there may be a greater incentive to "clean-up" this area. The estimated cost of this two year study is approximately $200,000.

WDNR will collect fish from the Sheboygan AOC and perform congener specific PCB analyses as specified in the 1988 fish collection schedule. The approximate cost of the laboratory analyses is $1000. The cost for the total Sheboygan AOC fish contaminant effort is approximately $6000.

#I. A.1.b. Perform 2,3,7,8-TCDF (furan) analyses in fish to determine if they are present in the ecosystem.

Who's Responsible: WDNR
Estimated Cost: $10,000
Target Completion Date: 1989-1991

Resident fish tissue need to be analyzed for 2,3,7,8-TCDF compounds since it is not clear whether furnas are present in the Sheboygan AOC. Detection of these compounds would be expected in sediment with highly concentrated PCBs (as in the case with some Sheboygan River sites). If present, they could have a significant impact on toxicological assessments. The WDNR should collect and contribute for low level furan analysis.

#I. A.1.c. Conduct sediment bioassays and in situ assessments of biota to assess toxicity and bioavailability of contaminants.

Who's Responsible: U.S. EPA and WDNR
Estimated Cost: $85,000 (Clean Water Act Amendments of 1987 - Great Lakes Demonstration Project)
Target Completion Date: 1990-1991

Bioassays with Sheboygan River sediment and other in situ studies should be conducted to assess the toxicity and bioavailability of the contaminants. The specific types of bioassays to be conducted need further exploration, but consideration should be given to using the midge, Chironomas tentans. In situ assessments of biota would then be required to provide a relative indication of contaminant effects versus the myriad of chemical, physical, and biological interactions to which a particular community responds. These assessments could be in the form of resident fish histopathology or identification of benthic community structure (Willford 1980, Chapman 1986, and others). U.S. EPA (Great Lakes National Program Office) is a potential source for the implementation of the these studies. The Sheboygan Harbor was named for

consideration as a site for a Demonstration Project under the Clean Water Act Amendments of 1987 under GLNPO's guidance. The total estimated cost for analysis is estimated at $85,000.

Remedial Action #I. A. 2. Complete Remedial Investigation and Feasibility Study (RI/FS) for the Sheboygan River and Harbor.

Who's Responsible: Tecumseh Products Co., U. S. EPA
Estimated Cost: $1,000,000 +
Target Completion Date: 1989

The Remedial Investigation phase of the Superfund Project was completed by Tecumseh Products Co. (Blasland and Bouck Engineers, P.C.) in October 1988. This phase included sample collection, analysis, and interpretation, contaminant transport assessment, endangerment assessment, and screening of remedial alternatives. The Feasibility Study will proceed, which includes the selection of remedial actions. The cost associated with this investigation and study are being borne by Tecumseh Products, Inc. in cooperation with the U.S. EPA.

Remedial Action #I. A. 3. Implement Superfund Remediation.

Who's Responsible: USEPA-identified PRP's (Tecumseh Products Co., Kohler Co. Thomas Industries, Inc.)
Estimated Cost: To be identified in Sheboygan River and Harbor RI/FS
Target Completion Date: After completion of the RI/FS

Table IX.3 illustrates the processes for the management of contaminated sediment (IJC Sediment Subcommittee report 1987a). Assuming that the sediment poses a problem, there are various remedial options for the contaminated sediment. Current (1988) options include leaving the sediment in place, capping the sediment with clean material, dredging and treating portions or all of the contaminated sediment, and others. All available options will be identified in the Remedial Investigation and Enhanced Screening Report. The Feasibility Study Report will further develop the remedial alternatives and provide an evaluation of them. The recommended remedial alternative(s) will be presented to the public in another document, the Proposed Plan. Following public comment, the Record of Decision will document the selected remedial alternative(s). Cost estimates to cleanup alternatives will also be presented in the Feasibility Study prepared by Tecumseh Products, Inc.

#I. A.3.a. In selection of remedial actions, the following concerns should be addressed:

-- The results of bioaccumulation studies done in the Area of Concern.

-- Dredging should be done at the end of the navigation season when biological activity and temperature are low to minimize bioaccumulation, and performed in a manner which minimizes suspension of contaminated sediment (McFarland et al. 1985).

-- Treatment and disposal plans need to be evaluated based on state & federal policy.

-- Cost and the associated economic impacts need to be considered.

-- Public perception & expectations need to be reconciled.

Current data for the Sheboygan Area of Concern indicates that PCBs will bioaccumulate in aquatic organisms when exposed to "high" or "low" sediment PCB concentrations (Tatem 1986). The Corps study concluded that high PCB concentrations in sediment did not result in proportionately high concentrations in the organisms' tissue and that the degree of sediment contamination (by itself) is much less a determinant of bioaccumulation than are the sum total of physical, chemical, and biological processes affecting bioavailability. There does not appear to be a simple sediment - organism relationship, i.e. a sediment concentration which would establish a "desired" (or predetermined) level of PCBs in organisms. Thus, when using bioaccumulation of PCBs for determining "How Clean is Clean?", a relatively low sediment concentration may produce levels in fish that could also be obtained from a relatively high sediment PCB concentration. So, while dredging of just the "hot spots" is a possible management alternative, it is stressed that the problems identified to date will likely remain, i.e. PCBs in organisms, fish and waterfowl consumption advisories, and harbor dredging restrictions.

Disposal and treatment options for dredged spoils include confined disposal facility, incineration, and other options:

Confined Disposal Facility (CDF): CDFs are the most frequently used disposal option within the Great Lakes (IJC 1987a). There are currently 35 CDFs in the Great Lakes. They are prepared as sediment disposal sites located either totally or partially in water. CDFs may be constructed adjacent to existing breakwaters or the shoreline (e.g. Milwaukee) or may be made as an island (e.g. Green Bay). Disposal facilities for maintenance dredging are generally designed to provide capacity for 10 years of dredging. Life-time designs vary for disposal facilities prepared for specific projects. After the CDF is filled with dredged material, it is then capped with clean sediment and vegetation or pavement.

CDFs are not generally viewed as a continuing option (IJC 1987a). Some of the reported problems are leaking, conflicting land and water use, and attractiveness to wildlife. Over 145 species of birds including gulls, terns, herons, and waterfowl have been observed at CDFs (IJC 1987a). The shallow water and mud flat areas may cause waterfowl botulism problems (IJC 1987a). Wildlife may also accumulate toxic substances which may be present in the CDF.

Fish have also been reported to be in the interior pond water due to trapping through original construction or from introduction with waters from dredging. It has also been reported that fish may obtain potentially toxic compounds from the sediments in the CDF (IJC 1987a).

A report on cost comparisons of dredged material disposal facilities (Grefe 1988) estimated an overall cost for CDF construction, sediment dredging and transportation, closure, monitoring, and regulatory and tonnage fees of approximately $47 million (CDF along the shoreline) and $54 million (upland). Table IX.1 summarizes the individual components as well as the total costs. These figures are for the lifetime of the CDF, assumed to be 20 years. Some of the other assumptions used to estimate the cost were:

Item	CDF Shore Annual	CDF Shore Total	CDF Island Annual	CDF Island Total	Landfill Annual	Landfill Total
Preconst. sub.		200,000[1]– 300,000[2]		200,000[1]– 300,000[2]		200,000[1]– 300,000[2]
Plan rev. fees		3,600[1]– 8,100[2]		3,600[1]– 8,100[2]		3,600[1]– 8,100[2]
Lic. Fees	800[2]	17,500[2]	800[2]	17,500[2]	800[2]	17,500[2]
Construction		17,931,000		26,847,000		8,480,000
Dredge & haul	1,270,000	25,400,000	1,220,000	25,400,000	2,070,000	41,400,000
Closure		2,427,000		2,427,000		2,472,000
Tonnage fees	76,950[2]	1,538,000[2]	76,950[2]	1,539,000[2]	76,950[2]	1,539,000[2]
Monitoring	20,400	408,000	20,400	408,000	20,400	408,000
Total Costs						
Nonlic.	1,290,400	46,369,600	1,290,400	55,285,600	2,090,400	52,918,600
$/yd^3		11.59		13.82		13.23
Lic.	1,368,200	48,030,600	1,368,200	56,946,600	2,168,200	54,579,000
$/yd^3		12.01		14.24		13.64

Notes:

1 - Charged for nonlicensed facility.

2 - Charged for licensed facility.

Table IX.1 Cost Comparisons of Confined Disposal Facilities and Landfills

- the sediment to be dredged was sufficiently contaminated to cause the Corps to determine it to be confined

-- CDF design similar to eastern Wisconsin CDFs

-- mechanical dredging

-- direct transfer of dredged material to a CDF

-- CDF a few miles away from dredging site

-- design fill volume of 4×10^6 yd^3

-- the future use of the CDF was not evaluated

Variations in site design, as well as changes due to regulatory reviews could change the individual cost components substantially and contractors could also have an effect through judicious selection of materials, construction techniques, experience, labor, and machinery (Grefe 1988). The report also noted that the IJC total cost estimates varied, but individual construction costs often equaled or exceeded WDNR construction cost estimates (IJC estimates range from $\$1\text{-}5/m^3$).

PCB concentrations greater than 50 ppm in dredge spoils must be disposed at a federally licensed chemical waste facility under the rules of the Toxic Substance Control Act. This could be an approved landfill or an incinerator. A report by the EPA (Carpenter 1987) presented a cost of between \$260 and $\$490/m^3$ for sediment disposal in a chemical waste landfill (Table IX.2).

Incineration: Incineration is another alternative after the sediment is dredged. A cost estimate for incineration (including disposal of the ash residue) was reported to be $\$1680/m^3$ (Table IX.2).

Other: Other types of options with dredging include treatments for removing the contaminants. Many of these treatments are in developmental stages and may not be available for application. Table IX.3 summarizes possible treatment technologies for PCB contaminated sediment. Included in the table is a process rating based on technical and economic assessments, indicating that many of these treatments have potential for future application.

All of the treatment processes for PCBs that were given a "1" for an evaluation rating in Table IX.3 were assessed further as shown in Table IX.4.

These 11 processes are characterized as chemical (low-temperature oxidation, chlorine removal, pyrolysis), physical (removing and concentrating by extraction or vitrification) or biological (microorganisms) technologies. The majority of the 11 processes are within the range of costs of a chemical waste landfill (Table IX.5).

Although the processes are in developmental stages, with most in pilot testing as of 1987, the assessments provide useful information. It appears that supercritical water oxidation (Modar), pyrolysis (Advanced Electric Reactor) and chlorine removal (KPEG) have the potential to handle PCB concentrations greater than 3000 ppm and achieve background levels of < 0.1 ppb, < 1 ppb, and

Table IX.2 Unit Cost Estimates for Steps Involved in Treatment and Disposal of PCB-Contaminated Sediments

Operation	Cost, $/m^3
Dredging	20
Transport	13 to 126
Storage	10
Landfill and Disposal	260 to 490
Landfarming	33
Restricted Land Disposal	111
Incineration	1680

Source: Carpenter, 1987

Table IV.2 Screening of PCB Treatment Processes

Screening of PCB Treatment Processes

Generic technology	References	Process	Evaluation
Chemical.	*Centofanti 1971; Chen 1982; Childs 1982; Craddock 1982; Edwards et al. 1982; Environment Canada 1983; Hornig 1984; Massey and Walsh 1985; Rogers and Kornel 1985; Rogers 1983; Rogers 1985.*		
Low-temperature oxidation			
Wet air oxidation	*Baillod et al. 1978; Miller and Sevientoniewski (n.d.); Miller and Fox 1982.*	*Uncatalyzed, general*	*2*
		Zimpro Process, Santa Maria, CA Waste Site	*4, 13*
		Catalyzed	
		Dow Chemical Co. Patent 3,984,311	*2*
		IT Environmental Science	*2*
Supercritical water oxidation	*Modell et al. 1982.*	*Modar*	*1*
Chemical oxidants	*FMC Corporation (n.d.); March 1968.*	*Potassium permanganate plus Chromic Acid and Nitric Acid*	*6*
		Chloroiodides	*4, 7*
		Ruthenium tetroxide	*3, 4, 8*
Ozonation	*Arisman et al. 1981; Lacy and Rice Deschlaeger 1976; Prengle and Mauk 1978.*	*GE UV/ozonation process*	*2*
Chlorine removal	*U.S.P. 346, 636*	*Molten aluminum/distillation*	*14*
Dehydrochlorination	*Chu and Vick 1985; Lapiere et al. 1977.*	*Catalytic:*	*2, 3*
		Nickel on kieselguhr	*2, 3*
		Pd on charcoal	*2, 3*
		Lithium aluminum hydride	*2, 3*
		Butyl lithium	*2, 3*
		Raney Nickel	*2, 3*
Reducing agents	*Chu and Vick 1985; Sworzen and Ackerman 1982.*	*Sodium in liquid ammonia*	*7, 9*
		Nickel-catalyzed zinc reduction	*7, 9*
		Hydrazine	*7, 9*
		UV light plus hydrogen	*2*
		Mildly acidic zinc powder, Sweeney and Fischer (1970)	*2, 14*
Nucleophilic substitution	*Brown et al. 1985a; Brunelle and Singleton 1985; March 1968; New York University 1984; Ruzz et al. 1985; Smith and Gurbacham 1981; Sunohio (n.d.); Sweeney and Fischer 1970; United States Patent Office 1984b; Weitzman 1984; Weitzman 1984; Weitzman 1985.*	*Sodium-based processes;*	
		Goodyear, sodium in naphthalene (1980)	*10*
		Acurex, proprietary solvent	*10*
		PCBX/Sun Ohio	*10*
		PPM	*10*
		Ontario Hydro Power	*10*
		Potassium poly (ethylene glycolate) based:	
		EPA In-house KPEG	*1*
		KPEG Terraclean-C1	*1*
		GE KOH-PEG	*11*
		New York University KPEG	*12*
Radiant energy	*Bailin and Hertzler 1977; Bailin and Hertzler 1978; Bailin et al. 1978; Craft et al. 1975; Dev et al. 1985; Kalmaz et al. 1981; Meuser and Weimer 1982; Plimmer 1978; Rogers and Kornel 1985; Rogers 1985; Trump et al. 1973; West et al. 1983.*	*UV/photolysis*	*3*
		Syntex photolytic	*3, 4*
		Thermal corona glow	*5*
		Microwave plasma	*9, 17*
		RF insitu heating	*18*
		Gamma radiation (Craft et al. 1975)	*9*
		LARC	*1*
Electromechanical reduction	*Massey and Walsh 1985*	*Electromechanical research process*	*14*
Chlorinolysis	*Sworzen and Ackerman 1982.*	*Hoechst process*	*9*
		Goodyear catalytic hydrogenolysis	*9*
		Exhaustive chlorination	*9*
Hydrolysis	*Boyd 1985; New York State Department of Environmental Conservation 1985a; New York State Department of Environmental Conservation 1985b.*	*Advanced Electric Reactor*	*1*
		Wright-Malta alkaline catalyst fuel-gas process	*12*

Source: Carpenter 1987

Table IX.3 (cont.)

(Continued)

Generic technology	References	Process	E... [a]
Physical			
Removing and concentrating	Angiola and Soden 1982; Caron 1985; Gilmer and Freestone 1978; Githens 1984; Hancher et al. 1984; Hawthorne 1982; Lee et al. 1979; Saunders 1985; Schwinn et al. 1984; Versar, Inc. 1984.		
Heated Air Stripping		American Toxics Disposal Inc	[illegible]
Extraction		Critical Fluid Systems, CO_2	[illegible]
		Furfural	[illegible]
		Acurex solvent wash	[illegible]
		O.H.M. extraction	[illegible]
		Soilex process	[illegible]
Adsorption		Carbon adsorption, general	[illegible]
		Neoprene rubber adsorption	18
Vitrification	Timmerman 1985.	Battelle vitrification process	1
Stabilizing	Ghassemi and Haro 1985; Law Engineering Testing Company 1982; Stroud et al. 1978; Subramanian and Mahalingam 1977; Tittlebaum et al. 1985.	Asphalt with lime pretreatment	14
		Z-Impremix	15
		Sulfur-asphalt blends (K-20)	16
		Ground freezing	13
Bottom recovery	Carich and Tofflemire 1983; Hand and Ford 1978; Murakami and Takeishi 1978; U.S. Army Corps of Engineers Water Resources Support Center 1983; Zimmie and Tofflemire 1978.	Dredging	13
Biological			
Microorganisms	Bedard et al. 1985; Bumpus et al. 1985; Clark et al. 1979; Dawes and Sutherland 1976; Furakawa 1982; Isbister et al. 1984; Kong and Sayler 1983; McCormick 1985.	Bio-Clean	1
		Sybron Bi-Chem 1006 PB	1
		Composting	1
		Bio-Surf	4, 13
	New York State Department of Environmental Conservation 1985a; New York State Department of Environmental Conservation 1985b; Rhee et al. 1985b; Rhee et al. 1985; Unterman et al. 1985.	Ecolotrol, Inc.	4, 13
		Wormes Biochemical's Phenoback	11, 13
		Rhee anaerobic degradation	14
Enzymes	Catelani et al. 1971; Rochkind et al. Unterman et al. 1985	No processes found	

[a]Explanation of process rating:

1. Identified emerging sediment treatment process.
2. Destruction efficiency appears to be too low to meet environmental goals.
3. Processing time appears to be extremely long for practical timely cleanup.
4. Data available for dioxin, other chlorinated compounds, or other contaminants, but not PCB's.
5. Process has been shown to destroy PCB's in gas streams only. It may be feasible for sediments, but has not been shown to be.
6. PCB's with 5-7 chlorine atoms per molecule are not destroyed.
7. Products of partial degradation may be toxic.
8. Reagent is very costly/toxic or both.
9. Process costs appear to be excessively high compared with other emerging treatment processes.
10. Water destroys the reagent or interferes with its action, thus the process would require excessive drying of sediments and, probably extraction in pretreatments. The process would therefore have application only as a subordinate final step to several extraction and concentration operations.
11. This particular process was not evaluated because data were not available for assessment.
12. This process is an alternative to another process using the same generic tehnology, but it is in very early stages of development, and data were not available for assessment.
13. This technique is basically applicable to preliminary operations prior to treatment or to treatment of wastestreams (e.g., wastewaters) from chemical or physical treatments.
14. This process is in the concept stage and data are insufficient to assess it for PCB-contaminated sediments.
15. This process has been found to be ineffective.
16. This technology provides only for encapsulation of the PCB-contaminated sediments.
17. This process supports incineration of PCB's.
18. The process does not appear to be feasible for submerged sediments.

Table IX.4 Treatment Process Assessment

Treatment Process Assessment						
Process	Status[a]	Estimated D/D/R efficiency, %[b]	Estimated residual PCB, ppm	Test and evaluation data needs	Estimated costs, $/m³	Rating[c]
Chemical/physical						
Supercritical water oxidation, Modar	Field test with PCB liquids	>99.9995	<0.1 ppb	1,2,3,4,5,6,7	250-733	4.58
KPEG Terraclean-CL	Pilot tests	>98	<1 ppm	1,6	208-375	5.42
LARC	Lab tests	>90	38-50	2,3,4,5,6,7	223-336	5.26
Advanced electric reactor	Pilot tests	>99.9999	<1 ppb	None[d]	830-943	4.58
Physical						
O. H. Materials, methanol extraction	Field tests under way	97	<25 ppm	2,3,6,7	401-514	4.16
Soilex	Pilot tests	95 (3 stages)	6-9 ppm	5,6,7	856-913	3.26
Acurex solvent wash	Pilot-scale (field tests planned)	[e]	<2 ppm	Identity of mixed solvent, 6,7	196-569	5.21
In-situ vitrification Battelle Pacific NW for EPRI	Pilot test of soil	99.9	None in vitrified block, 0.7 ppm in adjacent soil	6	255-548	4.53
Biological						
Composting, aerobic	Lab-scale	62	504-908	4,5,6	——	2.47
anaerobic	Lab-scale	18-47	825-1268	4,5,6	——	2.47
Bio-Clean, aerobic	Bench-scale	99.99	25 ppb	3,5,6,7	191-370	4.84
Sybron Bi-Chem 1006	Lab-scale and concept	50	——	3,4,5,6,7	——	1.48

NOTE—Data needs key:

1. D/D/R data
2. Residual PCB data
3. Unit operations data
4. Bench-scale data
5. Pilot-scale data
6. Field test data
7. Cost data
8. RCRA waste

[a] Status is defined in terms of the types of studies completed.

[b] D/D/R = destruction/detoxification/removal.

[c] Rating was obtained as shown by the example, under Characterization.

[d] AER is fully permitted under TSCA in EPA Region IV for destruction of PCB.

[e] Treatment is applied until a residual of <2 ppm PCB's is obtained.

Table IX.5 Treatment Process Cost Comparison/m^3

KPEG	$ 211-378
LARC	$ 223-336
Acurex Solvent Wash	$ 196-569
Bio-Clean	$ 191-370
Modar Supercritical Water	$ 250-733
Advanced Electric Reactor	$ 830-942
Vitrification	$ 255-548
OHM Methanol Extraction	$ 400-514
Soilex Solvent Extraction	$ 856-913
Composting	Unable to Estimate Cost
Sybron Bi-Chem 1006	Unable to Estimate Cost
Chemical Waste Landfill	$ 293-636
Incineration	$1713-1826

Source: (Carpenter, 1987)

< 1 ppm, respectively. It appears that removing and concentrating (vitrification) has the potential to achieve no residual PCBs in the vitrified block and 0.7 ppm in adjacent soil. Microbial processes vary in PCB concentrations that are treatable and the residual concentrations attained. All of the processes were reported to have achieved better than 90% destruction/detoxification/removal efficiency. These processes are emerging as potential alternatives to incineration and chemical waste landfills.

Remedial Action #I. A. 4. Establish State and Federal In-Place Pollutant Management Program.

Who's Responsible: Wisconsin DNR, U.S. EPA
Estimated Cost: $240,000 (start-up costs for state program)
Target Completion Date: 1990

Neither the state nor federal environmental protection authorities have established an in-place pollution program. Wisconsin will be developing guidance documents for establishing a program. The guidance should be completed within 2 years. It is estimated that $240,000 will be required to establish this program in Wisconsin. This cost is not specific to the Sheboygan AOC.

Remedial Action #I. A. 5. Apply state and federal programs if Superfund Implementation programs do not meet sediment quality criteria as established in Remedial Action A.1.

Who's Responsible: WDNR, U.S. EPA, local municipalities and citizens
Estimated Cost: Unknown
Target Completion Date: To be determined in 1991

If implementation of the Sheboygan River and Harbor Superfund project does not achieve water and sediment quality criteria for the Sheboygan AOC, state and federal sources will be responsible for completing the remaining remedial work. Support will be required from local municipalities, industry, commerce and citizens. The actual cost at this time is unknown.

REMEDIAL ACTION #I. B: CONTROL TOXIC SOURCES TO MEET NEW STATE WATER QUALITY STANDARDS FOR TOXIC SUBSTANCES (NR 105).

Remedial Action #I. B. 1. Identify and reduce point sources of heavy metals and other toxic substances, incorporating control requirements into WPDES permits.

Who's Responsible: WDNR, WPDES Permit Holders
Estimated Cost: $25,000 for identification of sources
Target Completion Date: 1993

The Wisconsin Department of Natural Resources conducted a preliminary screening of potential toxic materials from dischargers regulated by the Wisconsin Pollution Discharge Elimination System. This information is presented in the Point Source Report of the Sheboygan River Basin Water Quality Management Plan update (September, 1988) Many heavy metals have been reported to be of potential concern from sources within and upstream of the AOC.

Follow-up chemical monitoring and/or bioassay studies will be conducted at the following facilities:

* Village of Belgium Wastewater Treatment Plant
* City of Plymouth WWTP
* City of Sheboygan WWTP
* Village of Waldo WWTP
* City of Keil WWTP
* Lakeland College
* Kohler Company (in progress; a permit will be issued)

Facilities identified as having toxic materials in their waste discharge will be regulated under the proposed administrative codes NR 105 and NR 106. Identification of toxic sources will cost approximately $25,000 and will be the responsibility of permit holders. Treatment for reduction of toxics from point sources is not estimated.

Remedial Action #I. B. 2. Identify and reduce nonpoint sources of toxicity.

Who's Responsible: WDNR, Sheboygan County, Cities of Sheboygan and Sheboygan Falls and Village of Kohler
Estimated Cost: (See cost estimates for Remedial Action #II.D.2)
Target Completion Date: 1998

The Nonpoint Source Water Pollution Abatement Program will help reduce sources of lead from urban runoff through implementation of the Sheboygan River Priority Watershed Plan. (See Remedial Action II.D.2 for more detailed information).

Remedial Action #I. B. 3. Complete Remedial Investigation and Feasibility Study to guide cleanup and management of Kohler Company Landfill.

Who's Responsible: Kohler Company and USEPA
Estimated Cost: Not Known
Target Completion Date: 1990

The Remedial Investigation and Feasibility Study for the Kohler Company Landfill Superfund site will assess whether the landfill is a source of heavy metals to the Sheboygan River. This investigation is in progress. The Kohler Company has accepted financial responsibility for the conduct of this work.

Remedial Action #I. B. 4. Prevent, to the maximum extent possible, fertilizer and pesticide spills from storage tanks.

Who's Responsible: Wisconsin Department of Agriculture and Consumer Protection, C. Reiss Coal Co.
Estimated Cost: No new cost, required by existing state law.
Target Completion Date: Ongoing

The Wisconsin Department of Agriculture, Trade, and Consumer Protection should continue efforts to obtain/maintain C. Reiss Coal Co.'s compliance with Wisconsin Administrative Code Ag 162.

REMEDIAL ACTION #I. C: MONITOR TO EVALUATE RESTORATION OF BENEFICIAL USES AND ACHIEVEMENT OF GOAL I.

Remedial Action #I. C. 1. Monitor contaminant levels in wildlife.

Who's Responsible: WDNR Wildlife Management
Estimated Cost: $2700 (1988)
Target Date: Annually

WDNR (Southeast District Wildlife staff in conjunction with the Bureau of Wildlife Management) will continue to collect waterfowl and perform tissue analyses to determine toxic contaminant levels. This information will be used to refine waterfowl consumption advisories, if necessary, and track trends in contaminant levels. The approximate cost for the laboratory analyses is $2700 for 30 samples. Fifteen mallard ducks will be collected from the Sheboygan River and 15 lesser scaup from the harbor in 1988.

Remedial Action #I. C. 2. Monitor contaminant levels in fish.

Who's Responsible: WDNR Fishery Management
Estimated Cost: $7,000 (Annually)
Target Date: Annually

WDNR (Southeast District Fishery Staff in conjunction with the Bureau of Fisheries Management) will continue to collect various species of resident and migrant fish from the Sheboygan River and Harbor to determine contaminant levels. This information will be used to refine the fish consumption advisory, if necessary, and to track trends in contaminant levels. The annual cost of collection, processing and analysis is $7,000.

Remedial Action #I. C. 3. Conduct acute and chronic toxicity testing of fish and aquatic life.

#I. C. 3. a. WPDES permit monitoring.

Who's Responsible: Permit holders, WDNR
Estimated Cost: $1,500/test
Target Date: Ongoing, according to permit schedule

Dischargers are permitted by the WDNR. Permit holders are required in their permit to monitor their discharge for compliance. Biomonitoring will be required for discharges which contain toxic materials. Results from these tests will be utilized in determining permit conditions. Biomonitoring costs $1,500 per test and will be the responsibility of the permit holder.

#I. C. 3. b. Conduct in-situ assessments of biota.

Who's Responsible: WDNR
Estimated Cost: $20,000
Target Date: Upon completion of Sheboygan River and Harbor Superfund implementation and/or other state and federal in-place pollutant cleanup projects.

In order to determine the effectiveness of the above sediment management remedial actions, evaluation monitoring will be required. The WDNR will conduct in-situ assessment of biota to determine if the effects of toxic substances has been reduced to an acceptable level for restoration of beneficial use.

ECOSYSTEM GOAL II. MAINTAIN AND ENHANCE A DIVERSE COMMUNITY OF AQUATIC AND TERRESTRIAL LIFE

Objectives:

- **Protect natural areas (greenspaces) along the waterway and enhance habitat for aquatic and terrestrial communities**

- **Maintain diverse resident fishery and with the attainment of the toxic substance reduction, establish seasonal runs of coho and chinook salmon and steelhead**

- **Continue to control nutrient inputs to the Sheboygan River and nearshore areas of Lake Michigan to meet the goals of the Great Lakes Water Quality Agreement and to reduce abnormal occurrence of undesirable algae in the marina area of the harbor**

Presently, the Lower Sheboygan River supports a diverse population of fish and wildlife species. However, this diversity is being threatened due to:

* Loss of wildlife habitat through agricultural and urban development,
* Degradation of fish and aquatic life habitat due to sedimentation and dams and
* Potential impacts of toxics

The following actions will continue to assist in maintaining diverse aquatic and terrestrial communities throughout the AOC.

REMEDIAL ACTION #II. A: PROTECT WETLANDS THROUGH LOCAL, STATE, AND FEDERAL REGULATORY PROGRAMS AND ENCOURAGE PRIVATE WETLAND PRESERVATION.

Who's Responsible: Sheboygan County, City of Sheboygan, City of Sheboygan Falls, Village of Kohler, WDNR, U.S. Army Corps of Engineers
Estimated Cost: none
Target Completion Date: (WDNR Water Regulation and Zoning priority for Village of Kohler and City of Sheboygan Falls)

Under Section 404 of the Clean Water Act, the U.S. Army Corps of Engineers regulates the filling of wetlands. Wetland protection activities are reviewed by the U.S Fish and Wildlife Service and U.S. Environmental Protection Agency. Permits for the filling of wetlands in the Sheboygan River basin will not be granted unless it can be demonstrated that the action will not cause adverse impacts to water quality or fish and wildlife habitat. The WDNR will seek

commitment from the U.S. Army Corps of Engineers to conduct an Advanced Identification and Special Area Management Plan for the Sheboygan AOC to assure critical areas are protected.

Under Wisconsin administrative codes NR 115 and NR 117, local communities and counties are required to protect wetlands located in the shoreland area of navigable streams. Sheboygan County and the City of Sheboygan presently have wetland zoning ordinances. Due to the lack of wetlands and limited development pressure, the City of Sheboygan Falls and Village of Kohler have not been required to adopt wetland zoning ordinances to date. In the future, these communities will be required to have wetland zoning ordinances. All communities may wish to consider going beyond minimum requirements of NR 115 and 117. Rezonings, allowing the filling and draining of wetlands protected under these ordinances, will not be granted for parcels that provide water quality protection or important fish and wildlife habitat.

REMEDIAL ACTION #II. B: PROTECT GREEN SPACES THROUGH ADOPTION AND IMPLEMENTATION OF A SEWER SERVICE AREA PLAN.

Who's Responsible: Bay Lakes Regional Planning Commission, Village of Kohler, City of Sheboygan Falls, City of Sheboygan
Estimated Cost: $30,000 (WDNR)
Target Completion Date: 1990

Under the Federal 208 Water Quality Planning Program, administered by the State of Wisconsin (Wisconsin Administrative Code NR 121), sewer service areas for major communities are mapped. Within the boundaries of these service areas, environmentally sensitive lands are delineated. Servicing these areas with private or public sanitary sewers is prohibited by the State of Wisconsin. Presently, the sewer service area for the City of Sheboygan Falls, Village of Kohler, and City of Sheboygan is being delineated by the Bay Lakes Regional Planning Commission, under contract with the state. The estimated cost of this planning is $30,000. This plan will be completed in 1990. Communities should adopt the sewer service plan when completed. State and federal funding for this effort will be maintained to complete the Sheboygan Area Sewer Service Plan on schedule.

REMEDIAL ACTION #II. C: PROTECT PUBLIC INTEREST IN NAVIGABLE WATERS THROUGH COMPLIANCE WITH CHAPTER 30, WISCONSIN STATUTES.

Who's Responsible: Project sponsors, with approval from WDNR
Estimated Cost: No new cost, existing program.
Target Date: Ongoing

Under Wisconsin Statute Chapter 30, activities regarding the alteration of navigable waters of the state are regulated. These activities include dredging, filling or placement of structures in navigable waters of the state. Permits under this statute are not granted for projects that are detrimental to the public interest and trust in navigable waters (water quality, fish and game habitat, navigation, flood flow, etc.). These types of permit applications in the AOC are thoroughly investigated for negative impacts before WDNR grants approval.

REMEDIAL ACTION #II. D: REDUCE SEDIMENTATION SO THAT [illegible] CONCENTRATIONS IN THE LOWER SHEBOYGAN RIVER ARE REDUCED TO A MEAN CONCENTRATION OF LESS THAN 25 MG/L FOR 90% OF THE TIME AND BEDLOAD (SOLIDS TRANSPORTED AND DEPOSITED ALONG RIVER BOTTOM) IS REDUCED BY 50 TO 75 PERCENT.

Suspended solid concentrations in the lower Sheboygan River from 1977 through 1987 have ranged from zero to 75 mg/l approximately 90 percent of the time. Sediment can impact the local fish and aquatic life in the following ways:

* By acting directly on fish by either killing them or reducing their growth rate, resistance to disease, etc.,
* By preventing the successful development of eggs and larvae,
* By modifying natural movement and migration,
* By reducing availability and abundance of food, and
* By degrading habitat

Research by the European Inland Fishery Commission (EIFAC) has shown that suspended solid concentrations below 25 mg/l have no impact on fish health. However, concentrations ranging from 25 to 80 mg/l produce populations with reduced yield, and concentrations greater than 80 mg/l are likely to produce an unbalanced fishery.

In addition to impacts on the local fishery, excess sediment deposited in the Sheboygan harbor is inhibiting commercial navigation. The U.S Army Corps of Engineers presently maintains navigation channels in the Sheboygan harbor. It is estimated that the Sheboygan River transported 21815, 16278 and 27280 tons of sediment in 1980, 1981 and 1982, respectively to the lower Sheboygan River and harbor (Bannerman et al. 1984). The City of Sheboygan is interested in maintaining a commercial harbor to sustain a diverse industrial and commercial base. It is estimated that the cost of dredging compared to upland control of erosion is 10 to 15 times greater. Therefore, sediment loads to the harbor need to be reduced to lessen the frequency of dredging required to maintain navigation channels.

Remedial Action #II. D.1: Seek continuation and strengthening of U.S. Department of Agriculture and Wisconsin DATCP programs that reduce sediment loads.

Who's Responsible: Sheboygan County, Wisconsin citizens
Estimated Cost: No new cost
Target Date: Annually

Wisconsin citizens and counties will seek continuing commitment of U.S.D.A. and DATCP for funding and implementation of programs designed to manage sediment reduction which include the Agricultural Conservation Program, the Conservation Reserve Program, the Conservation Compliance provision of the 1985 Farm Bill, the Farmland Preservation Program, and county erosion control plan implementation.

The Agricultural Conservation Program (ACP) provides cost share grants to landowners to install conservation practices to reduce soil erosion.

The Conservation Reserve Program (CRP) pays landowners to set aside highly erodible lands into grass or forest cover for a ten year period. As of June

1987, 1214 acres of land have been set aside under this program in Sheboygan County. There are 24,000 eligible acres in Sheboygan County.

Under the Conservation Compliance provision of the 1985 Farm bill, agricultural producers receiving assistance from USDA programs (price supports, crop insurance, low interest loans, etc.) and farming highly erodible land, will be required to implement soil conservation practices. Landowners must have a conservation plan approved by the Soil Conservation Service (SCS) by January 1, 1990 and implemented by January 1, 1995 to remain eligible for USDA programs. This program will impact 60% of the cropland in the Sheboygan River Watershed, or approximately 26,000 acres.

The Wisconsin Farmland Preservation Program gives tax incentives for maintaining land in agricultural land use as well as for reducing soil erosion rates to tolerable levels. Presently, about 850 landowners have entered approximately 170,000 acres into this program in Sheboygan County. Erosion Control Plans completed by each county also identify problem areas and potential funding assistance.

Remedial Action #II. D.2: Implement intensive nonpoint source control programs in the Sheboygan River Basin's three watersheds:

* Initiate and complete implementation of the Sheboygan River Priority Watershed Project;

* Complete implementation of and maintain practices installed by the Onion River Priority Watershed Project; and

* Seek designation of the Mullet River as a priority watershed project.

Who's Responsible: Sheboygan County and local units of government in the Onion, Sheboygan, and Mullet River Watersheds; WDNR; WDATCP; Landowners.
Estimated Cost: ~ $ 6 million
Target Date: 2000

The Sheboygan River basin is made up of three major rivers including the Sheboygan River mainstream, Onion River and Mullet River. Presently, the Sheboygan River mainstream and Onion River are priority watersheds under Wisconsin's Nonpoint Source Water Pollution Abatement Program and have active projects to control nonpoint sources of pollution. This program was created by the Legislature in 1978 as a means to reduce surface and ground water pollution caused by nonpoint sources of pollution. Each priority watershed project includes inventorying sources, development of a management plan, and cost-sharing of best management practices in critical areas. A project typically takes 10 years to complete.

In 1985, the Sheboygan River watershed was designated as a Priority Watershed under the Wisconsin Nonpoint Source Water Pollution Abatement Program. Sheboygan and Fond du Lac Counties have completed an extensive inventory and assessment of the various sources of urban and rural nonpoint pollution within the Sheboygan River watershed. An appraisal of each water resource (stream, lake, and groundwater) within the watershed will be completed by WDNR. These water resource appraisals determine the current uses the resource is

supporting, what the potential uses could be for each resource, and how much reduction of specific pollutants (including lead, copper, zinc, fecal coliform, and nutrients) must be attained to reach these potential uses. WDNR will combine these inventories to develop a management plan to attain the objectives for each water resource in the watershed through the control of nonpoint sources of pollution.

The planning process for the Sheboygan River began in 1987 and will be completed in late 1989. Upon completion of the planning, funding will be provided by the state to support local units of governments in carrying out the plan and installing necessary nonpoint source control measures. The project cost for the Sheboygan River is estimated at $2 to $3 million. The period of plan implementation will likely be eight years in length.

The Onion River Priority Watershed Project, selected in 1980, nears completion. 1989 is the last year cost sharing will be provided for implementation of nonpoint source controls. The management plan for the watershed was completed in 1981. The plan identifies $3.1 million of nonpoint source controls (best management practices) needed in the watershed to address the critical cropland, animal waste, and stream bank sources. $1.7 million of that amount was eligible for state funding under the project. During the sign-up period, 81 cost-share agreements were signed with landowners.

As of May, 1989, $311,650 in cost-sharing had been expended to install management practices. Thus a major focus of the remainder of this project (and future projects) must be encouraging landowners to install needed practices that are eligible for cost-sharing.

Studies of the Mullet River indicate that it is also a major source of sediment, nutrients and bacteria to the Lower Sheboygan River. While many of the erosion and animal waste problems in the Mullet River are eligible for assistance under federal programs, resources in these programs are generally too limited to address enough of the problems to show significant water quality improvements. Sheboygan County should work with state and federal agricultural agencies to determine if their programs can be more effective in controlling the Mullet River Watershed nonpoint sources (See recommendation #II. D. 1). The county should also consider funding a nonpoint source control project in a portion of the watershed or seeking selection of the watershed as a nonpoint source priority watershed under the Wisconsin Nonpoint Source Water Pollution Abatement or similar federal program. Guidelines for selection of priority watersheds (NR 120, Wisconsin Administrative Rules) are being revised. The Mullet River was identified as having high priority for nonpoint source control in the Sheboygan River Water Quality Management Plan (Meyer et al. 1988). Thus, the watershed is likely to be eligible for consideration in the next Priority Watershed selection. Local support is critical. Therefore, Sheboygan County and local municipalities should seek designation of the Mullet River as a priority watershed.

It is estimated that the cost of an intensive nonpoint source project in the Mullet River watershed, including planning, administration, technical assistance and cost share grants to land owners will be between 2.0 and 2.5 million dollars.

Remedial Action #II. D.3: Seek compliance with Wisconsin Act 297.

Who's Responsible: WDNR, Landowners
Estimated Cost: Ongoing program
Target Date: As necessary

The State of Wisconsin will issue orders for corrective action of any water pollution and habitat problems caused by nonpoint sources, including erosion problems where voluntary compliance cannot be obtained. The new law, passed in 1988, impacts on both urban and rural lands.

REMEDIAL ACTION #II. E: MANAGE DAMS TO MINIMIZE ANY ADVERSE ENVIRONMENTAL IMPACTS.

Who's Responsible: Owners of dams, with assistance from WDNR
Estimated Cost: $2,500/dam
Target Date: Upon request

There are three dams located in the AOC of which two are in the Village of Kohler and one in the City of Sheboygan Falls. These dams segregate the river, prevent natural migration of fish and contribute to degraded habitat for fish and aquatic life.

The WDNR has recommended terms and conditions to the Federal Energy Regulation Commission regarding the operation of the Sheboygan Falls dam. Under the proposed conditions, the operators of the dam would have to maintain run-of-the river. The intent of the terms and conditions is to insure that dam operation does not exacerbate PCB problems in the river and that adequate flow be maintained for sustaining fish and wildlife populations. The WDNR does not have any additional management recommendations for the other two dams. However, if requested by the dam owners, the Department may be able to help conduct an environmental and economic analysis of the various dam management options with the owners of the dams. This analysis will cost approximately $2,500 per dam and will be borne by the owner of the dam and WDNR. Dam restoration costs are not estimated.

REMEDIAL ACTION #II. F: REINSTATE STOCKING WHEN PCB LEVELS IN FISH ARE REDUCED.

Who's Responsible: WDNR
Estimated Cost: $40,000 annually
Target Date: Upon resolution of PCB contamination problem in the AOC

The Sheboygan River and harbor has historically been a stocking site for coho and chinook salmon and rainbow trout. Stocking in the area ceased in 1987 due to PCB contamination problems. Without future stocking, the last run of mature coho up the Sheboygan River will occur in the fall of 1988 and in 1989 for full-term (4-year) chinook. Rainbow trout will maintain their runs only through the fall of 1990. Without future stocking, salmonid runs will be reduced, which may affect the diversity of the fishery and recreational sport fishing. After the PCB fish contamination issue is resolved, the WDNR Bureau of Fisheries management will reinstate salmonid stocking in the Sheboygan Harbor. The cost of annual stocking is estimated at $40,000. This amount includes raising the fish only, not transportation or staff time costs.

REMEDIAL ACTION #II. G: CONSIDER ESTABLISHMENT OF AN EGG COLLECTION FACILITY IN THE SHEBOYGAN AOC.

Who's Responsible: WDNR
Estimated Cost: $250,000
Target Date: Upon resolution of the PCB contamination problem in the AOC

The Sheboygan River is an excellent location for a coho salmon egg collection facility. Once the PCB issues are resolved, a Sheboygan River facility could be established as a back-up to the Kewaunee facility. WDNR Fisheries management will evaluate the need for a back-up facility to locate in the Sheboygan area. Cost for establishing this facility will be the responsibility of WDNR and are estimated at $250,000.

ECOSYSTEM GOAL III. CONTROL EUTROPHICATION (NUTRIENT ENRICHMENT OF WATER) FOR THE PROTECTION OF LAKE MICHIGAN

Objective: Continue to control nutrient inputs to the Sheboygan River and nearshore areas of Lake Michigan to meet the goals of the Water Quality Agreement and to reduce abnormal occurrence of undesirable algae in the marina area of the harbor.

Eutrophication in the AOC has not been a major problem due to the fast flushing rate of the Sheboygan River and harbor. Water movement is too rapid for excess nutrients to be utilized to form severe algal blooms. However, nutrients discharged from the Sheboygan River do cause some undesirable algal growth in the harbor and are contributing to the potential eutrophication of Lake Michigan. Presently, nearshore areas of Lake Michigan in the vicinity of Sheboygan do not show any signs of severe eutrophication.

Increases in nitrate and nitrite concentrations have been well documented throughout the Great Lakes (IJC 1987b). The short and long term impacts of these increasing levels are unknown. IJC scientists are concerned that increased nitrate and nitrite concentrations may have an impact on phytoplankton community composition. This issue is presently being studied by the U.S. EPA and IJC.

Phosphorus concentrations in-lake from 1983 through 1987 have ranged from 4 ug/l to 9 ug/l, with mean concentrations ranging from 5-6 ug/l. In the Great Lakes Water Quality Agreement of 1978 and amendments in 1987, the IJC developed a phosphorus control strategy for the Great Lakes. This strategy is based on maintaining an in-lake concentration of 7 ug/l to sustain the trophic status of Lake Michigan. Total phosphorus loadings from the Sheboygan River for 1980, 1981 and 1982 were estimated at 74.9, 58.4 and 97.6 tons respectively. Since 1981, estimated total phosphorus loadings to Lake Michigan from all sources (tributaries, atmosphere, wastewater treatment plants,...) have remained under the target value of 5,670 tons per year.

REMEDIAL ACTION #III. A: REDUCE PHOSPHORUS IN DETERGENTS AND FROM MUNICIPAL WASTEWATER TREATMENT PLANTS TO MEET THE OBJECTIVES OF THE GREAT LAKES WATER QUALITY AGREEMENT.

Who's Responsible: State of Wisconsin and the Cities of Keil, Plymouth, and Sheboygan Wastewater Treatment Plants,
Estimated Cost: No new cost
Target Date: Ongoing

In 1978, the State of Wisconsin enacted a phosphorus detergent ban. This ban, reauthorized in 1983, limits phosphorus in domestic detergents to 0.5%, machine dishwashing and medical and surgical equipment cleaning agents to 8.7%, and water conditioners to 20% (by weight). This law provides an effective way of reducing phosphorus treatment costs at wastewater treatment plants and reducing phosphorus discharges to Great Lakes tributaries.

All municipal treatment plants treating the waste of communities greater than 2500 in population are required to limit phosphorus discharges to 1 mg/l in their effluent. Communities required to meet this limit include the City of Keil, City of Plymouth, and City of Sheboygan. These municipalities and WDNR will assure compliance with WPDES permit requirements.

REMEDIAL ACTION #III. B: IMPLEMENT INTENSIVE NONPOINT SOURCE CONTROL PROGRAMS IN THE SHEBOYGAN RIVER BASIN'S THREE WATERSHEDS.

* Initiate and complete implementation of the Sheboygan River Priority Watershed Project;

* Complete implementation of and maintain practices installed by the Onion River Priority Watershed Project; and

* Seek designation of the Mullet River as a priority watershed project.

See recommendation #II.D.2. for more information.

ECOSYSTEM GOAL IV. ENHANCE RECREATIONAL USES

Objectives: Reduce bacteria Levels in the Onion, Mullet, and Sheboygan rivers to meet state recreational use standards. Provide adequate public access and recreational facilities.

The State of Wisconsin has established bacterial standards for the protection of public health. The AOC has been classified as a full recreational use water body and, since 1987, should be protected for full body contact. While presently there are no public beaches in the lower River or harbor, protection of the public's ability to contact these waters without health risk is an objective of this plan.

Bacterial contamination of the lower Sheboygan River has been a long term problem. The 1980 Sheboygan River Areawide Water Quality Management Plan (WDNR 1980) identified that 12 of the 14 watershed sites monitored for fecal

coliform bacteria experienced violations of state standards. These high levels still exist today based on monthly monitoring at the U.S. Geological Survey station located 4.2 miles upstream of the harbor. The sources of these bacteria are a combination of point source discharges, malfunctioning septic systems, and runoff from animal feedlots.

The City of Sheboygan operates two public beaches, located north and south of the Sheboygan harbor. Bacterial monitoring of these beaches have not shown bacteria to be a problem outside the river and harbor. Records of the past three years show no beach closings due to bacterial contamination.

REMEDIAL ACTION #IV. A: REDUCE BACTERIA INPUTS.
REMEDIAL ACTION #IV. A.1: Conduct Bacteria Survey

Who's Responsible: WDNR
Estimated Cost: $3,000
Target Date: 1989

The specific sources and contributions of bacterial contamination to the lower Sheboygan River are unknown. A review of monthly discharge reports submitted by municipal wastewater treatment plants in the Sheboygan River Basin show that several are discharging bacteria at concentrations that exceed criteria for full body contact. Several of these plants discharge to stream reaches that are not designated for full recreational use and therefore technically do not need to meet the strict levels necessary in the lower Sheboygan River. These sources include the Lakeland College, Hingham, Plymouth, Waldo, and Belgium wastewater treatment plants. The bacterial contribution from these point sources to the lower river is not known. The WDNR, as part of the Basin Assessment Monitoring Program, will conduct a bacterial survey to identify the significance of these point sources to the lower Sheboygan River. In addition, bacteria from animal waste and private waste disposal systems should be quantified to identify the significance of these bacterial sources to the lower Sheboygan River.

Remedial Action #IV. A.2: Revise WPDES Permits as Necessary to Achieve State Water Recreation Use Standards.

Who's Responsible: WDNR
Estimated Cost: Ongoing program
Target Date: Upon scheduled permit reissuance (1995)

If it is determined from the above survey that the Lakeland College, Hingham, Plymouth, Waldo, and Belgium wastewater treatment plants are causing violations of recreational use standards in the AOC, the WDNR will modify WPDES permits as necessary.

Remedial Action #IV. A.3: Manage animal waste through implementation of local, state, and federal programs.

Who's Responsible: WDNR, DATCP, Agricultural Stabilization and Conservation Service
Estimated Cost: To be determined
Target Date: Upon completion of bacteria survey

Runoff from animal feedlots and areas spread with manure have been significant sources of bacteria to the Onion, Mullet and Sheboygan Rivers. Several federal and state programs are presently being implemented to control these sources.

Wisconsin continues to rely on federal programs administered by the Agricultural Stabilization and Conservation Service (ASCS) to help control animal waste runoff. These include the Agricultural Conservation Program (ACP) for cost-sharing installation of barn yard runoff control systems, and the Dairy Termination Program which retired 44 herds in Sheboygan County in 1987.

If deemed necessary by the results of the bacteria survey, the State can implement the following animal waste control programs to achieve water recreational use standards:

The Wisconsin Farmers Fund Program: administered by the Wisconsin Department of Agriculture, provides cost-share grants to land owners for the installation of barn yard runoff systems.

The Wisconsin Nonpoint Source Pollution Abatement Program: administered by the Wisconsin Department of Natural Resources, provides cost-share grants to land owners for the installation of animal waste control systems. Grants are provided to land owners in watersheds designated as "priority" areas by the state. The Onion and Sheboygan Rivers are designated as Priority Watersheds for nonpoint source pollution abatement.

NR 243 Animal Waste Management Program: approved in 1984, authorizes the Wisconsin DNR to regulate animal feeding operations that cause water quality problems as point source dischargers. Feedlots regulated under this law are required to meet the same water quality standards as industry. Under this program, the WDNR has responded to 20 animal waste complaints in Sheboygan County from 1984 to the present.

Remedial Action #IV. A.4: Correct malfunctioning waste disposal systems.

Who's Responsible: Wisconsin Department of Industry, Labor, and Human Relations and Sheboygan County, Landowners
Estimated Cost: To be determined
Target Date: Ongoing

Private onsite waste disposal systems, such as holding tanks and septic systems, are regulated under the plumbing section of Wisconsin's Uniform Building Code. The state Building Code requires all onsite waste disposal systems to meet minimum requirements. Systems not meeting these requirements can be ordered to undertake corrective action. Administration of onsite systems is overseen by the Wisconsin Department of Industry, Labor and Human Relations (DILHR) and administered locally by county sanitarians and building inspectors. In 1987, Sheboygan County issued 179 permits for new or replacement systems and responded to 55 complaints regarding potential malfunctioning systems. DILHR and Sheboygan County will continue their efforts to identify and correct any malfunctioning onsite waste disposal systems. Restoration of private waste disposal systems is the responsibility of the landowner.

REMEDIAL ACTION #IV. B: ENSURE ADEQUATE PUBLIC ACCESS AND RECREATIONAL FACILITIES

Who's Responsible: Local municipalities, U.S. Army Corps of Engineers, and WDNR
Estimated Cost: $17,000,000
Target Date: 2000

Although there is public access to the river and harbor primarily through several boat launches, fishing piers, parks, and walkways along the harbor which are associated with the commercial development, additional access may be desired as water quality improves. Past studies have looked at recreational needs in the area (U.W. Extension, 1987).

The City of Sheboygan is interested in developing a marina within the Sheboygan harbor. The marina would increase public access to Lake Michigan and provide an important economic and recreational resource to the City of Sheboygan. Proposed plans for a 580 slip marina have been developed. The marina would be built in three phases and cost approximately $17 million.

Development of the Sheboygan Marina has been on hold since 1979. WDNR determined that sediment from sampling conducted by the Superfund Project in 1987-88 in the area of the proposed marina was not contaminated (Frank Trcka, WDNR, to Mayor Schneider, in letter June 24, 1988). The City initiated dredging of this area on May 8, 1989. Phase 3, which is development of a park area on top of a confined disposal site for contaminated river sediment, will remain on hold until long range plans for management of these sediments are developed.

ALL ECOSYSTEM GOALS: I, II, III AND IV

Objective: Enhance public understanding, education, and participation to support the ecosystem goals of this plan

REMEDIAL ACTION #A: CONTINUE PUBLIC PARTICIPATION EFFORTS THROUGH PLANNING PROCESSES.

It is important to have strong involvement by the public to develop an effective water quality management program for the AOC and thereby enhance recreational uses.

Presently, there are several on-going management projects in the AOC which have active public participation efforts. These include:

Remedial Action A.1: Superfund Projects

Who's Responsible: U.S. EPA, WDNR
Estimated Cost: Not known
Target Date: Ongoing

Public participation efforts for the two Superfund Projects are being coordinated by the Region 5 office of U.S. EPA. This effort includes:

-- the preparation and implementation of a Community Relations Plan for each site

-- the preparation and distribution of at least 3 Fact Sheets

-- the preparation and submittal of site update reports as needed

-- providing a public comment period and public meeting once a remedial action is proposed

-- a written response to public comments

-- maintaining public information repositories

-- and holding public meetings.

Remedial Action A.2: Sheboygan River Priority Watershed Project

Who's Responsible: Sheboygan County, WDNR, DATCP
Estimated Cost: Existing program
Target Date: Ongoing

This nonpoint source pollution abatement program is being coordinated by the Wisconsin DNR and Sheboygan and Fond Du Lac Counties. The project is being overseen by a citizen advisory committee composed of sportsman groups, landowners, and county and municipal officials.

Remedial Action A.3: Sheboygan River Basin Water Quality Management Plan

Who's Responsible: WDNR
Estimated Cost: Existing Program
Target Date: Ongoing

Public participation includes review of the draft plan by the impacted communities, one public informational meeting, and a public hearing.

Remedial Action A.4: Sheboygan, Kohler, Sheboygan Falls Sewer Service Area Plan

Who's Responsible: Bay Lakes Regional Planning Commission
Estimated Cost: No new cost
Target Date: Ongoing

Bay Lakes Regional Planning Commission will be preparing this plan. To oversee plan preparation, the Planning Commission has formed an advisory committee composed of municipal officials from the City of Sheboygan Falls, Village of Kohler, City of Sheboygan, Town of Sheboygan, Town of Wilson, Town of Lima, Town of Sheboygan Falls and Sheboygan County.

Remedial Action A.5: Sheboygan Remedial Action Plan

Who's Responsible: Sheboygan County Water Quality Task Force, WDNR
Estimated Cost: $2,000
Target Date: Ongoing

The WDNR has requested that the Sheboygan County Water Quality Task Force act as the citizen advisory committee for the RAP. The Task Force is a self formed group of concerned groups and citizens in the Sheboygan area. They represent several interests including charter captains, local yacht club, sportsman, commercial fisherman, industry and local government. The role of the Task Force is outlined in "Chapter VII. Historical Record".

REMEDIAL ACTION B: INCLUDE PUBLIC PARTICIPATION/CITIZEN INVOLVEMENT THROUGHOUT REMEDIAL ACTION PLAN IMPLEMENTATION

Who's Responsible: Sheboygan County Water Quality Task Force and WDNR
Estimated Cost: $2,000 annually
Target Date: Ongoing

Public participation efforts should include an annual review meeting, newsletters, informational releases, and involvement in local events.

REMEDIAL ACTION C: EVALUATE THE NEED FOR INCREASING AWARENESS OF FISH AND WATERFOWL CONSUMPTION ADVISORIES

Who's Responsible: WDNR and UW-Sea Grant
Estimated Cost: $1,000
Target Date: 1990

Fish and waterfowl consumption advisories were developed by the WDNR and the Department of Health and Social Services to inform anglers of the risk of consuming contaminated fish. The WDNR will evaluate the need for a Vietnamese translation of fish consumption advisories in the Sheboygan area and other means to increase awareness of these advisories if necessary. (The University of Wisconsin-Sea Grant is studying this issue in the Green Bay area. Sea Grant staff will aid the WDNR in the Sheboygan effort, if necessary.).

X. PROGRAMS, PARTICIPANTS, AND IMPLEMENTABILITY

APPLICABLE PROGRAMS (INCLUDING RESPONSIBLE IMPLEMENTATION ENTITIES)

Wisconsin Department of Natural Resources

Water Resource Management

-- Sheboygan River Priority Watershed Plan

Control of eutrophication, sedimentation, and bacteria levels will be addressed in this plan which is scheduled for implementation beginning in late 1989.

-- Onion River Priority Watershed Plan

This project is scheduled for completion in late 1988.

-- Water Quality Management Plan for the Sheboygan River Basin

This plan identifies water quality goals, problems, improvements, and management needs for the lakes and streams in the Sheboygan River Basin (which includes the AOC) and will also examine existing and future wastewater treatment facility and management needs. This updated plan is scheduled for implementation beginning in October 1988.

-- Administrative Codes NR 105 and 106

These proposed toxics codes are to protect public health and welfare, fish and aquatic life, and wild and domestic life; and to protect the present and prospective future use of all surface waters for public and private water supplies from toxic effluents. Water quality criteria will be used to impose effluent limits on dischargers to surface waters.

-- Ambient Monitoring

This includes fixed station river monitoring.

-- Fish Consumption Advisories in conjunction with Wisconsin Department of Health and Social Services

Water Regulation and Zoning

-- Administrative Codes NR 115 and 117

These codes are intended to protect aquatic quality and habitat through wetland zoning ordinances.

-- Administrative Codes NR 347

This code is intended to protect public trust waters by setting guidelines on sediment sampling and analysis.

-- Wisconsin State Statute 30

This statue regulates dredging, filling, and placement of structures in navigable waters of the state.

Fisheries Management

-- Fish Collection and Stocking

Fishery managers are responsible for collection of fish for contaminant monitoring. 1988 analyses will include PCB congener analyses. Also, once the PCB problem is resolved, fishery managers will continue salmonid stocking within the Sheboygan harbor and evaluate the need for coho salmon egg collection facility.

Wildlife Management

-- Waterfowl Collection and Permit Review

Wildlife managers are responsible for collection of waterfowl for contaminant monitoring, review of Water Regulation and Zoning permits for potential impacts on wildlife habitat, and banding mallards to determine migration pattern.

Solid Waste Management

The Bureau of Solid Waste is responsible for groundwater monitoring, recycling (reducing landfilled waste), and review of dredging projects and Superfund projects.

-- Administrative Code NR 522 (proposed)

This code is intended to provide procedural and operational requirements for dredged material disposal facilities.

Wastewater Management

-- Administrative Code NR 243
(Animal Waste Management Program)

-- Implementation of WPDES recommendations in the Water Quality Management Plan update (1988) and monitoring of compliance with WPDES Permit conditions.

Air Management

-- Ambient Air Quality Monitoring

Air Management staff are responsible for reporting ambient air quality. Sheboygan County is a nonattainment area for ozone. A strategy for reducing ozone levels will be continued.

-- Administrative Code NR 445

This code is intended to protect the environment from toxic emissions. Over 400 chemicals are listed for regulation in this code, including PCBs.

Wisconsin Department of Agriculture, Trade, and Consumer Protection

-- Administrative Code Ag 166

This code covers implementation of the Soil and Water Resource Management Program.

-- Administrative Code Ag 162

This code contains procedures for storing fertilizer.

-- Farmland Preservation Program

This program gives tax incentives for maintaining land in agricultural land use as for reducing soil erosion rates.

Wisconsin Department of Industry, Labor, and Human Relations

-- Regulation of on-site waste disposal systems

-- Regulation of underground storage tanks

Wisconsin Department of Administration

-- Coastal Zone Management-sponsored study in conjunction with the WI Sea Grant Program (PCB Dechlorination of Sheboygan Harbor Sediment)

This work will:

a. identify PCB congeners present in the Sheboygan River and harbor sediment and other environmental samples

b. determine if dechlorination and detoxification has occurred

c. demonstrate whether such processes could also occur in a confined disposal facility that would contain Sheboygan River and harbor sediment

d. determine the implications of study findings for in-place PCB pollution management

This project is scheduled for completion in October 1990.

Bay Lakes Regional Planning Commission

-- Sheboygan Sewer Service Area Plan

A sewer service area plan is being developed for Sheboygan by Bay Lakes Regional Planning Commission. The plan is scheduled for completion in June 1990.

Sheboygan County

-- Implement Sheboygan County Erosion Control Plan and Farmland Preservation Program

-- Regulate on-site wastewater disposal systems

-- Protect wetlands under Wisconsin Administrative Code NR 115

-- Carry out Sheboygan and Onion, and seek designation for the Mullet River Priority Watershed plans. Work with WDNR in inventory development, planning, and assisting landowners in design and installation of practices.

Cities of Sheboygan and Sheboygan Falls, and Village of Kohler and Upstream Communities

-- Protect wetlands under Wisconsin Administrative Code NR 117 and adopt sewer service area plans and wetland zoning ordinances

-- Develop plans for a marina (City of Sheboygan)

-- Operate and maintain wastewater treatment plant

WPDES Permit Holders

-- Comply with respective WPDES permits and operate and maintain treatment facilities

U.S. Environmental Protection Agency

-- Sheboygan River and harbor Remedial Investigation/Feasibility Study (Superfund)

The Remedial Investigation is completed and has included collection and analysis of sediment and water samples. The next step is to complete the Enhanced Screening report which will screen potential remedial alternatives. This is scheduled for completion by July, 1989. A Feasibility Study which develops and evaluates the remedial alternatives identified at the end of the Enhanced Screening process, will be completed by April, 1991. The EPA and WDNR will then propose a remedial alternative for the site and accept comments. Remedial action will occur after a decision is made.

-- Kohler Co. Landfill RI/FS

The Remedial Investigation for the Kohler Co. landfill is in progress. A Remedial Investigation report is expected in 1990.

-- Water Quality Act Demonstration Project - Great Lakes National Program Office

The Federal Water Pollution Control Act of 1987 proposed the Sheboygan harbor as a site for priority consideration for a five year study and a demonstration project. The U.S. EPA GLNPO will carry out a 5 year study and demonstration

project relating to toxic pollutants in the Great Lakes areas. Chemical, biological, and physical data will be utilized for the development of a Sediment Action Index. This work will emphasize site specific toxicity and bioavailability of contaminants when assessing the problem and remedial options. The Sheboygan harbor investigation is expected to be initiated in the summer of 1989.

U.S. Army Corps of Engineers

-- Wetland Regulation

Section 404 of the Clean Water Act requires that the U.S. Army Corps of Engineers regulate wetland filling.

-- Limited Dredge Project

The limited dredge project is designed to provide an access channel to the C. Reiss Coal Co. docks in the Sheboygan Harbor. Approximately 46,000 cubic yards of sediment would need to be dredged initially. A report on the evaluation of 19 sites for the disposal of the dredge spoils was completed in April, 1989.

U.S. Fish and Wildlife Service

-- Review U.S. Army Corps of Engineers permits for wetland filling operations (404 permits)

-- Review Federal dredging projects for effects on fish and wildlife

U.S. Department of Agriculture

-- Agricultural Conservation Program (ACP), Conservation Reserve Program (CRP), and Dairy Termination Program

These federal programs are intended to control animal waste runoff and soil erosion.

U.S. Coast Guard

The Coast Guard has responsibility for responding to spills if they should occur from shipping vessels within federal navigable waters.

International Joint Commission

Review and approve RAP

Sheboygan County Water Quality Task Force

Created in 1984, this group has actively explored possible clean-up solutions and coordinated restoration efforts for the Sheboygan River and harbor. They are the citizen advisory committee for the RAP.

PUBLIC INVOLVEMENT

Participation by the public in this planning process is viewed as a critical element to its success. Therefore, extensive efforts were and continue to be made to involve the citizens in all planning phases. The Sheboygan County Water Quality Task Force has been the information and education liaison between the public and the environmental agencies since 1985. They have continued to play this role by acting as the Citizen Advisory Committee for the RAP and as a local citizen participation group for Superfund. Environmental advocacy groups, especially Lake Michigan Federation, have also provided significant input.

An interagency technical advisory committee was utilized for review purposes. The members are from Coastal Zone Management, Department of Health and Social Services, U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, and U.S. EPA. This group will oversee the coordination and promote exchange among the various investigations and ongoing work in the AOC.

Other specific efforts to involve the public have included:

1. The preparation and distribution of a questionnaire by the Task Force. The questionnaire was distributed to Sheboygan area citizens between February and April 1988 and gathered information on peoples' perceptions and uses of the river. Approximately 100 responses were received (Appendix F).

2. Three public informational meetings were held during February and March for the purposes of explaining the planning process, answering questions, and obtaining input from citizens.

3. A four page 'popular summary' of the plan was developed to further encourage public participation. This summary was designed to be read and understood by those without a technical background in environmental toxicology. Approximately 1,700 copies were distributed.

4. A series of formal presentations involving a slide program, verbal discussion, and question and answer session were offered to fifteen groups in the area. These groups included local governmental bodies, service clubs, public schools, environmental organizations, private business, and private sportsmen's clubs. Seven groups requested a presentation and approximately 535 individuals attended (Appendix F).

5. A public hearing moderated by an attorney for the Department of Natural Resources was held in April. The purpose of the hearing was to provide a final opportunity for citizens to comment on the plan in a public forum (Appendix F).

IMPLEMENTATION STRATEGY

We have gained a great amount of insight in the Sheboygan River and harbor toxics problem over the years. Acquiring knowledge on toxic problems is an ongoing process, as is Remedial Action Planning. Thus, the RAP will be updated in order to monitor the status of ongoing work and refine remedial

action steps (Table X.1). WDNR staff will communicate with those involved in ongoing work. The Interagency Technical Advisory Group established for the Sheboygan RAP will convene meetings with those individuals or agencies to promote and obtain coordination of the various ongoing investigations.

The investigations outlined in this plan are scheduled to be completed by mid-1991 (Table X.1). At that time, the Sheboygan RAP update will specify the selected method of remediation along with a schedule of implementation. The update will also identify surveillance and monitoring needs for tracking the effectiveness of the remedial efforts.

Sheboygan has the opportunity for setting a precedent for the Great Lakes. We are encouraged by the public commitment to protecting and remediating the Sheboygan Area of Concern ecosystem and feel confident that the public will remain interested and active in the process.

Table X.1 Remedial Action Plan Recommendations: Implementation Responsibilities, Costs, and Schedule

Goals and Remedial Actions	Responsible Entity*	Cost (Thousand $)	Funding Source (Potential)	Target Date
I. PROTECT THE ECOSYSTEM FROM THE ADVERSE EFFECTS OF TOXIC SUBSTANCES				
A. Clean Up In-Place Pollutants				
1. Determine site-specific sediment criteria				
a. Perform congener specific PCB analysis	UW & WDNR	200	WI Coastal Mgt. & WI Sea Grant	Oct. 88-91
b. Perform furan analysis	WDNR	10	WDNR	1989-91
c. Conduct sediment & in-situ biomonitoring	USEPA & WDNR	85	WQA Great Lakes Demo	1990-91
2. Complete RI/FS* for Sheb. River & Harbor	Tecumseh Prod & USEPA	1000+	Tecumseh Prod.	1988-91
3. Implement superfund remediation	All Responsible Parties	Undetermined	All responsible parties	1991-?
4. Establish in-place pollutant mgt. prog.	WDNR & USEPA	240	Undetermined	1990
5. Apply in-place pollutant mgt. program	WDNR, USEPA, Local Mun.	Undetermined	Undetermined	1991
B. Control Toxic Sources				
1. Identify & reduce point sources	WPDES permittees & WDNR	25	WPDES	1993
2. Identify & reduce nps sources	Sheboygan Co., Mun. & WDNR	6000	WDNR-Cost Share	1997
3. Complete RI Kohler Co. Landfill	Kohler Co. & USEPA	Unknown	Kohler Co. & USEPA	1990
4. Prevent fertilizer & pesticide spills	WDATCP & C. Reiss Co.	Will vary per spill	Responsible Parties	ongoing
C. Monitor to Evaluate Restoration				
1. Monitor contaminated levels in wildlife	WDNR	3 annually	WDNR	ongoing
2. Monitor contaminated levels in fish	WDNR	7 annually	WDNR	ongoing
3. Conduct toxicity testing of aquatic life				
a. Conduct WDPES permit biomonitoring	WPDES permittees & WDNR	1.5/test	Permit Holder	ongoing
b. Conduct in-situ assessments of biota	WDNR	20	WDNR	After implementation is complete
II. MAINTAIN & ENHANCE A DIVERSE COMMUNITY OF AQUATIC & TERRESTRIAL LIFE				
A. Protect Wetlands	Municipalities, USACOE, WDNR	None	–	ongoing
B. Adoption & Implementation of SSA Plan	Bay-Lakes RPC, Municipalities	30	Federal	1990
C. Protect Navigable Waterways	Project sponsors, WDNR	None	–	ongoing

Table X.1 Remedial Action Plan Recommendations: (con't)

Goals and Remedial Actions	Responsible Entity*	Cost (Thousand $)	Funding Source (Potential)	Target Date
II. D. Reduce Sedimentation				
1. Continue and strengthen USDA programs	Sheb. Co., USDA	None	–	ongoing
2. Implement priority watershed NPS control	Sheb. Co., WDNR	6000	WI Fund	2000
3. Seek compliance with Act 297	WDNR, DATCP	Will vary	Responsible parties, state	as necessary
E. Manage Dams to Minimize Adverse Env. Effects	Owners, WDNR	2.5/DAM	Owners, WDNR	Upon request
F. Reinstate Fish Stocking when PCB Levels Reduced	WDNR	40 annually	WDNR	upon clean-up
G. Consider Fish Egg Collection Facility	WDNR	250	WDNR	upon clean-up
III. CONTROL EUTROPHICATION FOR PROTECTION OF LAKE MICHIGAN				
A. Reduce Phosphorus	State, WPDES permittees	Will vary	WPDES permittee	ongoing
B. Implement Intensive NPS Control Program in Watersheds	Sheb. Co., WDNR	6000	WI Fund	2000
IV. ENHANCE RECREATIONAL USES				
A. Reduce Bacterial Sources				
1. Conduct bacteria survey	WDNR	3	WDNR	1991
2. Revise WPDES permits	WDNR, Mun. permittees	None	--	1995
3. Manage animal waste	WDNR, ASCS, Sheb. Co., DATCP	Unknown	Federal and State	ongoing
4. Correct malfunctioning private waste disposal systems	WDILHR, Sheb. Co.	Unknown	Private landowner	ongoing
B. Ensure Adequate Public Access & Facilities	Municipals, USACOE, WDNR	17,000	Private/county funds	2000
V. CONTINUE PUBLIC PARTICIPATION EFFORTS THROUGH PLANNING & IMPLEMENTATION				
A. Continue Public Participation in Planning				
1. Continue Superfund Project	USEPA, WDNR	Unknown	Responsible parties	2000
2. Continue priority watershed projects	Sheb. Co., UWEX, WDNR	2000	WI Fund	1997
3. Continue Sheboygan R. basin WQ plan	WDNR	Existing Program	--	ongoing
4. Continue sewer service area plan	Bay Lakes RPC	No new costs	--	ongoing
5. Continue Sheboygan remedial action plan	Sheb. Co. W.Q.T.F., WDNR	2 annually	Various grants	ongoing
B. Include Citizen Involvement Implementation	Sheb. Co. W.Q.T.F., WDNR	2 annually	Various grants	ongoing
C. Evaluate Need for Increasing Awareness of Consumption Advisories	WDNR, UW	1	Sea Grant	1990

Table X.1 Remedial Action Plan Recommendations: (con't)

*Abbreviations

Mun.	= Municipalities (Village of Kohler, Cities of Sheboygan & Sheboygan Falls
UW	= University of Wisconsin
WPDES	= Wis. Pollutant Discharge Elimination System Permit (issued to waste water dischargers)
WDNR	= Wisconsin Department of Natural Resources
USEPA	= U.S. Environmental Protection Agency
WDATCP	= WI Dept. of Agriculture, Trade & Consumer Protection
RI/FS	= Remedial Investigation/Feasibility Study
RPC	= Regional Planning Commission
USACOE	= U.S. Army Corps of Engineers
USDA	= U.S. Dept. of Agriculture
NPS	= Nonpoint Source
PCB	= Polychlorinated Biphenyls

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XII. GLOSSARY FOR TERMS AND ABBREVIATIONS FOUND IN THIS PLAN

Abbreviations

208 plans: See Areawide Water Quality Management Plans.

ACP: See Agricultural Conservation Program.

AOC: See Area of Concern.

ASCS: Agricultural Stabilization Conservation Service of the U.S. Department of Agriculture.

BACT: Best Available Control Technology.

BCT: Best Conventional Technology.

BMP: See Best Management Practice.

BOD: See Biochemical Oxygen Demand.

BPT: Best Practicable Technology.

CDF: See Confined Disposal Facility.

COE: United States Army Corps of Engineers.

CFS: Cubic Feet Per Second.

CSO: Combined Sewer Overflow.

DO: See Dissolved Oxygen.

EPA: U.S. Environmental Protection Agency.

GLFC: Great Lakes Fishery Commission.

IJC: See International Joint Commission.

LC_{50}: Lethal concentration for 50% of the test population exposed to a toxicant substance.

LCCs: Land Conservation Committees (of county boards).

LD_{50}: Lethal dose for 50% of the test population exposed to a toxicant substance.

MGD: Million of Gallons Per Day; a measurement of water flow.

mg/L:	Milligrams Per Liter; a unit of measure of concentration generally equivalent to parts per million.
ng/L	Nanogram Per Liter; a unit of measures of concentration generally equivalent to parts per trillion (ppt).
NO_2:	Nitrogen Dioxide.
NOAA:	National Oceanic and Atmospheric Administration.
NPDES:	National Pollution Discharge Elimination System.
O&M:	Operation and Maintenance.
PAHs:	See Polyaromatic Hydrocarbons.
PCBs:	See Polychlorinated Biphenyls.
POTW:	See publicly owned treatment works.
PPM:	Parts Per Million; a unit of measure of concentration.
RAP:	See Remedial Action Plan.
RI/FS:	See Remedial Investigation/Feasibility Study
RPCs:	Regional Planning Commissions.
RCRA:	See Resource Conservation and Recovery Act of 1976.
SCS:	Soil Conservation Service of the United States Department of Agriculture.
SO_2:	Sulfur Dioxide.
SS:	See Suspended Solids.
TSCA:	Toxic Substances Control Act.
ug/L:	Microgram Per Liter; a unit of measure of concentration generally equivalent to parts per billion (ppb).
USDA:	United States Department of Agriculture.
USEPA:	United States Environmental Protection Agency.
USFWS:	United State Fish and Wildlife Service, U. S. Department of Interior.
USGS:	United States Geological Survey.
USLE:	Universal Soil Loss Equation.
USGB:	University of Wisconsin - Green Bay.

UWEX:	See University of Wisconsin Extension.
VOC:	Volatile Organic Compounds.
WDATCP:	Wisconsin Department of Agriculture, Trade and Consumer Protection.
WDHSS:	Wisconsin Department of Health and Social Services.
WDILHR:	Wisconsin Department of Industry, Labor and Human Relations.
WDNR:	Wisconsin Department of Natural Resources.
WDOA:	Wisconsin Department of Administration.
WDOD:	Wisconsin Department of Development.
WDOT:	Wisconsin Department of Transportation.
WGNHS:	Wisconsin Geologic and Natural History Survey.
WLA:	See Wasteload Allocation.
WPDES:	See Wisconsin Pollution Discharge Elimination System.
WSLH:	Wisconsin State Laboratory of Hygiene.
WWTP:	Wastewater Treatment Plant.

Glossary

ACUTE TOXICITY:
Any poisonous effect produced by a single short-term exposure to a chemical that results in a rapid onset of severe symptoms.

ADDITIVITY:
The characteristic property of a mixture of toxicants that exhibit a cumulative toxic effect equal to the arithmetic sum of the individual toxicants.

ADVANCED WASTEWATER TREATMENT:
The highest level of wastewater treatment for municipal treatment systems. It requires removal of all but 10 parts per million of suspended solids and biological oxygen and/or 50% of the total nitrogen. Advanced wastewater treatment is also known as "tertiary treatment."

AGRICULTURAL CONSERVATION PROGRAM (ACP):
A federal cost-sharing program to help landowners install measures to conserve soil and water resources. ACP is administered by the USDA ASCS through county ACP committees.

AIR POLLUTION:
Contamination of the atmosphere by human activities.

ALGAE:
A group of microscopic, photosynthetic water plants. Algae give off oxygen during the day as a product of photosynthesis and consume oxygen during the night as a result of respiration. Thus algae effect the oxygen content of water. Nutrient-enriched water increases algae growth.

AMMONIA:
A form of nitrogen (NH_3) found in human and animal wastes. Excess ammonia can be toxic to aquatic life.

ANAEROBIC:
Without oxygen.

AREA OF CONCERN:
Areas of the Great Lakes identified by the International Joint Commission (IJC) as having serious water pollution problems.

AREAWIDE WATER QUALITY MANAGEMENT PLANS (208 PLANS):
A plan to document water quality conditions in a drainage basin and make recommendations to protect and improve basin water quality. Each basin in Wisconsin must have a plan prepared for it, according to section 208 of the Clean Water Act.

ANTIDEGRADATION:
A policy which states that water quality will not be lowered below background levels unless justified by economic and social development considerations. Wisconsin's antidegradation policy is currently being revised to make it more specific and meet EPA guidelines.

ASSIMILATIVE CAPACITY:
The ability of a water body to carry a load of pollutants before its water quality decreases to a minimum set level.

AVAILABILITY:
The degree to which toxic substances or other pollutants that are present in sediments or elsewhere in the ecosystem are available to affect or be taken up by organisms. Some pollutants may be "bound up" or unavailable because they are attached to clay particles or are buried by sediment. The amount of oxygen, pH, temperature and other conditions in the water may affect availability.

BACTERIA:
Single-cell, microscopic organisms. Some can cause disease, and some are important in the stabilization of organic wastes.

BASIN PLAN:
See "Areawide Water Quality Management Plan".

BENTHIC ORGANISMS (BENTHOS):
The organisms living in or on the bottom of a lake or stream.

BEST MANAGEMENT PRACTICE (BMP):
The most effective, practical measures to control nonpoint sources of pollutants that runoff from land surfaces.

BIOACCUMULATION:
The uptake and retention of substances by an organism from its surrounding medium and from its food. Oil soluble chemicals move through the food chain and tend to end up at higher concentrations in organisms at the upper end of the food chain such as predator fish, or in people or birds that eat these fish.

BIOASSAY STUDY:
A test for pollutant toxicity. Tanks of fish or other organisms are exposed to varying doses of treatment plant effluent; or specific pollutants. Lethal doses of pollutants or effluent are thus determined.

BIOCHEMICAL OXYGEN DEMAND (BOD):
A measure of the amount of oxygen consumed in the biological processes that break down organic matter in water. BOD_5 is the biochemical oxygen demand measured in a five day test. The greater the degree of pollution by biodegradable matter, the higher the BOD_5.

BIODEGRADABLE:
Waste which can be broken down by bacteria into basic elements. Most organic wastes such as food remains and paper are biodegradable.

BIOTA:
All living organisms that exist in an area.

BUFFER STRIPS:
Strips of grass or other erosion-resisting vegetation between disturbed areas and a stream or lake.

BULKHEAD LINES:
Legally established lines which indicate how far into a stream or lake an adjacent property owner has the right to fill. Many of these lines were established many years ago and allow substantial filling of the bed of the River and Bay. Other environmental laws may limit filling to some degree.

CARCINOGENIC:
A chemical capable of causing cancer.

CATEGORICAL LIMITS:
All point source discharges are required to provide a basic level of treatment. For municipal wastewater treatment plants this is secondary treatment (30 mg/l effluent limits for SS and BOD). For industry the level is dependent on the type of industry and the level of production. More stringent effluent limits are required, if necessary to meet water quality standards.

CHLORINATION:
The application of chlorine to wastewater to disinfect it by killing bacteria and other organisms.

CHLORORGANIC COMPOUNDS (CHLORORGANICS):
A class of chemicals of which the molecular structure contains chlorine, carbon and hydrogen atoms. Commonly refers to toxic persistent pesticides and herbicides. Examples include PCBs and pesticides such as DDT and dieldrin.

CHLOROPHYLL-A:
A green pigment in plants used as an indicator of plant and algae productivity.

CHRONIC TOXICITY:
The effects of long-term exposure of organisms to concentrations of a toxic chemical that is injurious or debilitating to an organism in non-lethal ways. An example of the effect of chronic toxicity could be reduced reproductive success.

CLEAN WATER ACT:
See "Public Law 92-500."

COMBINED SEWERS:
A wastewater collection system that carries both sanitary sewage and stormwater runoff. During dry weather, combined sewers carry only wastewater to the treatment plant; during heavy rainfall, the sewer becomes swollen with stormwater. Because the treatment plant cannot process the excess flow, untreated sewage is discharged to the plant's receiving waters, i.e., combined sewer outflow.

CONFINED DISPOSAL FACILITY (CDF):
A structure built for the containment of disposed dredged material.

CONGENERS:
A class or family of chemical compounds that have the same "core" molecular structure, but whose individual members differ from each other in the number and position of substituent atoms. For example, the congeners of PCBs differ by having different numbers of chlorine atoms on the biphenyl molecule as well as by the chlorine atoms located in different positions on the biphenyl molecule.

CONSERVATION TILLAGE:
Planting row crops while disturbing the soil only slightly. In this way a protective layer of plant residue stays in the surface; erosion is decreased.

CONSUMPTION ADVISORY:
A health warning issued by WDNR and WDHSS that recommends that people limit the fish they eat from specified rivers and lakes based on the levels of toxic contaminants found in the fish.

CONTAMINANT:
Some substance that has been added to water that is not normally present. This is different from a pollutant, as a pollutant suggests that there is too much of the substance present.

CONVENTIONAL POLLUTANTS:
Refers to suspended solids, fecal coliforms, biochemical oxygen demand, and pH, as opposed to toxic pollutants.

COST-EFFECTIVE:
A level of treatment or management with the greatest incremental benefit for the money spent.

CRITERIA:
See water quality standard criteria.

DDT:
A chlorinated hydrocarbon insecticide that has been banned because of its persistence in the environment.

DIOXIN (2,3,7,8-tetrachlorodibenzo-p-dioxin):
A chlorinated organic chemical which is highly toxic and produced as a by-product of the manufacture of certain herbicides.

DISINFECTION:
A chemical or physical process that kills organism that cause disease. Chlorine is often used to disinfect wastewater.

DISSOLVED OXYGEN (DO):
Oxygen dissolved in water. Low levels of dissolved oxygen threaten fish survival and are often due to inadequate wastewater treatment. The Department of Natural Resources considers 5 ppm DO necessary for fish and aquatic life.

DREDGING:
Removal of sediment from the bottom of water bodies.

ECOSYSTEM:
The interacting system of a biological community and its environment which functions as a unit.

EFFLUENT:
Solid, liquid or gas wastes (byproducts) which are disposed on land, in water or in air. As used in the RAP generally means wastewater discharges.

EFFLUENT LIMITS:
The Department of Natural Resources issues WPDES permits that establish the maximum amount of pollutant that can be discharged to a receiving stream. Limits depend on the pollutant involved and the water quality standards that apply for the receiving waters.

EMISSION:
A direct (smokestack particles) or indirect (busy shopping center parking lot) release of any contaminant into the air.

ENVIRONMENTAL PROTECTION AGENCY (USEPA):
The primary federal agency responsible for enforcing federal environmental regulations. The Environmental Protection Agency delegates some of its responsibilities for water, air and solid waste pollution control to state agencies.

ENVIRONMENTAL REPAIR FUND:
A fund established by the Wisconsin Legislature to deal with abandoned landfills.

EPIDEMIOLOGY:
The study of diseases as they affect populations rather than individuals, including the distribution and incidence of a disease, mortality and morbidity rates, and the relationship of climate, age, sex, race and other factors. EPA uses such data to establish national air quality standards.

EROSION:
The wearing away of the land surface by wind or water.

EUTROPHIC:
Refers to a nutrient-rich lake. Large amounts of algae and weeds characterize a eutrophic lake (see also "Oligotrophic" and "Mesotrophic").

EUTROPHICATION:
The process of nutrient enrichment of a lake loading to increased production of aquatic organisms. Eutrophication can be accelerated by human activity such as agriculture and improper waste disposal.

FACILITY PLAN:
A preliminary planning and engineering document that identifies alternative solutions to a community's wastewater treatment problems.

FECAL COLIFORM:
A group of bacteria used to indicate the presence of other bacteria that cause disease. The number of coliform is particularly important when water is used for drinking and swimming.

FISHABLE AND SWIMMABLE:
Refers to the water quality goal set for the nation's surface waters by Congress in the Clean Water Act. All waters were to meet this goal by 1984.

FLUORANTHENE:
A specific polyaromatic hydrocarbon (PAH) with toxic properties.

FLY ASH:
Particulates emitted from coal burning and other combustion, such as wood burning, and exited into the air from stacks, or more likely, collected by electrostatic precipitators.

FOOD CHAIN:
A sequence of organisms in which each uses the next as a food source.

FURANS (2,3,7,8-tetra-chloro-dibenzofurans):
A chlorinated organic compound which is highly toxic and produced as a by-product of PCB manufacture.

GREEN STRIPS:
See buffer strip.

GROUNDWATER:
Underground water-bearing areas generally within the boundaries of a watershed, which fill internal passageways of porous geologic formations (aquifers) with water which flows in response to gravity and pressure. Often used as the source of water for communities and industries.

HABITAT:
The place or type of site where a plant or animal naturally lives and grows.

HEAVY METALS:
Metals present in municipal and industrial wastes that pose long-term environmental hazards if not properly disposed. Heavy metals may contaminate ground and surface waters, fish and other food stuffs. The metals of most concern are: arsenic, barium, cadmium, chromium, copper, lead, mercury, selenium and zinc (see also separate listings of these metals for their health effects).

HERBICIDE:
A type of pesticide that is specifically designed to kill plants and can also be toxic to other organisms.

HYDROCARBONS:
Any of a large class of chemicals containing carbon and hydrogen in a virtually infinite number of combinations.

INCINERATOR:
A furnace designed to burn wastes.

INFLUENT:
Influent for an industry would be the river water that the plant intakes for use in its processing. Influent to a municipal treatment plant is untreated wastewater.

IN-PLACE POLLUTION:
As used in the RAP refers to pollution from contaminated sediments. These sediments are polluted from past discharges from municipal and industrial sources.

INTERNATIONAL JOINT COMMISSION (IJC):
An agency formed by the United States and Canada to guide management of the Great Lakes and resolve border issues.

ISOROPYLBIPHENYL:
A chemical compound used as a substitute for PCB.

LANDFILL:
A conventional sanitary landfill is "a land disposal site employing an engineered method of disposing of solid wastes on land in a manner that minimizes environmental hazards by spreading solid wastes in thin layers, compacting the wastes to the smallest practical volume, and applying cover materials at the end of each operating day." Hazardous wastes frequently require various types of pretreatment before they are disposed of, i.e., neutralization chemical fixation, encapsulation. Neutralizing and disposing of wastes should be considered a last resort. Repurifying and reusing waste materials or recycling them for another use may be less costly.

LC_{50}:
Lethal concentration for 50% of the test population exposed to a toxicant substance.

LD_{50}:
Lethal dose for 50% of the test population exposed to a toxicant substance.

LEACHATE:
The contaminated liquid which seeps from a pile or cell of solid materials and which contains water, dissolved and decomposing solids. Leachate may enter the groundwater and contaminate or inking water supplies.

LOAD:
The total amount of materials or pollutants reaching a given locality.

MACROPHYTE:
A rooted aquatic plant.

MASS:
The amount of material a substance contains as measured by its weight (in a gravitational field).

MASS BALANCE:
A study that examines all parts of an ecosystem to determine the amount of toxic or other pollutant present, its sources, and the processes by which the chemical moves through the ecosystem.

MESOTROPHIC:
Refers to a moderately fertile nutrient level of a lake between the oligotrophic and eutrophic levels. (See also "Eutrophic" and "Oligotrophic.")

MILLIGRAMS PER LITER (mg/l):
A measure of the concentration of substance in water. For most pollution measurement this is the equivalent to "parts per million".

MILLIGRAMS PER KILOGRAM (mg/kg):
Concentration of a substance in solids such as sediment. Equivalent to "parts per million".

MITIGATION:
The effort to lessen the damages caused, by modifying a project, providing alternatives, compensating for losses, or replacing lost values.

MIXING ZONE:
The portion of a stream or lake in which effluent is allowed to mix with the receiving water. The size of the area depends on the volume and flow of the discharge and receiving water.

NONPOINT SOURCE POLLUTION (NPS):
Pollution whose sources cannot be traced to a single point such as a municipal or industrial wastewater treatment plant discharge pipe. Nonpoint sources include eroding farmland and construction sites, urban streets, and barnyards. Pollutants from these sources reach water bodies in runoff, which can best be controlled by proper land management.

NPS:
See nonpoint source pollution.

OLIGOTROPHIC:
Refers to a water body of low nutrient levels and biological productivity. Such lakes typically have very clear water. (See also "Eutrophic" and "Mesotrophic.")

OUTFALL:
The mouth of a sewer, drain, or pipe where effluent from a wastewater treatment plant is discharged.

PATHOGEN:
Any infective agent capable of producing disease; may be a virus, bacterium, protozoan, etc.

PELAGIC:
Referring to open water portion of a lake.

PESTICIDE:
Any chemical agent used for control of specific organisms, such as insecticides, herbicides, fungicides, etc.

pH:
A measure of acidity or alkalinity, measured on a scale of 0 to 14 with 7 being neutral and 0 being most acid, and 14 most alkaline.

PHENOLS:
Organic compounds that are the byproducts of petroleum refining, textile, dye, and resin manufacture. Low concentrations can cause taste and odor problems in fish. Higher concentration can be toxic to fish and aquatic life.

PHOSPHORUS:
A nutrient that, in excess amounts, can lead to over fertile conditions and algae blooms in water bodies.

PLANKTON:
Tiny aquatic plants and animals.

POINT SOURCES:
Sources of pollution that have discrete discharges, usually from a pipe or outfall.

POLLUTION:
The presence of materials or energy whose nature, location, or quantity produces undesired environmental effects.

POLYCHLORINATED BIPHENYLS (PCBs):
A group of 209 compounds, PCBs have been manufactured since 1929 for such common uses as electrical insulation and heating/cooling equipment, because they resist wear and chemical breakdown. Although banned in 1979 because of their toxicity, they have been detected on air, land and water, and recent surveys have found PCBs in every section for the country, even those remote from PCB manufacturing and use.

POLYCHLORINATED ORGANIC COMPOUNDS:
A group of toxic chemicals which contains several chlorine atoms.

PRETREATMENT:
A partial wastewater treatment required from some industries. Pretreatment removes some types of industrial pollutants before the wastewater is discharged to a municipal wastewater treatment plant.

PRIORITY POLLUTANT:
A list of toxic chemicals identified by the USEPA because of their potential impact in the environment and human health. Major discharges are required to monitor for all or some of these chemicals when their WPDES permits are reissued.

PRIORITY WATERSHED:
A drainage area about 100,000 acres in size selected to receive Wisconsin Fund money to help pay the cost of controlling nonpoint source pollution.

Because money is limited, only watersheds where problems are critical, control is practical, and cooperation is likely are selected for funding.

PRODUCTIVITY:
A measure of the amount of living matter which is supported by an environment over a specific period of time. Often described in terms of algae production for a lake.

PUBLIC LAW 92-500 (CLEAN WATER ACT):
The federal law that set national policy for improving and protecting the quality of the nation's waters. The law set a timetable for the cleanup of the nation's waters and stated that they are to be fishable and swimmable. This also required all discharges of pollutants to obtain a permit and meet the conditions of the permit. To accomplish this pollution cleanup billions of dollars have been made available to help communities pay the cost of building sewage treatment facilities. Amendments in the Clean Water Act were made in 1977 by passage of Public Law 95-217, and in 1987.

PUBLIC PARTICIPATION:
The active involvement of interested and affected citizens in governmental decision-making.

PUBLICLY OWNED TREATMENT WORKS (POTW):
A wastewater treatment plan owned by a city, village or other unit of government.

RAP:
See Remedial Action Plan.

RECYCLING:
The process by which waste materials are transformed into new products.

REMEDIAL ACTION PLAN:
A plan designed to restore beneficial uses to a Great Lakes Area of Concern.

REMEDIAL INVESTIGATION/FEASIBILITY STUDY (RF/FS):
an investigation of problems and assessment of management options conducted as part of a superfund project.

RESOURCE CONSERVATION AND RECOVERY ACT OF 1976 (RCRA):
This federal law amends the Solid Waste Disposal Act of 1965 and expands on the Resource Recovery Act of 1970 to provide a program which regulates hazardous wastes, to eliminate open dumping and to promote solid waste management programs.

RIPRAP:
Broken rock, cobbles, or boulders placed on the bank of a stream to protect it against erosion by hydraulic forces.

RULE:
Refers to Wisconsin administrative rules. See Wisconsin Administrative Code.

RUNOFF:
Water from rain, snow melt, or irrigation that flows over the ground surface and returns to streams. Runoff can collect pollutants from air or land and carry them to receiving waters.

SECONDARY IMPACTS:
The indirect effects that an action can have on the health of the ecosystem or the economy.

SECONDARY TREATMENT:
Two-stage wastewater treatment that allows the coarse particles to settle out, as in primary treatment, followed by biological breakdowns of the remaining impurities. Secondary treatment commonly removes 90% of the impurities. Sometimes "secondary treatment" refers simply to the biological part of the treatment process.

SEDIMENT:
Soil particles suspended in and carried by water as a result of erosion. Sediment ultimately settles in the bottom of lakes, streams, and rivers.

SEICHES:
Changes in water levels due to the tipping of water in an elongated lake basin whereby water is raised in one end of the basin and lowered in the other as a result of being pushed by strong winds. Also known as "wind tide".

SEPTIC SYSTEM:
Sewage treatment and disposal for homes not connected to sewer lines. Usually the system includes a tank and drain field. Solids settle to the bottom of the tank; liquid percolates through the drain field.

SLUDGE:
A byproduct of wastewater treatment; waste solids mixed with water.

SOLID WASTE:
Unwanted or discharged material with insufficient liquid to be free flowing.

STANDARDS:
See water quality standards.

STORM SEWERS:
A system of sewers that collect and transport rain and snow runoff. In areas that have separated sewers, such stormwater is not mixed with sanitary sewage.

SUPERFUND:
A federal program which provides for cleanup of major hazardous landfills and land disposal areas.

SUSPENDED SOLIDS (SS):
Small particles of solid matter suspended in water. Cloudy or turbid water is due to the presence of suspended solids in the form of silt or

clay particles. These particles may carry pollutants adsorbed to the particle surfaces.

SYNERGISM:
The characteristic property of a mixture of toxicants that exhibits a greater-than-additive cumulative toxic effect.

TACS:
Technical advisory committees that assisted in the development of the Remedial Action Plan.

TERTIARY TREATMENT:
See advanced wastewater treatment.

TOP-DOWN MANAGEMENT:
A management theory that uses biomanipulation, specifically the stocking of predator species of fish to improve water quality.

TOTAL MAXIMUM DAILY LOADS:
The maximum amount of a pollutant that can be discharged into a stream without causing a violation of water quality standards.

TOXIC:
An adjective that describes a substance which is poisonous, or can kill or injure a person or plants and animals upon direct contact or long-term exposure. (Also, see toxic substance.)

TOXIC SUBSTANCE:
A chemical or mixture of chemicals which through sufficient exposure, or ingestion, inhalation of assimilation by an organism, either directly from the environment or indirectly by ingestion through the food chain, will, on the basis of available information cause death, disease, behavioral of immunologic abnormalities, cancer, genetic mutations, or development of physiological malfunctions, including malfunctions in reproduction or physical deformations, in organisms or their offspring.

TOXICANT:
See toxic substance.

TOXICITY:
The degree of danger posed by a toxic a substance to animal or plant life. Also see acute toxicity, chronic toxicity and additivity.

TOXICITY REDUCTION EVALUATION:
A requirement for a discharger that the causes of toxicity in an effluent be determined and measures taken to eliminate the toxicity. The measures may be treatment, product substitution, chemical use reduction or other actions that will achieve the desired result.

TREATMENT PLANT:
See wastewater treatment plant.

TROPHIC STATUS:
The level of growth or productivity of a lake as measured by phosphorus content, algae abundance, and depth of light penetration.

TURBIDITY:
Lack of water clarity. Turbidity is usually closely related to the amount of suspended solids in water.

UNIVERSITY OF WISCONSIN-EXTENSION (UWEX):
A special outreach, education branch of the state university system.

VARIANCE:
Government permission for a delay or exception in the application of a given law, ordinance or regulation. Also, see water quality standard variance.

VOLATILE:
Any substance that evaporates at a low temperature.

WASTELOAD ALLOCATION:
Division of the amount of waste a stream can assimilate among the various dischargers to a stream. Results in the limit on the amount (in pounds) of a chemical or biological constituent discharged from a wastewater treatment plant to a water body.

WASTEWATER:
Water that has become contaminated as a byproduct of some human activity. Wastewater includes sewage, washwater and the water-borne wastes of industrial processes.

WASTE:
Unwanted materials left over from manufacturing processes, refuse from places of human habitation or animal habitation.

WASTEWATER TREATMENT PLANT:
A facility for purifying wastewater. Modern wastewater treatment plants are capable of removing 95% of organic pollutants.

WATER QUALITY AGREEMENT:
The Great Lakes Water Quality agreement was initially signed by Canada and the United States in 1972 and was subsequently revised in 1978 and 1987. It proves guidance for the management of water quality, specifically phosphorus and toxics, in the Great Lakes.

WATER QUALITY LIMITED SEGMENT:
A section of river where water quality standards will not be met if only categorical effluent standards are met.

WATER QUALITY CRITERIA:
A measure of the physical, chemical or biological characteristics of a water body necessary to protect and maintain different water uses (fish and aquatic life, swimming, etc.).

WATER QUALITY STANDARDS:
The legal basis and determination of the use of a water body and the water quality criteria, physical, chemical, or biological characteristics of a water body, that must be met to make it suitable for the specified use.

WATER QUALITY STANDARD VARIANCE:
When natural conditions of a water body preclude meeting all conditions necessary to maintain full fish and aquatic life and swimming a variance may be granted.

WATERSHED:
The land area that drains into a lake or river.

WETLANDS:
Those areas that are inundates or saturated by surface or groundwater at a frequency and duration sufficient to support a variety of vegetative or aquatic life. Wetland vegetation requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally, include swamps, marshes, bogs and similar areas.

WISCONSIN ADMINISTRATIVE CODE:
The set of rules written and used by state agencies to implement state statutes. Administrative codes are subject to public hearing and have the force of law.

WISCONSIN FUND:
A state program that helps pay the cost of reducing water pollution. Funding for the program comes from general revenues and bonds and is based on a percentage of the state's taxable property value. The Wisconsin Fund includes these programs:

Point Source Water Pollution Abatement Grant Program - Provides loans for the cost of constructing wastewater treatment facilities. Most of this program's money goes for treatment plant construction, but 3% of this fund is available for repair or replacement of private, onsite sewer systems.

Nonpoint Source Water Pollution Abatement Grant Program - Funds to share the cost of reducing water pollution nonspecified sources are available in selected priority watersheds.

Solid Waste Grant Program - Communities planning for solid waste disposal sites are eligible for grant money. $500,000 will be available each year to help with planning costs.

WISCONSIN NONPOINT SOURCE WATER POLLUTION ABATEMENT GRANT PROGRAM:
A state cost-share program established by the State Legislature in 1978 to help pay the costs of controlling nonpoint source pollution. Also known as the nonpoint source element of the Wisconsin Fund or the Priority Watershed Program.

WISCONSIN POLLUTANT DISCHARGE ELIMINATION SYSTEM (WPDES):
A permit system to monitor and control the point source dischargers of wastewater in Wisconsin. Dischargers are required to have a discharge permit and meet the conditions it specifies.

ZOOPLANKTON:
Minute free-floating or weakly swimming aquatic animals. They form an important food supply for larger aquatic animals.