Lower Menominee River Remedial Action Plan

A Water Quality Restoration and Protection Plan

Page 6 - Cross out the words "the TAC" in the last sentence

Page 42 - Add the word "restrictions" after Total and partial body contact

Page 46 - Second paragraph, first sentence add the words "may not" after the word "there".

- Last paragraph has been changed to note that Wisconsin does issue a separate fish consumption advisory for mercury for part of the AOC.

Page 48 - The detection of dioxin in the carp fillet (09/26/85) should be 17.0 (ppt) instead of 1.7 (ppt).

Page 53 - In the second to the last sentence on this page replace the word "bioconcentrate" with the word "biomagnify".

Page 58 Description of fish tumor study is inaccurate, See Updates - Stage One Report in the next section.

Page 74 Second paragraph under Wildlife - The results of contaminant monitoring in waterfowl were not included as Appendix IV.5, see Updates - Stage One Report, in the next section.

Page 76 The mean value for total phosphorous (Table IV.11) in the Upper Scott Flowage should be 0.03, not 0.3 as reported

Page 80 The mean value for total phosphorous (Table IV.12) at the Hattie Street Bridge should be 0.025, not 0.25 as reported.

Page 84 - Add the following sentence at the end of the paragraph under the heading Sediment Quality Assessment:

> "All sediment concentrations of in-place pollutants in the following section are on a dry weight basis unless otherwise note."

Page 85 Add the words "dry weight" to the end of the description of the Table IV.14.

Page 182 The word "convenient" in the first goal statement should be changed to "conventional".

Page 183 The first two words of objective number 15 (clean up) should be replaced with "remediate".

Elevated levels of fecal coliform bacteria have previously been detected inside the Menominee Marina. Recent monitoring indicates that the bacteria levels have been reduced to an acceptable level. (For additional information: Updates - Stage One Report, next section.)

Violations of the Clean Water Act. A settlement was reached between the Menominee Paper Company and the U.S. Environmental Protection Agency (EPA) in 1989 concerning violations of the federal Clean Water Act. Past discharges from the Menominee Paper Company have caused disruptions in the City's Wastewater Treatment Plant. The company has since installed a wastewater treatment system and no longer discharges to the city's facility.

The city of Menominee has upgraded its wastewater treatment plant and is implementing a combined sewer overflow correction program.

The city of Marinette has also completed wastewater treatment plant renovations including the elimination of sewer by-passing from the city's combined sewer system. (For additional information: Updates in the next section.)

Advisory Committees. The RAP is being developed with a Citizen's Advisory Committee and a Technical Advisory Committee. The Citizen's Advisory Committee is made up of citizens, government officials, environmentalists, business and industry representatives from Marinette, WI and Menominee, MI. Community education and outreach activities will continue through the completion and implementation of the RAP. Three subcommittees (sediment, water, biota) are assisting the Technical Advisory Committee with development of stage two recommendations.

CORRECTIONS

The following corrections have been incorporated into the stage one report of the Lower Menominee River Remedial Action Plan dated September 1990.

Page 1 - under "Impaired uses identified in Stage I of the plan (Chapter IV) after "total and partial body contact" add the word "restrictions".

- under "loss of fish and wildlife habitat" delete "and wildlife"

- In the next paragraph, starting with, "Both conventional..." add the words "in-place pollutants (contaminated sediments)" after the word "spills," and before the word "and".

Page 2 - Last paragraph cross out the word "September". Also add the words "the impaired beneficial uses" in between the words "restore" and "and" on the same page.

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Carroll D. Besadny
Secretary

BOX 7921
MADISON, WISCONSIN 53707

October 16, 1990

File Ref:

To the Citizens of the Lower Menominee River Area:

I am pleased to submit the stage one report for the Lower Menominee River Remedial Action Plan on behalf of the Wisconsin Department of Natural Resources in conjunction with the Michigan Department of Natural Resources. The plan is an important contribution to the effort of restoring and protecting the ecosystem of this Great Lakes Area of Concern.

The Lower Menominee River is one Wisconsin's five Areas of Concern, one of 13 in Lake Michigan and one of 42 in the Great Lakes targeted for clean-up by the International Joint Commission. These plans represent a long range, comprehensive and community based effort in the United States and Canada to protect one of the world's greatest resources.

Impaired uses in this Area of Concern identified in the stage one report include: navigational dredging restrictions, degradation of benthos (bottom dwelling organisms), fish consumption restrictions, loss of fish and wildlife habitat, total and partial body contact restrictions and degradation of fish populations. Sources of pollution or other problems include hazardous waste storage and disposal, filling of wetlands, inadequate municipal wastewater collection and treatment and inadequate industrial wastewater treatment.

The Lower Menominee River Remedial Action Plan stage one report is a recognition of the importance of water resources to the environment, communities and regional economy for present and future generations. The stage one report has been developed cooperatively by area residents on the Citizen's Advisory Committee and by local, state and federal experts serving on the Technical Advisory Committee. Continued community participation in the implementation of this plan is critical to its success.

Special thanks goes to the Michigan Department of Natural Resources and the residents of Marinette and Menominee for their assistance and participation in this important process.

Should you have any questions on this report, please contact Mr. Terry Lohr at 608-267-2375.

Sincerely,

CD Besadny

C.D. Besadny
Secretary

THE LOWER MENOMINEE RIVER REMEDIAL ACTION PLAN

STAGE ONE REPORT

WISCONSIN DEPARTMENT OF NATURAL RESOURCES
MADISON, WI

MICHIGAN DEPARTMENT OF NATURAL RESOURCES
LANSING, MI

SEPTEMBER 1990

PUBL WR-246 90

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NOTE: Appendices printed separately, available on request.

ACKNOWLEDGEMENTS

Many people have contributed information and comments in the development of the Lower Menominee River Remedial Action Plan Stage One Report. Special thanks go to the Technical and Citizens' Advisory Committees for their input into this plan. Special thanks are also extended to the WDNR second floor word processing staff for typing this document.

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I. SUMMARY

Pollutants are a major problem in Great Lakes' urban and industrial areas. While much progress has been made in the last 25 years in controlling conventional pollutants with wastewater treatment plants, toxic pollutants are still a serious problem in the Great Lakes.

The Lower Menominee River is one of 42 areas of concern identified by the United States and Canadian International Joint Commission where a water quality restoration and protection plan is being developed. Remedial Action Plans are being developed to address water quality in the areas of concern and are included as part of the Great Lakes Water Quality Agreement.

A primary reason the Menominee River was cited as an area of concern by the International Joint Commission is because of arsenic contamination in the turning basin portion of the river (Figure III.2). Other pollutants besides arsenic (e.g. mercury) have resulted in impaired water uses in the area of concern. In addition, significant changes in land use over the last century have also contributed to impaired uses in the Lower Menominee River.

Impaired uses identified in Stage I of the plan (Chapter IV) include:

- restrictions on fish consumption
- degradation of fish populations
- degradation of benthos (bottom dwelling organisms)
- restrictions on dredging activities
- total and partial body contact
- loss of fish and wildlife habitat

Both conventional and toxic pollutants are present within the area of concern. Pollution sources include municipal wastewater treatment plants and sewage collection systems, industrial discharges and spills, and urban storm water runoff.

Building upon a broad information base from regulatory agencies, industries, and citizens, the remedial action plan process has used an "ecosystem approach" to analyze pollution sources and problems affecting the river and bay. Stage I of the plan is the result of that analysis and work to identify impaired water uses in the area of concern.

A desired future state or vision for the Lower Menominee River area of concern has been developed by the Citizen's Advisory Committee (Chapter VIII). The desired future state for the area of concern includes enhancement of environmental conditions to restore the beneficial uses of the area of concern while maintaining a healthy economy for the Cities of Marinette, WI and Menominee, MI.

Goals and objectives to guide the planning process were developed by the Citizen's Advisory and the Technical Advisory Committees (Chapter VIII). To meet these goals and objectives will require cooperative participation from citizens, the private sector and from local, state and federal government.

Stage II of the Remedial Action Plan, scheduled to be completed in September 1991, will include recommendations to restore and protect water quality in the area of concern.

II. INTRODUCTION

Background

The Wisconsin Department of Natural Resources (WDNR), with assistance from the Michigan Department of Natural Resources (MDNR), and in conjunction with the International Joint Commission (IJC) and the United States Environmental Protection Agency (U.S. EPA), has targeted the Lower Menominee River and Harbor and nearshore Green Bay as an Area of Concern (AOC) for remedial action (Figure II.1). Through the IJC, Canada and the United States cooperatively address problems associated with the Great Lakes.

The Great Lakes Water Quality Agreement as amended on November 18, 1987, defines an "Area of Concern" as "...a geographic area that fails to meet the General or Specific Objectives of the Agreement where such failure has caused or is likely to cause impairment of beneficial use or of the area's ability to support aquatic life." Areas of concern typically include major urban and industrial centers on Great Lakes rivers, harbors and connecting channels where pollution from a variety of sources, development of shoreline areas, and other ecosystem impacts have impaired beneficial uses. Of major concern in these areas is contamination by toxic substances. The Menominee River is one of the 42 Great Lakes AOCs.

The Remedial Action Plan (RAP) is one of several efforts underway to correct water quality problems in the Menominee Harbor area. The U.S. EPA and Ansul Fire Protection Company are in the process of negotiating a Consent Order pursuant to Section 3008(h) of the Resource Conservation and Recovery Act (RCRA) as amended by the Hazardous and Solid Waste Amendments of 1984. The Consent Order will require the Ansul Fire Protection Company to develop and implement a RCRA Facility Investigation (RFI), a Corrective Measure Study (CMS) and possibly a corrective action plan to address an arsenic contamination site. Michigan DNR is initiating assessment and cleanup plans for paint sludges which were deposited near the Lloyd/Flanders Furniture Company on the shore of Green Bay. This site is on the Michigan Act 307 priority list for state cleanup activities. Michigan DNR is involved in enforcement procedures with the City of Menominee over city landfill contamination of groundwater. The City of Menominee is also subject to a U.S. EPA consent order to upgrade its wastewater treatment plant (WWTP) and to implement a combined sewer overflow correction program. The Menominee WWTP upgrade requirements have been completed and the monitoring data have shown permit compliance (See Chapter VI). The City of Marinette is also upgrading its sewer system to eliminate bypassing of untreated wastewater and improve the treatment process. Menominee Paper Company has completed negotiations with U.S. EPA over violations of the Clean Water Act stemming from past inadequate wastewater treatment and has agreed to pay a $2.1 million civil fine. Menominee Paper completed expansion of its WWTP in July, 1989. Cleanup of coal tar residues discovered during excavation for the expanded City of Marinette WWTP is being addressed by the City and WDNR. Renewal of several industrial and municipal wastewater discharge (NPDES, WPDES) permits is also

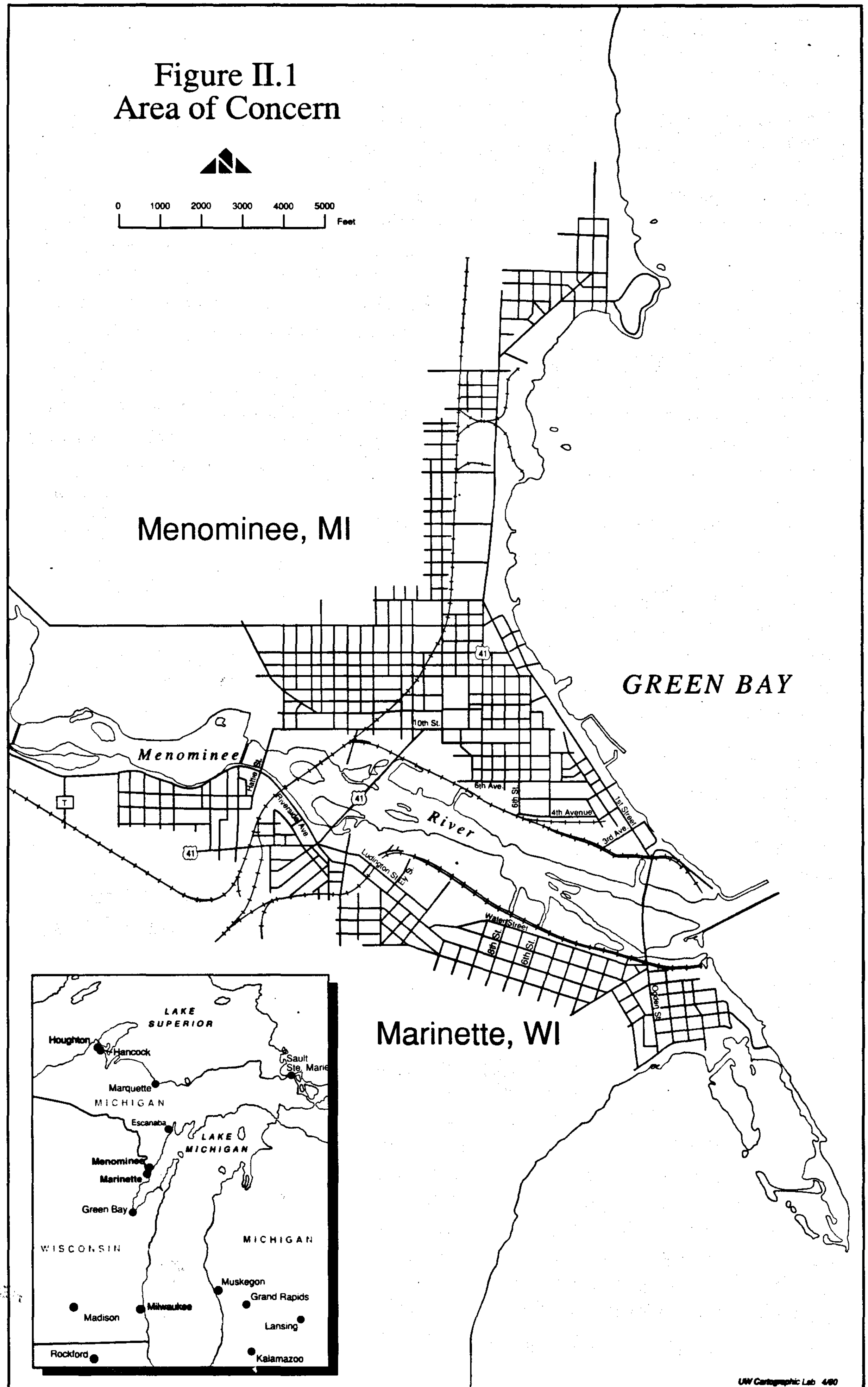

Figure II.1
Area of Concern

ongoing. Further details on these activities can be found in Chapter V Sources of Pollution and Chapter VII Historical Record of Management Actions.

The AOC has also been included in the study area for five resource management plans. The City of Marinette has recently completed a Strategic Harbor Plan, outlining proposed land use along the Wisconsin side of the riverfront. The Menominee River Basin Water Quality Study being developed by the U.S. Department of Agriculture, the U.S. Soil Conservation Service, and U.S. Forest Service will describe environmental problems and recommend actions on both the Michigan and Wisconsin sides of the river for the entire Menominee River Basin. The Green Bay Mass Balance Study (GBMBS) will also provide information on the Menominee River. The GBMBS will assess the loadings and fates of polychlorinated biphenyls (PCB), dieldrin, lead, and cadmium to Green Bay from the Menominee River as well as all other sources. This study is a joint effort of several agencies including U.S. EPA, U.S. Geological Survey, National Oceanic and Atmospheric Administration (NOAA); several universities; the States of Wisconsin and Michigan; as well as the private sector. The GBMBS will provide information to aid and support regulatory activities affecting Green Bay. However, its major goal is to pilot the use of the mass balance approach to the regulation of toxic substances in the Great Lakes ecosystems. The Menominee River Fish Management Plan is a joint effort of the Michigan and Wisconsin Departments of Natural Resources. The plan will address fish management practices to enhance the Menominee River fishery. The plan will tentatively be completed by the end of 1990.

The Wisconsin side of the AOC is also included in the Upper Green Bay Basin Areawide Water Quality Management Plan (January, 1980). The report describes existing and potential water quality problems in the Upper Green Bay Basin and sources of these problems. The report contains recommendations for point source, nonpoint source and septic system problems as well as recommendations for water quality monitoring needs throughout the Upper Green Bay Basin.

Public awareness of the problems in the AOC and the RAP process has been enhanced by several actions. A Citizens Advisory Committee has been formed to involve the community and include public opinion as much as possible in the RAP process. The local news media has covered the Menominee River RAP throughout its development. The Governors of Wisconsin and Michigan, and the State of Wisconsin Natural Resources Board visited the AOC in August, 1989. These visits helped to bring attention to the Menominee River RAP. Fact sheets on key RAP issues will be prepared and distributed to area residents and larger public meetings are being held as the plan is developed.

The cooperative effort of many people is needed to successfully prepare a RAP and achieve its goal of restoring impaired uses and protecting the resources of the area of concern. Wisconsin DNR's Bureau of Water Resources Management has primary responsibility for coordinating preparation of the Menominee River RAP. The plan is being prepared through this bureau, WDNR's Lake Michigan District and Michigan

DNR's Surface Water Quality Division. Michigan has identified their primary role in the development of the Menominee River RAP to include: providing data and information for the plan, review of the plan, helping with formulation and implementation of recommended actions, and assuring that Michigan citizens have a role in public participation efforts relating to the plan.

Advisory committees are also instrumental in preparing the RAP. The Technical Advisory Committee (TAC) was formed to bring together technical experts familiar with the area of concern. The TAC is providing information needed to prepare and implement the plan. The role of the TAC is:

* problem identification and objective setting;

* technical analyses of the problems and preliminary goals for management and restoration of the resource;

* identification and evaluation of alternative approaches to managing and restoring the resource;

* recommendation of a plan of action to restore the impaired uses and identification of implementation opportunities and problems.

The other advisory committee involved in preparation of the RAP, the Citizens Advisory Committee (CAC), is made up of area citizens, representatives from local governments, industries, educational institutions and environmental groups. The CAC activities include:

* representation of interests of key organizations and constituencies in plan development;

* review of RAP chapters and reports from the TAC;

* initiation of public education programs;

* promotion of a sense of responsibility for restoration of the Menominee River and acceptance of the remedial measures necessary to abate pollution problems;

* mobilization of citizen participation in the RAP process;

* development of the TAC a desired future state for the Lower Menominee River.

The RAP is being developed following a general process established by the IJC. The key steps in this process and their completion dates are listed below.

Component	Date Completed
Public Meeting	June, 1988
Scope of Study	September, 1988
TAC Established	December, 1988
CAC Established	September, 1988
Desired Future State Identified	January, 1989
Goals and Objectives Identified	
TAC	February, 1989
CAC	August, 1989
Problem Identification	December, 1989
Public Meeting	March, 1990

The desired future state of the Menominee River and the goals and objectives of the RAP are presented in Chapter VIII.

Disclaimer

The MDNR does not support the conclusions of the Tusler bioassay due to concerns with the field methods used to collect the samples. MDNR believes these sampling methods have not been validated, and therefore may not be representative of conditions in the Lower Menominee River.

Purpose of the Remedial Action Plan

The IJC requested WDNR and MDNR to prepare a Remedial Action Plan 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 1987 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 fourteen specific impaired uses (Table II.1).

The RAP will address the following specific points:

* define the environmental problem, including geographic extent of the area affected;

* identify beneficial uses that are impaired and the degree of impairment;

Table II.1 Impaired Uses as Defined by the Great Lakes Water Quality Agreement

1. Restrictions on fish and wildlife consumption;
2. Tainting of fish and wildlife flavour;
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; and
14. Loss of fish and wildlife habitat.

---

* describe the causes of the use impairment and sources of pollutants;

* identify remedial measures proposed to restore beneficial uses;

* identify jurisdictions and agencies responsible for implementing and regulating remedial measures;

* provide a schedule for implementing and completing 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 and sediment quality problems resulting from discharges of toxic substances, spills combined sewer overflows and bypasses, and other point and nonpoint sources of pollution in the Menominee River AOC has resulted in dredging restrictions, loss of fish and wildlife habitat and wetlands, degradation of fish, and degradation of the benthos fish consumption advisories, and restricted total and partial body contact. Impaired uses in the AOC are discussed in depth in Chapter IV, Definition of Problems.

There are several point and nonpoint sources of pollution in the Menominee River AOC. Significant point source dischargers are:

Ansul Fire Protection Company
City of Menominee WWTP and CSO's
City of Marinette WWTP
Menominee Paper Company
Scott Paper Company
SpecialtyChem Products Corporation

Nonpoint sources of pollution in the AOC include storm water runoff, and runoff from storage piles of coal, salt, and other materials. The former arsenic salt storage area on the Ansul Fire Protection Company property is releasing arsenic (via contaminated groundwater and sediment) to the Menominee River. Leachate from the Menominee City landfill (closed in 1982) is known to be contaminating that site's underlying groundwater. Other abandoned landfills and disposal sites are present along the river's shore. There are ten identified leaking underground storage tanks in the AOC. There is also a former paint sludge disposal site on the Michigan shore of Green Bay which is a source of pollution to the AOC. Sources of pollution are discussed in depth in Chapter V. Pollutant loadings from the sources are discussed in Chapter VI. Restoration of impaired uses will be guided by an ecosystem perspective which emphasizes the protection of the entire Great Lakes system.

Intended Use Of The Remedial Action Plan

The entire process of developing and implementing a RAP and confirming restoration of beneficial uses may take an extended period of time. The success of the RAP depends on the involvement of concerned citizens, local governments, and resource agencies for its continued development and implementation. This plan is intended for use by the public as well as local, state and federal environmental agencies as a guide for the restoration and protection of the desired future state of the AOC.

Stage I of the Lower Menominee River RAP includes the introduction, environmental setting, problem identification, sources of pollution, pollutant loadings, historical background of remedial actions, and RAP specific goals and objectives (Chapters 2 - 8). Stage II is being drafted and will be completed by September, 1991. It will include the executive summary, recommended remedial actions and alternative actions, sources, bibliography and appendices (Chapters 1, and 9 - 12 and Appendices).

III. ENVIRONMENTAL SETTING

Location

The Menominee River forms the boundary between Wisconsin and the Upper Peninsula of Michigan (Figure III.1). The river's headwaters are in both states. The lower main stem of the river flows between the Cities of Marinette, Wisconsin and Menominee, Michigan. Marinette has a population of approximately 12,000 people. Menominee is somewhat smaller with a population of approximately 10,000 people. These cities are located in the eleventh congressional district of Michigan and the eighth congressional district of Wisconsin and are situated on the river and harbors edge as well as the shores of Green Bay. The Menominee River enters the waters of Green Bay approximately 50 miles north of the City of Green Bay.

The Menominee River Area of Concern (AOC) includes the lower three miles of the river from the upper Scott Paper Company dam to the river mouth and approximately three miles north and south of the adjacent shoreline of Green Bay. There are six islands in the river within the AOC boundary. All of the islands are State of Wisconsin territory. The AOC includes portions of Marinette County in Wisconsin and Menominee County in Michigan (Figure III.2).

Natural Features

Drainage Basin

The Menominee River system is composed of a number of large and small tributaries. The major tributaries include the Brule, Michigamme, Pine, Pike, Paint, Iron and Sturgeon Rivers. The Menominee River originates at the confluence of the Michigamme and Brule Rivers and flows approximately 115 miles to the waters of Green Bay. The total area of the Menominee River watershed (Figure 111.1) is approximately 4,070 square miles - 2,618 square miles located in Michigan and 1,452 square miles located in Wisconsin. The gradient of the Menominee River is approximately five feet per mile (USDA, et al., 1988).

Topography

The topography in the Menominee River Basin was formed and heavily altered by periodic glaciation, the most recent of which was the Wisconsin glacial period (10,000 - 30,000 years ago). The AOC is located in the Eastern Ridges and Lowlands geographic province of Wisconsin, a province characterized by lakes and glacial lake plains, end moraines and poorly integrated east to west drainage. Specific AOC topographic features range from plains and depressions to gently sloping sandy ridges. Bedrock outcroppings and moraine deposits in the northern river basin create a more rugged terrain. The maximum elevation in the basin is 1300 feet (BLRPC, 1985).

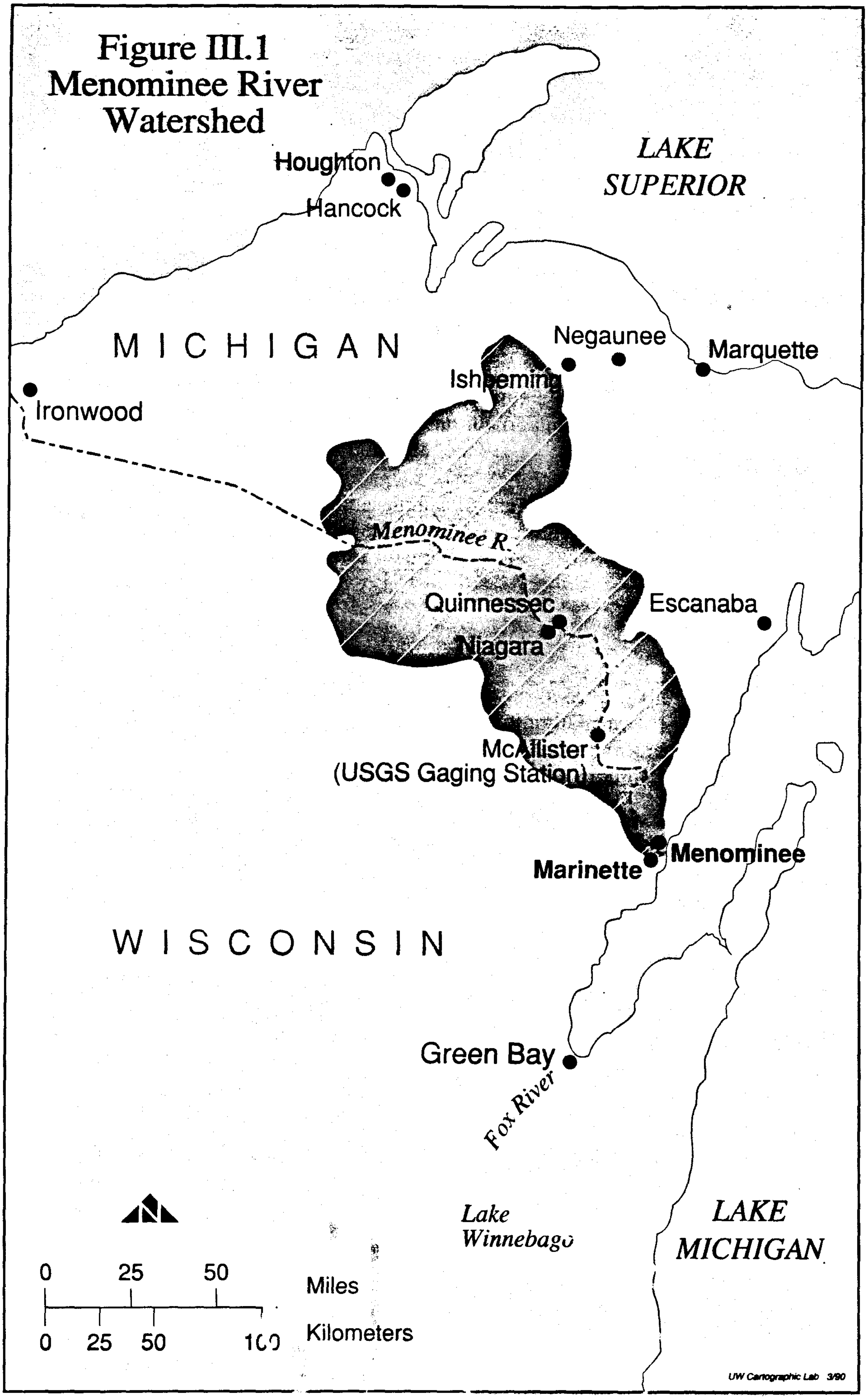
Figure III.1
Menominee River
Watershed
Houghton
Hancock
LAKE
SUPERIOR
MICHIGAN
Negaunee
Marquette
Ishpeming
Ironwood
Menominee R.
Quinnessec
Escanaba
Niagara
McAllister
(USGS Gaging Station)
Menominee
Marinette
WISCONSIN
Green Bay
Fox River
Lake
Winnebago
LAKE
MICHIGAN
0
25
50
Miles
0
25
50
100
Kilometers
UW Cartographic Lab 3/90

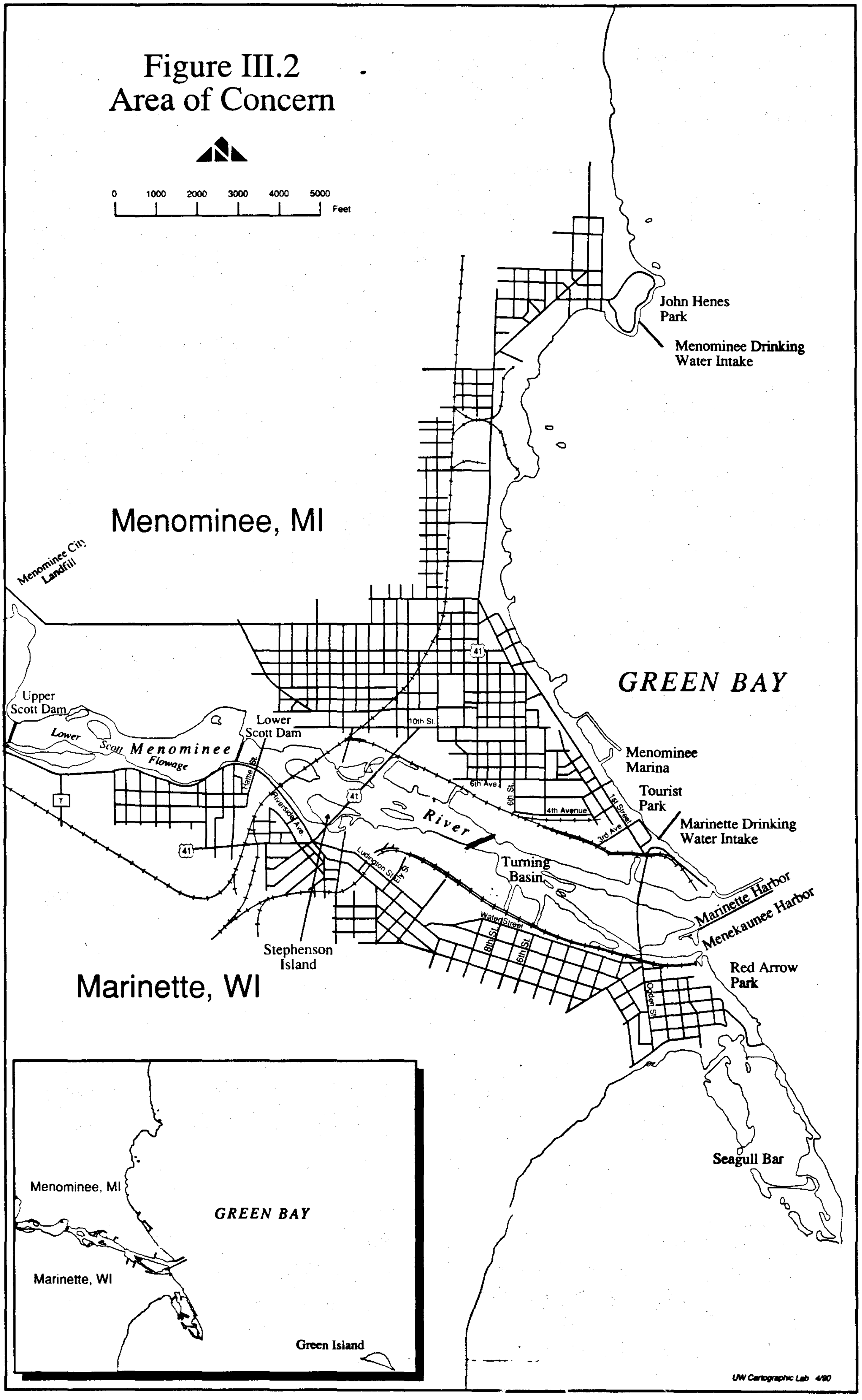
Figure III.2
Area of Concern
0 1000 2000 3000 4000 5000 Feet
Menominee, MI
Menominee City Landfill
GREEN BAY
John Henes Park
Menominee Drinking Water Intake
Upper Scott Dam
Lower Scott
Menominee Flowage
Lower Scott Dam
10th St
Menominee Marina
Tourist Park
6th Ave.
6th St.
4th Avenue
1st Street
3rd Ave.
Marinette Drinking Water Intake
River
Turning Basin
Marinette Harbor
Menekaunee Harbor
Hattie St.
Riverside Ave
Ludington St.
Ely St.
Water Street
8th St.
6th St.
Ogden St.
Stephenson Island
Red Arrow Park
Marinette, WI
Seagull Bar
Menominee, MI
GREEN BAY
Marinette, WI
Green Island
UW Cartographic Lab 4/90

Geology and Soils

Glacial activity which created and modified land forms also deposited parent soil materials, and established subsequent drainage conditions. Marinette County is overlain with a mantle of drift deposited by a series of glaciers during the Pleistocene epoch. Within the City of Marinette, most of the drift consists of water sorted sand or sand and gravel called outwash. City well logs indicate that there is some 85 feet of sand and gravel underlain by dolomite (BLRPC, 1987). Prevalent Roscommon soils and some of the marshy soils found along the Menominee River are moderately corrosive to steel. The corrosiveness of the soils within Marinette must be considered as detrimental to the use of buried steel structures as part of the sewer, water and utility systems (BLRPC, 1987).

Some developed areas along the river are constructed on man-made soils as a result of the lumbering boom around the turn of the century. Marsh land and low areas along the Menominee River were filled with sawdust and waste wood slabs and then overlain with sand or top soil. The depth and stability of these man-made areas is variable. Sewer and water lines constructed in this type of man made soil are subject to excessive settling and alignment shifting (BLRPC, 1987).

Surface Waters

The surface water resources in the AOC are the Menominee River and Green Bay. The Menominee River has a 23 year average flow of 3,580 cubic feet per second (cfs) (1946-1961, 1980-1986, 1988) at McAllister USGS gaging station and an average flow of 3980 cfs at the mouth (Holmstrom, 1990). Extreme flows of 32,500 cfs and 538 cfs occurred on May 9, 1960 and October 6, 1946 respectively (Belonger, 1989). Other rivers in the immediate area include the Peshtigo River located approximately 10 miles south of Marinette. In Menominee County there are an abundance of streams that drain marshes and lowlands in the central part of the county.

The Menominee River is susceptible to seiche effects from Green Bay. For Green Bay at the mouth of the Fox River a 12-hour seiche effect has been noted by the USGS during the Green Bay Mass Balance Study. The water elevation difference due to the seiche during quiet and rough water periods is 0.5-1 foot and 1.5-2 ft., respectively. A similar seiche effect might be expected for the Menominee River AOC (Hughes, 1990).

Currents in Green Bay tend to be counterclockwise with two main flow patterns in the upper and lower bay. Currents are heavily influenced by wave motion in the bay, particularly those currents in the southern bay. Central and northern portions of the bay are known to stratify. Presently the bay ranges from high concentrations of nutrients in the south to medium and low concentrations of nutrients near where the bay and Lake Michigan meet.

Navigation Channel and Harbor

The Federal Navigation Channel is made up of an entrance channel, an outer harbor formed by a north and south breakwater and an inner harbor formed by about a two mile navigable reach of the river beginning at the river's mouth and continuing upstream to the U.S. Hwy. 41 Bridge (Figure III.2). There is a 650 foot wide turning basin within the inner harbor approximately 6600 feet from the entrance channel. The turning basin was used to back large ships around allowing bow-first exit from the river. Ships currently using the river are equipped with bow thrusters allowing stern-first exit from the river, and do not use the turning basin.

The U.S. Army Corps of Engineers (COE) is responsible for maintaining a navigation channel 21 feet deep from the harbor entrance buoys to 2,000 feet upstream at a width of 600 feet. The channel continues at the same 21 foot depth but with a width of 300 feet to the Odgen Street (Menekaunee) Bridge. Above the bridge, for a distance of 4,700 feet, the channel is maintained at a 200 foot width. The turning basin has an authorized depth of 21 feet. Near the Ansul Fire Protection Company, south of the main channel, a smaller channel with an average width of 90 feet and an approximate depth of three feet runs from the Eighth Street Slip to Ogden Street (Technical Advisory Committee, 1989).

The COE last dredged the main channel and harbor of the Menominee River in 1982. However, to avoid having to dispose of contaminated sediment from the turning basin, the channel was not dredged within 200 feet upstream and downstream of the turning basin. The dredged material was disposed of in State of Michigan waters east of the north Menominee Harbor breakwater light (U.S.COE, 1982, Figure III.2).

The COE is currently examining previously authorized commercial and navigational improvements to the river. These improvements, authorized in 1960, were never implemented to the lack of economic justification in the ensuing years. If improvements are determined to be economically justifiable, portions of the harbor will be deepened by three feet.

Several bridges and dams cross the Menominee River within the AOC. The Ogden Street (Menekaunee) bridge is the only bridge to cross within the limits of the COE dredging project. There are also two roadway bridges, a railroad bridge, and two Scott Paper Company dams in the AOC. The lower dam blocks upstream navigation from the river's mouth (BLRPC, 1980).

Groundwater

Areas outside of Marinette and Menominee and inland from the Menominee River and Green Bay rely on groundwater for industrial, municipal, agricultural and domestic water supplies. While groundwater in this area is hard and can be high in iron, it is generally suitable for most purposes.

The major types of groundwater bearing strata in the AOC include: glacial drift, upper limestone, middle limestone and sandstone, lower sandstone and deep granites. The uppermost glacial drift aquifer is accessible by shallow wells but it yields less water and has a greater chance of contamination than do lower aquifers (BLRPC, 1987). The principal aquifer used for domestic water is the upper limestone, which is at a depth of 20 to 35 feet. Wells in this aquifer are generally of small diameter with flows of 10 to 25 gallons per minute (City of Menominee, 1979).

The level of the groundwater table is similar to the contour of the land surface except that its contours are less steep. In many low areas, the water table and land surface coincide, thereby producing numerous wetland zones. These wetlands are sites for ground water recharge.

Natural Areas

The Seagull Bar natural area (located on the Wisconsin side of the AOC) has been identified by the WDNR in the Natural Area Inventory (Figure III.2). A natural area is defined as a tract of land or water so little modified by man's activity or sufficiently recovered that it contains intact native plant and animal communities believed to be representative of pre-settlement landscape.

Seagull Bar Natural Area is a 20 acre site classified as a State Natural Area and is owned by the State of Wisconsin. Located just south of the Menominee River mouth, Seagull Bar is characterized by sand spits, lagoons and emergent vegetation. The area attracts migrating shore birds and waterfowl in great numbers. Beach and shoreland vegetation, submerged aquatics and coastal wetlands during low water periods are important features.

Another interesting site because of its habitat value is Green Island. Located approximately six miles offshore of the Menominee River (T30N, R25E, Sections 19 and 20), it was once the site of a lighthouse (Figure III.2). The undeveloped island is approximately 86 acres. One half of the island is wooded and the other half is a shrub and grass open area. The entire shoreline ranges from rock to pebbles (Rhude, 1989). Green Island provides habitat for gulls on the beach and significant habitat for black-crowned night herons and great blue herons in the wooded area. The herons feed near the Menominee River and nest in the trees on the island. Cormorants have also been sighted on Green Island. Hunting, usually for diving ducks, is allowed on the island however, human presence has caused disruption of the nesting birds (Amundson, 1989).

Wetlands

Most of the upland wetlands found in the Menominee River area are conifer swamps which include white cedar, black spruce, tamarack, and hemlock. Deciduous tree species such as black ash, white ash, poplar, silver maple, red maple, basswood, and elm are also found in wetland areas. Wet palustrine soils are suited for wet meadow and water tolerant species such as willow, alder, and dogwood (Foth and Van Dyke, 1987). Wetlands along the river and harbor have been reduced due to development of the river's edge (Figure III.3). Whether they are located along the shore of a surface water or upland, wetlands provide excellent habitat for a wide variety of birds, animals, and plants.

There are several regulatory methods available to protect wetlands. Wisconsin Administrative Code NR 1.95 provides a general policy statement for WDNR's preservation, protection and management of wetlands. Wisconsin Administrative codes NR 115 and NR 117 provide for the protection of wetlands in rural and urban areas of the state. Proposed Wisconsin Administrative Code NR 103 will set forth conditions necessary to protect water quality related wetland functions and values such as filtration, floodwater storage, and habitat among others. Wetlands in Michigan are protected from alteration under a variety of state laws. The most recent and comprehensive of these is the Wetland Protection and Management Act (Act 203, P.A. 1979). Others are the Shorelands Protection and Management Act (Act 247, P.A. 1955), which regulates activities along the Great Lakes shorelines, the Inland Lakes and Streams Act (Act 346, P.A. 1972), which regulates the physical alteration of adjoining lands, and the Michigan Environmental Protection Act (Act 127, P.A. 1979). The cities of Menominee and Marinette have both adopted local ordinances which restrict development of wetlands.

Wetlands along the shoreline are generally included in floodplain or shoreland zoning ordinances which restrict development in floodplain areas. Sewer service areas in Wisconsin identify wetlands, floodplains, shorelands and other natural features as "environmental corridors." Environmental corridors are excluded from sewer service areas to protect public health and safety; reduce damage from flooding; maintain important wildlife habitat and outdoor recreation areas; reduce the costs of public utilities; and minimize environmental damage (BLRPC, 1985). Thus, classification as an environmental corridor can result in protection of wetlands from development.

The most recent sewer service plan for the City of Marinette was approved in 1985 by WDNR. The majority of Wisconsin's side of the AOC is incorporated in the sewer service area. Most of the remaining, unsewered portions of the AOC in Wisconsin are typically identified as "environmental corridors" although they may not be zoned as such by the city of Marinette (Figure III.4).

Climate

Climate in the AOC is classified as continental and is characterized by marked changes in weather, common to locations in the interior of large land masses of middle latitudes. However, nearby Green Bay and Lake Michigan exert strong modifying influences on the climate. Most of the precipitation occurs during late winter and spring, and there are often drought periods each growing season. The normal precipitation rate is 30 inches per year. Runoff in the river basin is approximately 41% of the annual rainfall (USDA, et.al., 1988). The average annual temperature is about 46 degrees Fahrenheit (F). Average monthly temperatures range from 18 degrees F in January to 68 degrees F in July (BLRPC, 1987).

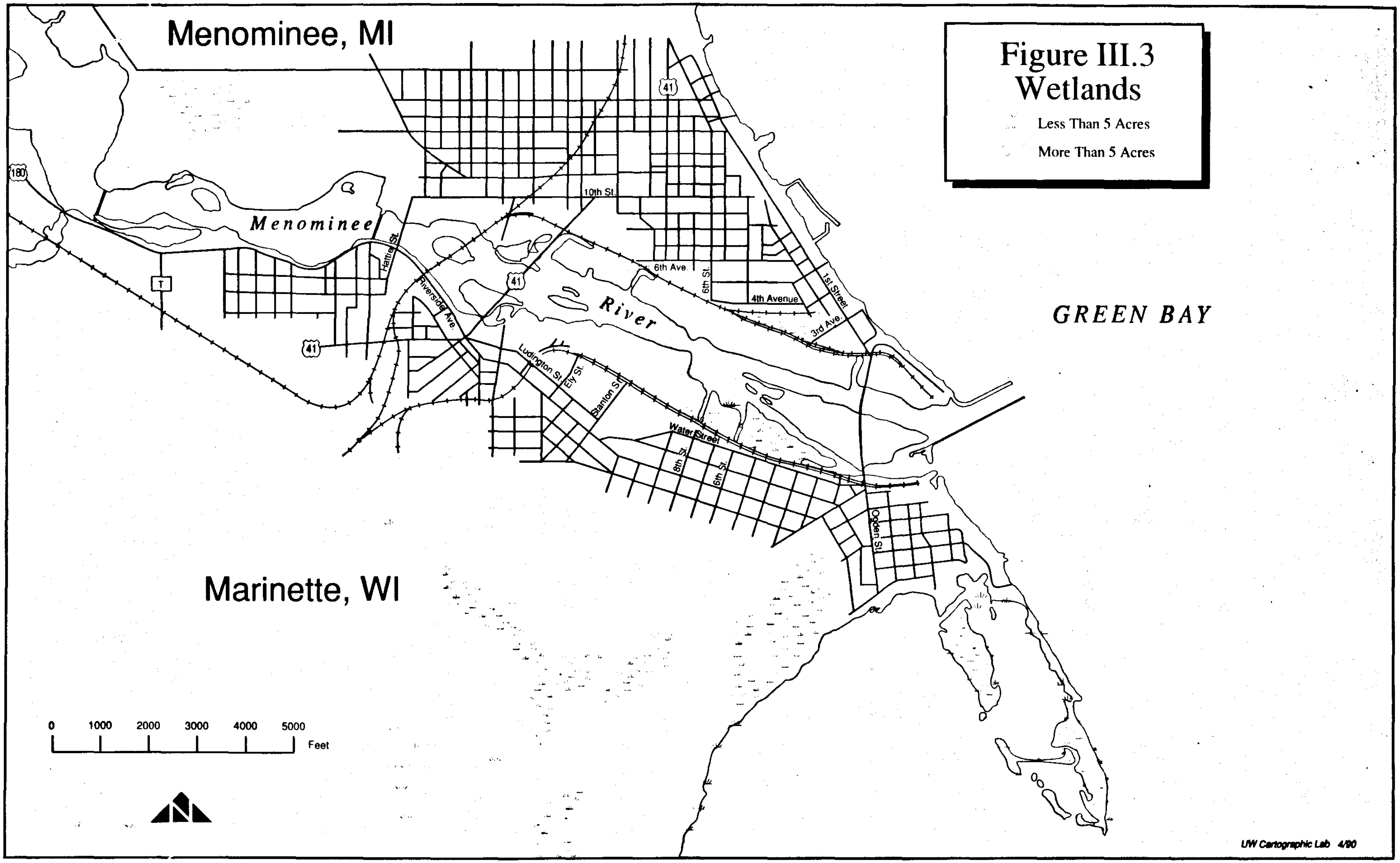

Figure III.3
Wetlands
Less Than 5 Acres
More Than 5 Acres
Menominee, MI
Marinette, WI
Menominee
River
GREEN BAY
10th St.
6th Ave.
6th St.
4th Avenue
1st Street
3rd Ave.
Hattie St.
Riverside Ave.
Ludington St.
Ely St.
Stanton St.
Water Street
8th St.
6th St.
Ogden St.
41
180
T
0
1000
2000
3000
4000
5000
Feet
UW Cartographic Lab 4/90

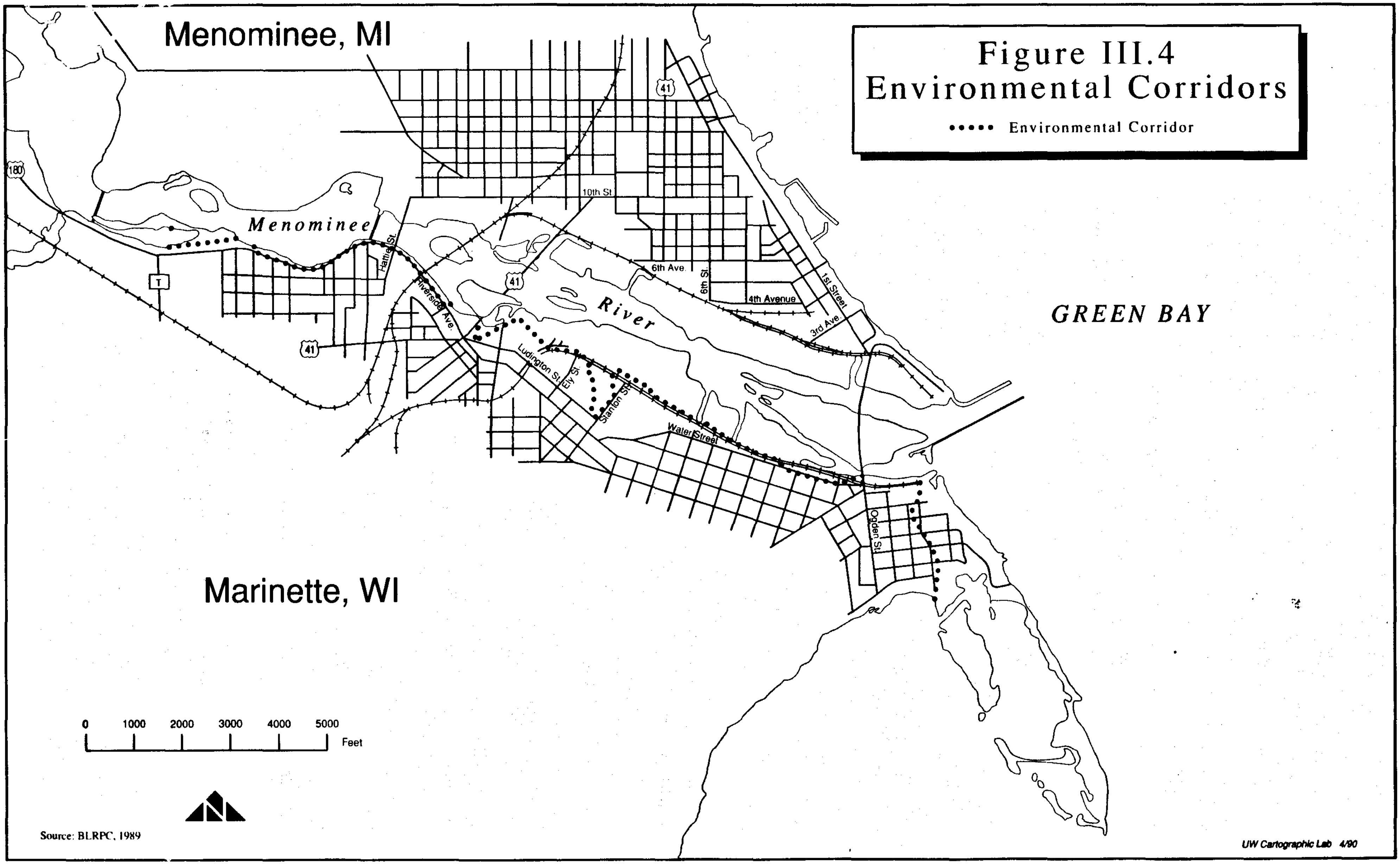
Figure III.4
Environmental Corridors
••••• Environmental Corridor
Menominee, MI
Marinette, WI
GREEN BAY
Menominee
River
10th St
6th Ave.
6th St.
4th Avenue
1st Street
3rd Ave.
Hattie St.
Riverside Ave.
Ludington St.
Ely St.
Stanton St.
Water Street
Ogden St.
41
180
T
0 1000 2000 3000 4000 5000
Feet
Source: BLRPC, 1989
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Air Quality

In 1977, the Ansul Fire Protection Company, located in Marinette, conducted total suspended particulate (TSP) monitoring at two sites within the city. The monitoring was conducted for only eight months (May through December), and two exceedances of the secondary 24-hour TSP standard (150 $\mu g/m^3$) were recorded at a water works monitor. The two exceedances constituted a violation of the standard since it was not to be exceeded more than once per year. The water works monitor was found to have been improperly sited since it was located directly over a partially unpaved alley used by heavy trucks. Also, Water Street, located about 150 feet north of the monitor, was being resurfaced at the time and may have contributed to the TSP standard violation. Thus it, seemed likely that the data collected at the water works monitor was not representative of the air quality experienced in Marinette.

In 1977, USEPA designated Marinette as an unclassified attainment area for TSP. The area was designated unclassified because the attainment status of the area could not be ascertained from the non-representative monitoring data. Subsequently, the WDNR, in cooperation with local industry, monitored TSP from three monitors in Marinette from 1981-1983. Two years of TSP monitoring data was collected at two sites while one year of TSP monitoring data was collected at the third site. During that monitoring period no exceedances of the 24-hour TSP standard were recorded. The WDNR submitted this monitoring data to USEPA and requested the City of Marinette be redesignated from unclassifiable for TSP to attainment. USEPA agreed and in the September 19, 1984 Federal Register redesignated the City of Marinette to full attainment for TSP.

No air quality monitoring sites are currently located in the City of Marinette. According to WDNR there have been a few documented complaints concerning air emissions from SpecialtyChem Products Corporation, Ansul Fire Protection Co. and Rodman Industries (Debrock, 1989 and Patterson, 1989).

The WDNR has modeled sulfur dioxide air emitting sources in Marinette County. Based on these modeling analyses some industries have modified their operations by decreasing hours of operation or adding pollution control equipment and procedures so that sulfur dioxide air quality standards are achieved.

Menominee County has been in attainment of the National Standard for TSP since 1978. The monitoring data was collected from the Bay Area Medical Center location (10th Avenue, Menominee) (Dellies, 1990). No ambient air quality monitoring sites are currently located in the City of Menominee. According to MDNR, there have been no complaints concerning air pollution problems in the area (Dellies, 1989). National ambient air quality criteria applicable in Wisconsin and Michigan are presented in Table III.1.

Annual air emission data for key sources in the AOC are discussed in Chapter V and summarized in Appendix V.4.

Land Uses

Land use in both Menominee and Marinette has been influenced by the river and the bay. Early industrial development, especially the lumber industry, occurred around the mouth of the river to take advantage of materials transportation via the waterway. Industrial land use remains prevalent along the riverfront but the cities themselves have a range of land uses (Figure III.5).

The total corporate area of Marinette encompasses 4,146.5 acres, about 6.5 square miles. In 1985, developed uses, which include residential, commercial, industrial, transportation, communications/utilities, institutional/government facilities and recreation, accounted for approximately 54.3 percent (2,252 acres) of the city's area. Residential and transportation uses make up almost three quarters of all developed uses in the city (BLRPC, 1987).

Undeveloped uses, which include natural areas and agricultural/ silviculture uses, account for the remaining 45.7% (1894.1 acres) of the city's area. Wetlands, woodlands, and grassy open areas are included in this category. A large portion of acreage of these use types is located on the city's western fringe outside the AOC. Table III.2 lists the land uses for the City of Marinette.

The City of Menominee, according to a 1975 survey, (City of Menominee, 1979) has a total corporate land area of 2,899 acres. Urban development in the city accounts for 1,925 acres and 974 acres are vacant. Developed land was 66.4 percent of the city's corporate area. More recent land use information from the City of Menominee is unavailable at this time.

Industrial and railroad uses continue to occupy more land in Menominee than is usually occupied in similar cities. There is nearly three times as much land in heavy industrial use than there is in comparable cities. Portions of that land are now vacant. In the 1986 Recreation Plan for the City of Menominee the need to bring this land back into production or to change it to another use was noted (City of Menominee, 1986). Table III.3 lists the land uses for the City of Menominee.

There are 43 parks and recreational areas in the two cities. Menominee has 14 park facilities and Marinette has 29 recreation or open space areas (City of Menominee, 1986; BLPRC, 1987). Several parks are located near the river and bay, offering public access to the water for swimming, wading, fishing, and boating. There are eight boat launches in the area, two on the bay shore and six on the river (Table III.4).

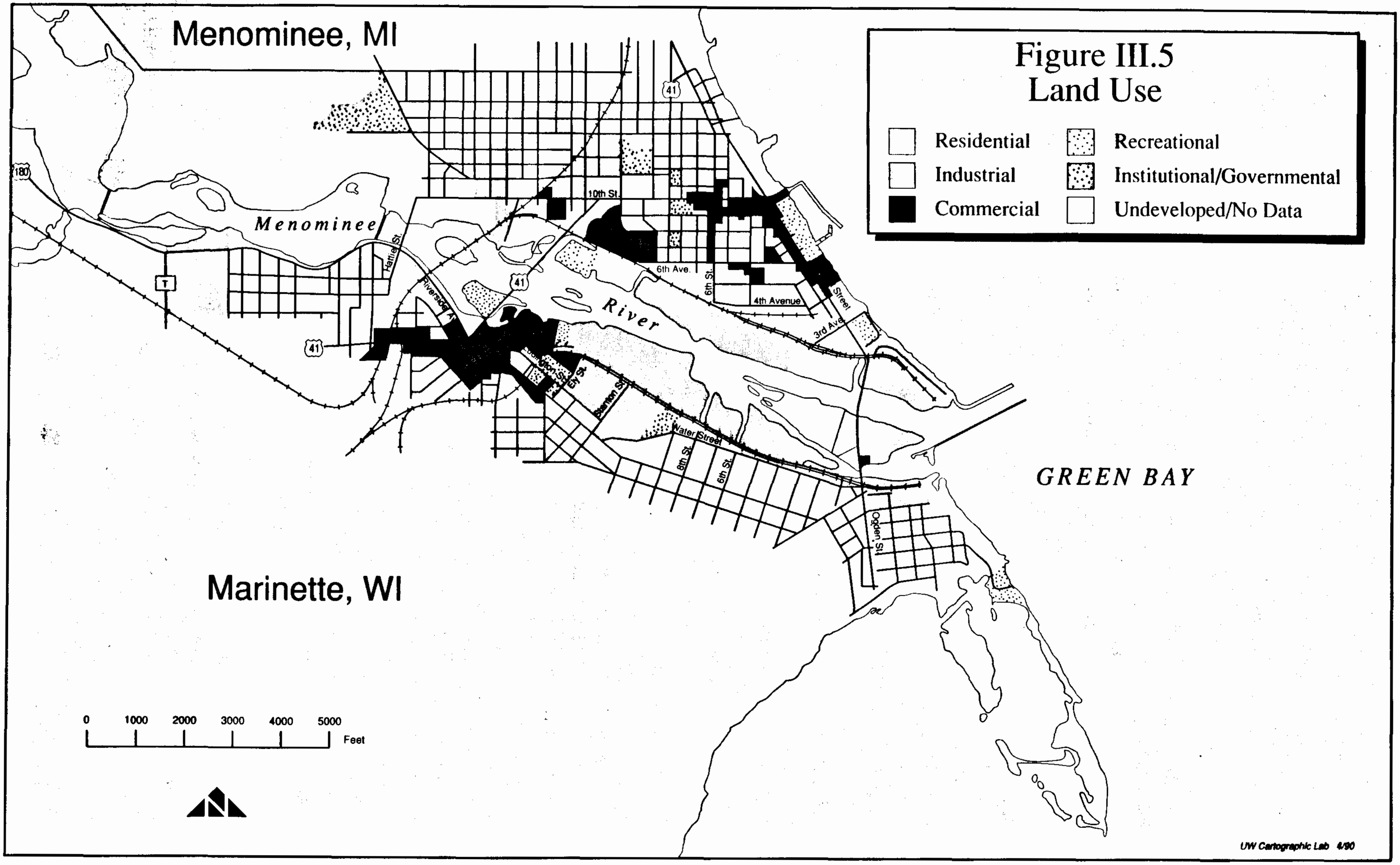
Figure III.5
Land Use
Residential
Industrial
Commercial
Recreational
Institutional/Governmental
Undeveloped/No Data
Menominee, MI
Marinette, WI
Menominee
River
GREEN BAY
10th St.
6th Ave.
6th St.
4th Avenue
3rd Ave.
Street
Hattie St.
Water Street
8th St.
6th St.
Ogden St.
Stanton St.
Ely St.
41
180
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0
1000
2000
3000
4000
5000
Feet
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In Menominee, John Henes Park is a community-wide recreational facility. The Park features: picnicking, swimming, nature trails, a children's zoo, playground, ball diamonds, and 2,600 feet of water frontage. It is located just within the northern boundary of the AOC (Figure III.2). Other Menominee parks located along the river or bay shore within the AOC include: Fishermen's Park, Tourist Park, River Park, Ann Arbor Park, Memorial Park and Marina Park (City of Menominee, 1986).

In Marinette two parks are located within the AOC. Red Arrow Park has approximately 1,500 feet of frontage on Green Bay and an additional 1,500 feet extends north toward the mouth of the river. Red Arrow Park is the northern part of the peninsula that extends out into Green Bay (Figure III.2). The only public area designated for swimming in the City of Marinette is the beach at Red Arrow Park. The southern part of the peninsula is Seagull Bar. Stephenson Island occupies eleven acres on the Menominee River directly north of Marinette's central business district (BLRPC, 1987).

On May 1, 1963 the City of Marinette obtained a bulkhead line (BHL) along the south shore of the southern channel of the Menominee River between Sixth Street and Ogden Street (Figure III.6). Bulkhead lines allow filling between the line and the natural shoreline. The BHL issued to the city is contingent on leasing this land from the state. The city's intention was to use the area behind the BHL as a disposal site for fill obtained from dredging of the Menominee River channel by the COE and from other excavation projects within the city. The land, once filled, would be sold as sites for industry requiring water access (State Public Service Commission, 1963). The city did not apply for a lease in 1963 and no further action was taken on this proposal until 1973 when the city and the Waupaca Foundry Division of Midwest Metalcast renewed efforts to have the BHL approved and a lease completed. Information received to date indicates that no lease was issued in 1973 and that the status of the BHL is the same today as it was in 1963.

Development on both the Michigan and Wisconsin sides of the Menominee River is generally of the same type. Land designated for industrial development occupies the majority of the riverfront in the AOC with recreational/open space and some commercial development accounting for the remainder.

Water Uses

Fish and Wildlife Habitat

Previous investigations by WDNR, along a portion of the southern channel of the Menominee River found many different species of fish and wildlife. Numerous northern pike were observed spawning throughout the area's wetlands. Yellow-headed blackbirds (a bird receiving special attention because of its uncertain breeding status and lack of "baseline" natural history data), mallards, blue winged teal, shovelor, and bufflehead were present and going through various breeding rituals. Green herons, sora

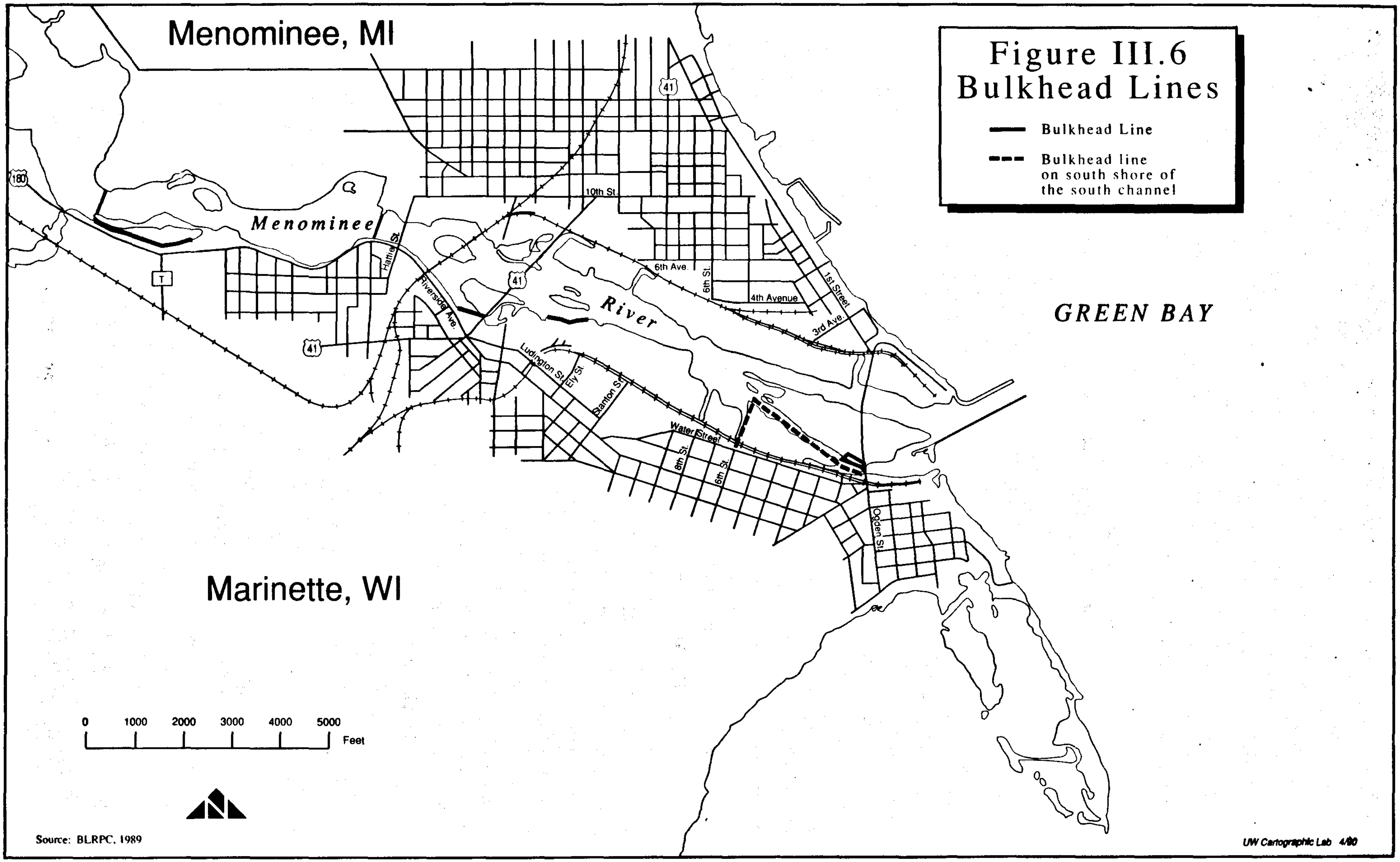
Figure III.6
Bulkhead Lines
Bulkhead Line
Bulkhead line on south shore of the south channel
Menominee, MI
Marinette, WI
GREEN BAY
Menominee
River
10th St.
6th Ave.
6th St.
4th Avenue
1st Street
3rd Ave.
Hattie St.
Riverside Ave.
Ludington St.
Ely St.
Stanton St.
Water Street
8th St.
6th St.
Ogden St.
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5000
Feet
Source: BLRPC, 1989
UW Cartographic Lab 4/90

rails, pheasants, ring billed and herring gulls, rock and mourning doves, flickers, tree swallows, purple martins, brown thrashers, robins, ruby crowned kinglets, (yellow, magnolia, and warblers myrtle), song sparrows, grackles and cowbirds were also present. Rabbits and muskrats were observed (Fassbender, 1975).

In the Marinette area, wildlife habitat areas have been delineated according to their level of quality and importance. These areas were identified as part of a 1976 fish and wildlife habitat study of coastal towns along the Lake Michigan shoreline (WDNR and BLRPC, 1976). In this study, habitat areas were identified as having either top, medium, or lower quality for supporting various types of wildlife habitat. The emphasis of the habitat delineation was on the presence of habitat corridors and the degree of habitat continuity rather than on the presence of wildlife species in these areas. The majority of inland water areas in Marinette county were described as streams or areas supporting a resident population of sport or commercial fish species. However, no wildlife habitat classifications were assigned to locations within the AOC except for Seagull Bar which was classified as medium quality (WDNR and BLPRC, 1976).

There are several threatened or endangered species in or near the AOC. Lake sturgeon are a threatened species found in the Menominee River (Hanson, 1989). However, the Lower Menominee River appears to have a rather substantial population. During the 1988 fall season sport anglers registered 22 sturgeon over the minimum 50 inch size limit (Belonger, 1989). Several rare species were identified in the study area for the Menominee Waste Water Disposal Facility Plan (Johnson and Anderson 1978) including: pigmy shrew, black-crowned night heron, four-toed salamander, five-lined skink, wood turtle, and hog-nosed snake.

Recreational Activities

The Menominee harbor is used as a recreational water port and provides numerous public access points to Lake Michigan and Green Bay. Boat launches are listed in Table III.4. The numerous parks and recreational areas are described in the Land Use section above. Fishing and recreational boating are popular activities for tourists as well as for the local population. A MDNR 1989 creel census indicated that 84,281 hours were spent fishing on the Menominee River April through August. Appendix III.1 contains more detailed information on angler use of the river. A WDNR Marinette County moored boat count in 1988 found: 106 sailboats, 48 non-fishing boats, 29 fishing boats, 7 charter boats. This count included boats moored at the Menominee Marina.

Commercial Shipping

The Menominee harbor has been classified by the Wisconsin Department of Transportation (WDOT) as a diversified cargo port. Ports in this category handle more than one or two types of freight, but the origins and destinations of the cargo are limited to the immediate vicinity of the port (BLRPC, 1987). Major users of the harbor include: Marinette Marine where ships are constructed; Ansul Fire Protection Company which receives coal by ship; Menominee Paper Company which receives coal and wood pulp; and Marinette Fuel and Dock Company which receives sand, stone, limestone, salt and coal by ship. The harbor received the commodities identified in Table III.5 for 1980-83. Rail service to industries in the harbor area provides some inland movement of cargo and freight (BLRPC, 1987).

Recreational boats also frequently use the lower river channel. During 1988, the Ogden Street (Menekaunee) bridge located at the mouth of the river was opened over 1,500 times for boat passage. Of these openings only 35% were for commercial vessels (Wisconsin Department of Transportation, 1988).

Fishing

Species Diversity/Balance

Fish species which are found year round or seasonally in the river include rainbow and brown trout, splake, chinook salmon, coho salmon, pink salmon, northern pike, walleye, alewife, smelt, smallmouth bass, perch, white suckers, long-nose suckers and carp. A comprehensive species list by river station is presented in Appendix III.2. The smelt runs have decreased, however, in the past few years (refer to Chapter 4 for details). Michigan has stocked walleye fry within the last ten years, and fingerlings more recently. Wisconsin is not stocking walleye. Michigan also stocks steelhead and rainbow and brown trout regularly in the Lower Menominee River. Wisconsin stocked brown trout, chinook, and splake in the Marinette area in 1985 and 1986; brown trout, chinook, and coho in 1987; brown trout, chinook, coho, and splake in 1988. Wisconsin DNR, with help from the M&M Great Lakes Sport Fishermen Club, stocked 1,300 spotted muskellunge at the Sixth Street Slip in 1989. Also in 1989, WDNR added two strains of steelhead (skamania and chambers creek strains) to the stocking quotas for the Menominee River. Michigan DNR stocked the Lower Menominee River with rainbow trout in 1985, steelhead in 1980, and both species in 1983, 1986, and 1987 (MDNR, 1988). Tag returns indicate there is some movement of walleye from the Fox River and Sturgeon Bay tagging sites to the Menominee River (Belonger, 1988). Sea lamprey reproduce in the river and have been an increasing problem. This has resulted in treatment of the water with TMF, a lampricide.

Sport Fishing

The overall fish population is diverse and supports a substantial sport fishery. Pier and breakwater fishing is usually heavy from April to November. Fishing from small boats is also popular.

Electric shocking in the Lower Scott Flowage showed a diverse fishable population, and good natural reproduction of walleye, smallmouth bass, and pan fish. The AOC up to the Lower Scott Paper Company dam is included in the Lake Michigan-Green Bay fish consumption advisories issued by Wisconsin and Michigan which address consumption of PCB and mercury contaminated fish (See Chapter IV for details). The advisories cover white suckers, walleye, northern pike, splake, carp, brook trout, chinook salmon, brown and rainbow trout and rock bass (WDNR, 1990).

Commercial Fishing

In 1989, there were 20 resident and one non-resident commercial licenses for the Menominee area according to WDNR (Belonger, 1989). Commercial fish data for 1988 indicate that 1,488,943 pounds of fish, with a commercial value of $478,868, were caught from Green Bay and Lake Michigan by the commercial fleet based in the Menekaunee harbor (Belonger, 1989). Commercial fishing catches are primarily landed in Marinette not Menominee. Of the twelve commercially caught species the majority were alewife, rainbow smelt, and lake whitefish. The three species with the greatest dollar per pound value were yellow perch, lake whitefish, and chubs.

Public Water Supply

Both Marinette and Menominee obtain their drinking water supplies from Green Bay. Raw water for Marinette is obtained via an intake pipe extending from a shorewell and pumping station in the City of Menominee 3,000 feet north of the mouth of the river (Figure III.2). The Marinette municipal water plant has a capacity of 4 million gallons per day (MGD). In 1988, the municipal water withdrawal for Marinette averaged 2.62 MGD. Specific water use categories of residential, industrial, municipal, and commercial averaged 0.67, 1.63, 0.08, 0.24 MGD respectively (Marinette Water Utility Office, 1989).

Menominee obtains its water from an intake main which extends out into Green Bay from Henes Park (Figure III.2). Treatment capacity is 4 MGD. Water use categories of residential, industrial, and municipal, averaged 0.68, 0.33, 0.05 MGD respectively (Menominee City Water Department, 1989). Treatment of the intake water is basically the same at both water plants. The treatment process combines alum flocculation, sedimentation, filtration, chlorination, and fluoridation.

Waste Disposal

The AOC receives six major point source (industrial and municipal effluent) discharges, combined sewer overflows and nonpoint (silvicultural, 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 fishable and swimmable water quality for the waters of the United States. The Menominee River is used for hydropower production, waste assimilation and industrial water supply as well as fishing, recreation, aesthetic values, and stock and wildlife watering. The Menominee River is a warmwater fishery and a Great Lakes tributary. Wisconsin has designated the Menominee as a river requiring warmwater protection standards to support fish and aquatic life and recreation. At the mouth of the river, Wisconsin Great Lakes standards apply. Michigan has designated the Menominee River at a minimum to be protected for total and partial body contact recreation (May 1 - October 31), navigation, agriculture, industrial and public water supply at the point of water intake, warmwater fish and other indigenous aquatic and wildlife species (Rydquist, 1989). The "designated use" of a river is the method WDNR and MDNR use to determine which regulations apply to that river. The AOC is included in both State's designations and must meet all appropriate standards. Table III.6 summarizes the water quality criteria for fish, aquatic life and recreational use designations for Michigan and Wisconsin.

Wisconsin Administrative Code NR 105 and Michigan Rule 57 contain water quality standards and guidelines for toxic substances. These standards are designed to protect public health and welfare and the present and prospective uses for public and private water supplies, propagation of fish and other aquatic life, wild and domestic animals, domestic and recreational uses, and agricultural, commercial, industrial and other legitimate uses. Michigan's water quality guidelines for toxic substances are recalculated under Rule 57 as new toxicological information becomes available and are published each year in February. Appendix III.3 summarizes water quality standards rules for Michigan and Wisconsin. The Michigan and Wisconsin water quality standards for various organic and inorganic compounds that apply to the designated uses of the Menominee River AOC are listed in Table III.7.

Table III.1 National Quality Standards for Ambient Air

(In micrograms or milligrams per cubic meter - $\mu g/m^3$ and mg/m^3 - and in parts per million - ppm)

Pollutant	Averaging Time	Primary Standards (health)	Secondary Standards (welfare, materials)
Particulates	Annual	75 $\mu g/m^3$	60 $\mu g/m^3$
	24-hour	260 $\mu g/m^3$	150 $\mu g/m^3$
Sulfur Dioxide	Annual	80 $\mu g/m^3$ (.03 ppm)	
	24-hour	365 $\mu g/m^3$ (.14 ppm)	
	3-hour		1300 $\mu g/m^3$ (.5 ppm)
Carbon Monoxide	8-hour	10 mg/m^3 (9 ppm)	Same as primary
	1-hour	40 mg/m^3 (35 ppm)	
Hydrocarbons (nonmethane)	3-hour (6-9 am)	160 $\mu g/m^3$ (.24 ppm)	Same as primary
Nitrogen Dioxide	Annual	100 $\mu g/m^3$ (.05 ppm)	Same as primary
Ozone	1-hour	240 $\mu g/m^3$ (.12 ppm)	Same as primary
Lead	3-month	1.5 $\mu g/m^3$ (.006 ppm)	

Table III.2 Land Use Summary, City of Marinette 1985

	# Acres	% Total
Developed Land Use		
Residential	981.88	23.7
Commercial	75.90	1.8
Industrial	271.64	6.5
Transportation	650.71	15.7
Communications/Utilities	26.33	0.6
Institutional/Governmental	131.07	3.2
Recreation	114.91	2.8
Undeveloped Land Use		
Agriculture/Silviculture	10.81	0.3
Natural Areas	1,883.28	45.4
Total	4,146.53	100.0

Source: BLRPC, 1985

Table III.3 Land Use Summary, City of Menominee 1975

	# Acres	% Total
Developed Land Use		
Residential	588.6	20.3
Commercial	96.8	3.3
Public & Park Land	447.6	15.4
Industry	206.7	7.1
Streets & Alleys	465.8	16.0
Railroads	119.5	4.1
Undeveloped Land Use		
Vacant	974.1	34.0
Total	2899.1	100.0

Source: City of Menominee Comprehensive Plan 1979

Table III.4 Boat Launches in the AOC

Launch	Provides Access To:
Red Arrow Park	Green Bay/Seagull Bar
Boom Landing	Menominee River/Green Bay
Eleventh Street	Menominee River
Stephenson Island	Menominee River/Green Bay
Menominee Marina	Green Bay
Mystery Ship	Menominee River/Green Bay
Light House	Menominee River/Green Bay
Sixth Street	Menominee River/Green Bay

Source: Bay Lake Regional Planning Commission, 1987.

Table III.5 Marinette-Menominee Waterborne Commerce by Commodity, 1980, 1981, 1982 and 1983.

			Short Tons	
Commodity	1980	1981	1982	1983
Coal and Ligrite	76,902	68,336	78,606	87,281
Non-metallic Minerals Except Fuel	54,726	42,928	39,487	28,184
Machinery, Except Electrical	--	--	--	14,803
Primary Metal Products	9,300	9,950	10,300	0
Pulp, Paper and Allied Products	1,972	2,503	2,563	0
Fresh Fish and Other Marine Products	251	84	80	154
Leather and Leather Products				44
Alcoholic Beverages				44
Basic Textiles				6
Farm Products	N.A.	N.A.	72	0
Total Commodities	143,151	123,806	131,108	130,816

Source: BLRPC and U.S. Army Corps of Engineers, Waterborne Commerce of the United States, Calendar Years 1980, 1981, 1982, and 1983, Part 3 Waterways and Harbors Great Lakes.

Table III.6 --Water Quality Criteria for Fish, Aquatic Life and Recreation

Water Quality Parameter	Wisconsin Criteria (a-g)	Michigan Criteria (h-r)
Maximum Temperature	89° F, <5° rise at mixing zone edge [b,c]	Seasonal, <5° rise at mixing zone edge [i]
pH Range	6.0-9.0 [e]	6.5-9.0 [j]
Minimum Dissolved Oxygen	5 mg/L [d]	5 mg/L [k]
Maximum Fecal Coliform	200/100 mL [f] 400/100 mL	200/100 mL [l]
Residual Chlorine	0.01 mg/L	0.006 mg/L
Maximum, Unionized Ammonia	0.04 mg/L (NH_3-N)	0.050 mg/L (NH_3)

WISCONSIN

a. All waters shall meet the following 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 the 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 actually harmful to animal, plant, or aquatic life.

b. 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.

Table III.6 Continued

c. There shall be no significant artificial increases in temperature where natural trout or salmon reproduction is to be protected. Dissolved oxygen shall not be lowered to less than 7.0 mg/L during the trout spawning season. The dissolved oxygen in the Great Lakes tributaries used by salmonids for spawning runs shall not be lowered below natural background levels during the period of habitation.

d. Dissolved oxygen and temperature standards apply to streams and the epilimnion of stratified lakes, the dissolved oxygen standard does not apply to the hypolimnion of stratified inland 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.

e. 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.

f. Shall not exceed a monthly geometric mean of 200 counts per 100 mL based on not fewer than five samples per month, nor a geometric mean of 400 counts per 100 mL in more than 10 percent of the all samples during any month.

g. 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.

MICHIGAN

h. Water quality standards are to protect the public health and welfare, to enhance and maintain the quality of water and to protect the state's natural resources, as a minimum all waters of the state are designated for and shall be protected for (a) agriculture; (b) navigation; (c) industrial water supply; (d) public water supply at the point of water intake; (e) warm water fish; (f) other indigenous aquatic life and wild life; (g) partial body contact. All waters of the state are designated for and shall be protected for total body contact recreation from May 1st to October 31st.

i. Rivers and streams naturally capable of supporting warm water fish shall not receive a heat load which would warm the receiving water at the edge, of the mixing zone more than five degrees Fahrenheit above the existing natural water temperature.

j. The hydrogen ion concentrations expressed as pH shall be maintained within the range of 6.5-9.0 in all waters of the state. Any introduced variation in the natural pH shall remain within this range and shall not exceed 0.5 units of pH.

Table III.6 Continued

k. For waters of the state designated for use for warm water fish and other aquatic life, the dissolved oxygen shall not be lowered below a minimum of four milligrams per liter, or below five milligrams per liter as a daily average, at the design flow during the warm weather season.

l. All waters of the state shall contain not more than 200 fecal coliform per 100 milliliters. This concentration may be exceeded if such concentration is due to uncontrollable non-point sources.

m. Waters of the state shall not have any of these (Turbidity, Color, Oil films, Solids (floating, suspended or settleable) Foams, Deposits) unnatural physical properties in quantities which are or may become injurious to any designated use.

n. Waters of the state shall contain no taste-producing or odor-producing substances in concentrations which impair or may impair their use for a public, industrial or agricultural water supply source or which impair the palatability of fish.

o. Toxic substances specific as determined by Rule 57.

p. Radioactive substances standards as prescribed by the U.S. Nuclear Regulatory Commission and the U.S. Environmental Protection Agency.

q. In addition to the maximum phosphorus discharge levels allowed, nutrients shall be limited to the extent necessary to prevent stimulation of growths of aquatic rooted, attached, suspended and floating plants, fungi or bacteria, which are or may become injurious to the designated uses of the waters of the state.

r. Toxic substances are controlled under a narrative rule (Rule 323.1057) specifying that they shall not be present in Michigan waters at concentrations that are, or may become, injurious to the public health, safety or welfare; plant and animal life; or the designated uses of those waters. Rule 57 is applicable to the 256 chemicals and classes of chemicals listed on the 1984 Michigan Critical Materials Register; the priority pollutants and hazardous chemicals in the Code of Federal Regulations; and any other toxic substances determined by the WRC to be of concern at a specific site.

   Under Rule 57, specific, allowable levels of toxic substances may be established by the MDNR following a detailed evaluation of data related to the chemical's affect on aquatic organisms, life-cycle safe concentrations for terrestrial organisms and humans, and the cancer risk associated with exposure to that chemical via surface water. Specific guidelines for the development of allowable levels of toxic substances in surface water have been developed and are available upon request from the MDNR, Surface Water Quality Division. Following these guidelines, concentrations of toxic

Table III.6 Continued

substances in surface water necessary to protect aquatic life, wildlife and human health are calculated, and the most restrictive is used as the allowable level in surface water. Allowable levels for certain toxic substances may also be water body specific. For example, the toxicity of some heavy metals is dependent on the hardness of the water. Therefore, allowable levels for those metals are also dependent on water hardness.

Sources:
Wis. Adm. Code NR 102 - NR 105
Michigan General Rule 323
Lundgren, 1989

Table III.7 A Comparison of Applicable Water Quality Standards For Michigan and Wisconsin

Substance	Wisconsin Toxic Substance Criteria To Protect Wild And Domestic Animals[1] (ug/L)	Wisconsin Warmwater Criteria (ug/L)[2] Acute	Chronic	Wisconsin Toxic Substance Human Threshold Criteria (ug/L)[2]	Wisconsin Toxic Substance Human Cancer Criteria(ug/L)	Michigan Rule 57(2) Value (ug/L)[8]
Aldrin	--	2.16	--	--	0.00057	--
Ammonia (unionized)	--	--	--	--	--	50 (ACV)
Arsenic* (+3)[3]	--	363.8	153	--	50	184 (ACV)
Arsenic (total)	--	--	--	--	--	184 (ACV)
Beryllium	--	--	--	--	0.2	--
Cadmium*	--	34.89	0.568	82	--	0.47 (ACV)
Chromium* (+6)[4]	--	14.2	9.74	9,000	--	3.0 (ACV)
Chlorine*	--	18.4	7.06	--	--	6 (ACV)
Copper*	--	19.37	13.45	--	--	12.5 (ACV)
Cyanide, free	--	46.2	4.96	40,000[5]	--	4.0 (ACV)
Dieldrin	--	2.10	--	--	--	0.0000315 (CRV)
Heptachlor	--	0.396	--	--	0.0014	0.002 (CRV)
Lead*[6]	--	208.7	12.45	50	--	3.8 (ACV)

TABLE III.7 Continued

Substance	Wisconsin Toxic Substance Criteria To Protect Wild And Domestic Animals(1) (ug/L)	Wisconsin Warmwater Criteria (ug/L)(2) Acute	Chronic	Wisconsin Toxic Substance Human Threshold Criteria (ug/L)(2)	Wisconsin Toxic Substance Human Cancer Criteria (ug/L)	Michigan Rule 57(2) Value (ug/L)(8)
Mercury* (+2)	0.002	1.53	--	0.08	--	0.006 (HLSC)
Methylmercury	--	--	--	--	--	0.0006 (HLSC)
Nickel*	--	1,240	76.07	460	--	38.8 (ACV)
PCBs(7)	0.003, 0.047, 0.233	--	--	--	0.00049	0.00002 (CRV)
Selenium (+4)(4)	--	58	7.07	170	--	--
Selenium (total)	--	--	--	--	--	20 (TLSC)
Silver*	--	2.42	2.42	430	--	0.10 (ACV)
Thallium	--	--	--	11	--	--
Toluene	--	--	--	110,000	--	100 (ACV)
1,1,1-trichloroethane(4)	--	--	--	33,000	--	117 (ACV)
Zinc	--	118.8	57.06	--	--	57 (ACV)

* Criterion listed is for the "total recoverable" form except for chlorine which is the "total residual" form.

NOTES: "--" indicates that no criteria exists; ug/L is equivalent to parts per billion.

The basis for Michigan's toxic guideline levels is Michigan Administrative Code Rule 57(2) Guidelines. Rule 57(2) is used in making water quality-based permit recommendations to the Michigan Water Resources Commission concerning toxic substances in the surface water after a point source discharge is mixed with the receiving stream. The calculated guideline levels do not represent or reflect necessary treatment-based considerations (Zugger, 1989).

Michigan and Wisconsin are in the process of evaluating a memorandum of understanding applicable to the water quality standards in this table.

TABLE III.7 Continued

(1) Warmwater criteria are the same as Great Lakes criteria for this designated use.

(2) Only Wisconsin's criteria for warmwater fish communities has been listed here. However, it should be noted that at the mouth of the Menominee River, Wisconsin criteria for Warmwater and Great Lakes use classifications both apply. The more stringent of the two criteria would be used.

(3) For arsenic the Wisconsin human cancer criteria equals the maximum contaminant level.

(4) For chromium (+6), selenium (+4) and 1,1,1-trichloroethane the Wisconsin human threshold criteria for surface waters classified as public water supplies equals the maximum contaminant level pursuant to s. NR 105.08(3)(b), Wis. Adm. Code.

(5) Total Cyanide

(6) For lead the Wisconsin human threshold criteria equals the maximum contaminant level.

(7) For purposes of regulating the discharge of polychlorinated biphenyls (PCBs) under ch. NR 106, the Wisconsin human cancer criteria for PCBs shall apply only to Arocolors 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 WDNR 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. If a discharge contains more than Aroclor mixture or if the Aroclor mixture in the discharge is unknown, the discharge will be regulated based on the most toxic Aroclor mixture.

(8) Michigan's Rule 57(2) value is the most restrictive of criteria calculated to protect aquatic life (ACV), wildlife (TLSC), human health threshold effects (HLSC) and human health cancer risk (CRV). The basis of the standard is given in parentheses following the rule 57(2) value.

Sources:
Wis. Adm. Code NR 105
Michigan Rule 57(2)

IV. DEFINITION OF PROBLEMS

IMPAIRED USES

The Technical and Citizen's Advisory Committees as well as the Wisconsin DNR and Michigan DNR studied the area of concern to identify the resource problems. Chapter IV discusses each of the fourteen beneficial uses identified by the IJC with emphasis on the impaired uses. Chapter IV is divided into two sections. The first section, Impaired Uses, is a description of impaired uses. The second section, Major Pollutants, presents the identified causes of impaired uses in subsections on water, sediment, and biota. The impaired and unimpaired uses of the Menominee River AOC are summarized in Table IV.1.

Table IV.1 **Summary of Impaired Uses**

	Use is Impaired (Restore the Resource)	Use is Unimpaired (Protect the Resource)
Restrictions on Fish and Wildlife Consumption		
- Fish	X	
- Wildlife		X
Tainting of fish and wildlife flavor		X
Degradation of fish and wildlife populations		
- Fish	X	
- Wildlife		X
Fish tumors or other deformities		X
Bird or animal deformities or reproduction problems		X
Degradation of benthos	X	

Table IV.1 Continued

	Use is Impaired (Restore the Resource)	Use is Unimpaired (Protect the Resource)
Restriction on dredging activities	X	
Eutrophication or undesirable algae		X
Restrictions on drinking water consumption, or taste and odor problems		X
Beach Closings		X
Total and partial body contact	X	
Degradation of water appearance aesthetics		X
Added costs to agriculture or industry		X
Degradation of phytoplankton and zooplankton populations		X
Loss of fish and wildlife habitat(1)	X	

(1)Loss of fish habitat is due to water quality problems and to urbanization. Loss of wildlife habitat is due strictly to urbanization.

Restrictions on Fish and Wildlife Consumption

Fish Consumption

Health advisories for people who eat sport fish from lakes and streams in Wisconsin are developed jointly by the Wisconsin DNR and the Wisconsin Department of Health and Social Services (WDHSS). The Wisconsin publication, issued in April and October, describes the health precautions that should be considered before eating fish caught from certain state waters. The advisory is based on the level of toxic pollutants contained in the fish (skin-on fillets) that do not meet health standards (Michigan analyzes standard edible portions). Recommendations in the fish advisory are listed by species as well as by the length of the fish and contain two separate sets of health risks. One is for fish contaminated with polychlorinated biphenyls (PCBs) and pesticides, and the other is for fish contaminated with mercury. Because of PCB contamination, consumption advisories exist for various fish species in Green Bay. These advisories comprise all tributaries in Green Bay south of Marinette, including the Menominee River from its mouth up to the first dam. Table IV.2 details the fish consumption advisory for PCBs for the Menominee River AOC based on the latest advisory publications (WDNR, April, 1990 and MDPH, February 1990). A number of fish species are listed in the April 1990 Wisconsin advisory for the Menominee River. In addition to listing the affected species, the advisory also includes the length of fish that should not be consumed due to exceedance of the FDA action level for PCBs of 2 ppm.

The Michigan Department of Public Health annually issues health fish consumption advisories to apprise anglers of contamination which has been found in fish in Michigan. The Michigan advisory contains two categories of restrictions for consumption of fish contaminated with PCBs. That health advisory is listed in Table IV.2. Appendix IV.1 contains the entire fish consumption advisories for Wisconsin and Michigan as well as Michigan consumption advisory trigger levels.

Table IV.2. Public Health Fish Consumption Advisory for the AOC.

Michigan

Lake Michigan Watershed	Restricted Consumption	No Consumption
Green Bay (South of the Cedar River; applies to Michigan and Wisconsin waters including the Menominee River from mouth to the first dam)[1]	Splake up to 16"[2]	Rainbow Trout over 22", Chinook over 25", Brown Trout over 12", Brook Trout over 15", Splake over 16", Northern Pike over 28", Walleye over 20", White Bass and Carp

Wisconsin

	Group 1	Group 2	Group 3
	These fish pose the lowest health risk.	Women and children should not eat these fish	No one should eat these fish.
GREEN BAY south of Marinette and its tributaries (except the Lower Fox River, which has a separate advisory), including the **Menominee, Oconto, and Peshtigo Rivers,** from their mouths up to the first dam.	Rainbow trout up to 22" Chinook salmon up to 25" Brook trout up to 15" Smallmouth bass Northern pike up to 28" Perch Walleye up to 20" Brown trout up to 12" Bullhead White sucker	Splake up to 16"	Rainbow trout over 22" Chinook salmon over 25" Brown trout over 12" Brook trout over 15" Carp[3] Splake over 16" Northern pike over 28" Walleye over 20"[3] White bass

(1) The advisory is for Polychlorinated biphenyls (PCBs)

(2) Nursing mothers, pregnant women, women who intend to have children, and children age 15 and under should not eat these fish.

(3) Ninety percent or more of these Group 3 fish species contain contaminant levels higher than one or more health standards.

The Michigan and Wisconsin advisories also provide general guidance to the consumer on preparation and cooking techniques which can significantly reduce contaminant levels.

Fish have been collected and monitored for contaminants by different agencies during various time periods as summarized below:

- Wisconsin DNR fish contaminant monitoring program - 1976-1989.
- U.S. Fish and Wildlife Service - 1984 and 1988.
- Michigan DNR - 1984-1988.
- Dames and Moore - 1979.
- Menominee River RAP Technical Advisory Committee fish contaminant monitoring recommendation - 1989.

Wisconsin DNR and Michigan DNR Fish Contaminant Monitoring Program (1976-1989)

Data generated from 1976-1988 as part of the WDNR and MDNR fish contaminant monitoring program detected levels of PCBs for carp as high as 20 ppm (1976 data from a 26 inch fish) and 5.5 ppm for walleye (Michigan monitoring based on 1988 data from a 25 inch fish). These data results reflect fish that were processed from skin-on fillets (Note that Michigan analyzes skin-off fillets for carp). In addition, a number of other fish tested since 1976 in the Lower Menominee River exceeded the 2 ppm FDA health standard for PCBs. While PCB concentrations have tended to decline in recent sampling, some fish species in the Menominee River still exceed the health standard for PCBs.

Appendix IV.2 provides summary data from the Wisconsin fish contaminant monitoring program for the Menominee River in the AOC from 1976-88 and also 1988 data from the Michigan fish contaminant monitoring program from the mouth of the Menominee River.

PCB concentrations in fish exceed FDA action levels, not only in the Lower Menominee River, but throughout Green Bay, Lake Michigan, and major tributaries near the AOC, such as the Fox, Oconto, and Peshtigo Rivers. The greatest tributary contribution of PCBs to Green Bay is coming from the Fox River. The PCB contamination problem in fish is a bay-wide phenomenon due to the mobility of fish. Because the fish advisory is the result of a regional PCB contamination problem, the source of the problem is likely to be outside the AOC.

The Green Bay Mass Balance Study is currently addressing the sources and extent of PCB contamination in Green Bay and its tributaries including the Menominee River.

The study, which began in 1986, is designed to determine the relative contribution of PCBs to Green Bay. Results from the study will be available in late 1991.

The 1989 sample results from the rock bass collected in the Lower Menominee River indicates there be a PCB contamination problem as a result of source(s) in the AOC. The rock bass, which is considered a resident species in the Menominee River, were below the detection limit for PCBs in nine out of ten composite samples. Five fish constitute a composite sample (refer to Table IV.5 and the discussion preceding the table).

Examination of the sediment data in the AOC (refer to Table IV.14 in the "Major Pollutant" Section) shows concentrations of PCBs that range from <.03 to 2.0 parts per million (ppm). These values are below U.S. EPA's Great Lakes classification guideline for heavily polluted sediments of 10 ppm (refer to the discussion in the "Sediment Quality Assessment" Section). Comparison of the PCB sediment concentrations in the Menominee River to areas such as the Fox River, where problems are known to exist, seems to indicate that PCB contamination problems observed in the fish are not likely the result of source(s) in the AOC.

Although mercury has not been specifically listed in Wisconsin's fish advisory for the Menominee River, levels in some game fish exceed the state's health advisory limit of 0.5 ppm. Samples collected in the Menominee River in 1987, as part of the fish contaminant monitoring program, reveal that eating walleyes larger than 20 inches constitutes a health risk to pregnant women, nursing women and children under 18. Mercury concentrations ranged from 0.66 to 0.76 in walleye fillets. In addition, elevated mercury levels in rock bass were observed in two samples collected in 1989 from the Lower Scott Flowage (1.20 ppm and 0.53 ppm). Rock bass have been included in Wisconsin's April 1990 fish consumption advisory for mercury contamination. The advisory lists rock bass less than ten inches as group three for mercury (pregnant or breastfeeding women, women who plan to have children, and children under 18 should not eat these fish). There is not enough information on rock bass greater than ten inches to issue a health advisory for that size fish. The Wisconsin mercury advisory for rock bass encompasses the Lower Scott Flowage. Refer to Table IV.5 for the test results on the rock bass; also a discussion of the rock bass data is contained later in this section. Michigan sampling results from 1988 showed concentrations of mercury in walleye fillets similar to the Wisconsin data (refer to Appendix IV.2).

Since an advisory for walleyes already exists in the Menominee River AOC because of PCB contamination (in the "do not eat" category for fish over 20 inches), Wisconsin and Michigan do not issue a separate advisory for mercury. However, the public should be made aware that health advisories for mercury are exceeded in the Menominee River AOC for walleyes larger than 20 inches. As PCB levels drop below FDA action levels, walleye may remain on the advisory because of mercury contamination. From the 1989 rock bass data collected by the WDNR, mercury contamination in resident fish populations has been documented in the AOC (refer to the later portions of this section). Because mercury is considered to be ubiquitous, further studies are needed to determine whether the mercury contamination in fish is from source(s) within or outside the AOC.

The fish contaminant monitoring data compiled by WDNR from 1976-1988 has also shown trace levels of other toxic pollutants in fish collected from the Menominee River near the mouth. These trace contaminants include: dieldrin, hexachlorobenzene, copper, chlordane and metabolites of DDT. These toxicants were detected below concentrations which would be of concern to human health and do not result in a fish consumption advisory. Data from these tests are listed in Appendix IV.2.

In 1985 and 1986, the Wisconsin DNR collected fish from the Menominee River and harbor area for dioxin and furan analyses. The location of the sampling sites were:

- Menominee River at Quinnesec,
- Menominee River in Lower Scott Flowage, and
- Menominee River harbor at Marinette

Refer to Figures II.1 and III.1 for a general location of the above sampling sites.

Results from these tests are contained in Table IV.3. The test results from 1985 and 1986 showed detectable levels for both dioxin and furans for the majority of the fish species sampled at all three locations. The concentrations observed in the fish fillets were well below the FDA action level for dioxin (25 parts per trillion). (Furans do not have an advisory level at present). However, the fact that dioxin and furans were detected at all in the fish samples taken from the Menominee River was a cause for concern, because there is a possible source of dioxins above the AOC. Dioxin has been detected upstream of the AOC in the effluent of Champion International (Quinnesec, Michigan) by the U.S. EPA in 1986.

As a result of 1985-86 data, additional monitoring for dioxin and furans was included in the 1989 WDNR fish collection schedule for the Menominee River. Sites for the dioxin/furan analyses included: Little Quinnesec Flowage, Lower Scott Flowage (between the two Scott Paper dams), and above Piers Gorge (below the Niagara Dam). Refer to Figures II.1 and III.1 for the general location of those sites. With the exception of the Lower Scott Flowage, all these locations are a considerable distance above the AOC.

Only the dioxin and furan test results from the Lower Scott Flowage have been analyzed so far. The toxicity equivalency concentration (the combined toxicity of selected types of dioxin and furans) was 1.89 parts per trillion (ppt) for the walleye and 7.79 ppt for the carp. These concentration levels are below the FDA guideline of 25 ppt for dioxin and the WDHSS and MDPH guidelines of 10 ppt. Refer to Appendix IV.3 for a summary of the dioxin and furan sample results from the Lower Scott Flowage.

Table IV.3 Dioxin Summary Data

Waterbody	Site Date	Species (#)	Fillet(F)/ Whole fish (WF)	Length (IN)	Dioxin 2,3,7,8 TCDD (ppt)[1]	Furans 2,3,7,8 TCDF (ppt)[1]
Menominee River @ Quinnesec, Mi						
	10/09/86	Carp	WF	31.0	21.0	17.0
	10/09/86	Redhorse (5)	WF	22.0	1.4	8.8
	10/09/86	S.M. Bass (5)	F	15.0	1.4	4.0
Menominee River @ Scott Paper Co., Marinette						
	09/26/85	Brown Trout	F		ND (3.2)[2]	
	09/26/85	Brown Trout	F		ND (3.2)[2]	30
	09/26/85	Brown Trout	F		2.8	
	09/26/85	Brown Trout	F		2.8	22
Menominee River Harbor						
	09/26/85	Carp (4)	F		8.0	
	09/26/85	Carp (4)	F		1.7	ND (17)[2]
	09/26/85	Carp (3)	WF		7.3	
	09/26/85	Brown Trout (5)	F	1.8		
	09/26/85	Brown Trout (5)	WF	1.4		

[1] ppt is parts per trillion
[2] ND means not detected at the detection level shown.

Dioxin/furan analyses from the other two sites above the AOC (Little Quinnesec Flowage and above Piers Gorge) are not available at this time. Data results from these locations will be compared to the Lower Scott Flowage when the analyses are completed later in 1990.

U.S. Fish and Wildlife Service (1984 and 1988)

In 1984, the U.S. Fish and Wildlife Service (USFWS) collected and analyzed 10 brown bullheads and 10 walleyes from the Lower Menominee River. Results of the whole fish analyses revealed detectable concentrations for the following toxic pollutants: PCBs, lead, nickel, mercury, arsenic, DDT, chlordane, furans, and dioxins. Results from the Menominee River were elevated for arsenic, lead, and nickel.

It should be noted that the USFWS data was the result of whole fish analyses rather than fish fillets. Because many contaminants selectively concentrate in specific body organs, the data were used to relate chemical body burdens in fish to the incidence of tumors, rather than for establishing health advisories for fish consumption. The USFWS test results will be discussed further in the section on "Fish Tumors or Other Deformities" below.

Michigan DNR (1987 and 1988)

The Michigan DNR collected fish in May 1988, at the mouth of the Menominee River as part of their fish contaminant monitoring program. The fish collected included carp and walleye. Ten individual fillets were analyzed for mercury and PCBs, as well as a general pesticide scan. Test results from the Michigan data are contained in Appendix IV.2.

Results of the analytical tests show elevated levels for mercury in the fillets of three of the ten walleye analyzed (0.86, 0.86, and 0.96 ppm), which is above both the MDPH trigger levels of 0.5 ppm (see Appendix IV.1). Concentrations of mercury in the carp fillets were below the 0.5 ppm level.

The results showed that some of the walleye and carp exceeded the FDA action limit for PCBs (2.0 ppm). PCB concentration levels were as high as 5.86 ppm in the carp and 5.52 ppm in the walleye. The Michigan data confirms the fish monitoring results from Wisconsin, that there is a health risk associated with eating walleyes over 20 inches in size because of mercury and PCB contamination, and that are also health risks associated with eating carp because of the high PCB levels.

Michigan test results for the rest of the contaminants monitored in the fish fillets revealed concentrations at less than detection, or below FDA action levels, with one exception. A sample analyzed for chlordane showed concentration levels in a walleye fillet at 0.53 ppm, which is above the FDA and MDPH action level of 0.3 ppm. Walleye over 20 inches in size are already listed in the Michigan and Wisconsin fish advisories.

Dames and Moore (1979)

Dames and Moore (1979) analyzed liver and fillet samples from walleyes and black bullheads for arsenic, mercury and cadmium. Samples were collected in July, 1979 upstream of the second Scott Paper Dam and below the first Scott Paper Dam. Mean concentrations in the muscle tissue of the bullheads and walleyes for arsenic, cadmium, and mercury are listed in Table IV.4.

Table IV.4. Mean Muscle Tissue Concentrations in Walleyes and Black Bullheads for Arsenic, Cadmium, and Mercury (Dames and Moore, 1979)

Species/Location	Arsenic (ppm)	Cadmium (ppm)	Mercury (ppm)
Species - Walleye			
Above the second Scott Paper Dam	0.007	0.35	0.69
Below the first Scott Paper Dam	0.006	0.40	0.46
Species - black bullhead			
Above the second Scott Paper Dam	0.005	0.38	0.33
Below the first Scott Paper Dam	0.016	0.17	0.15

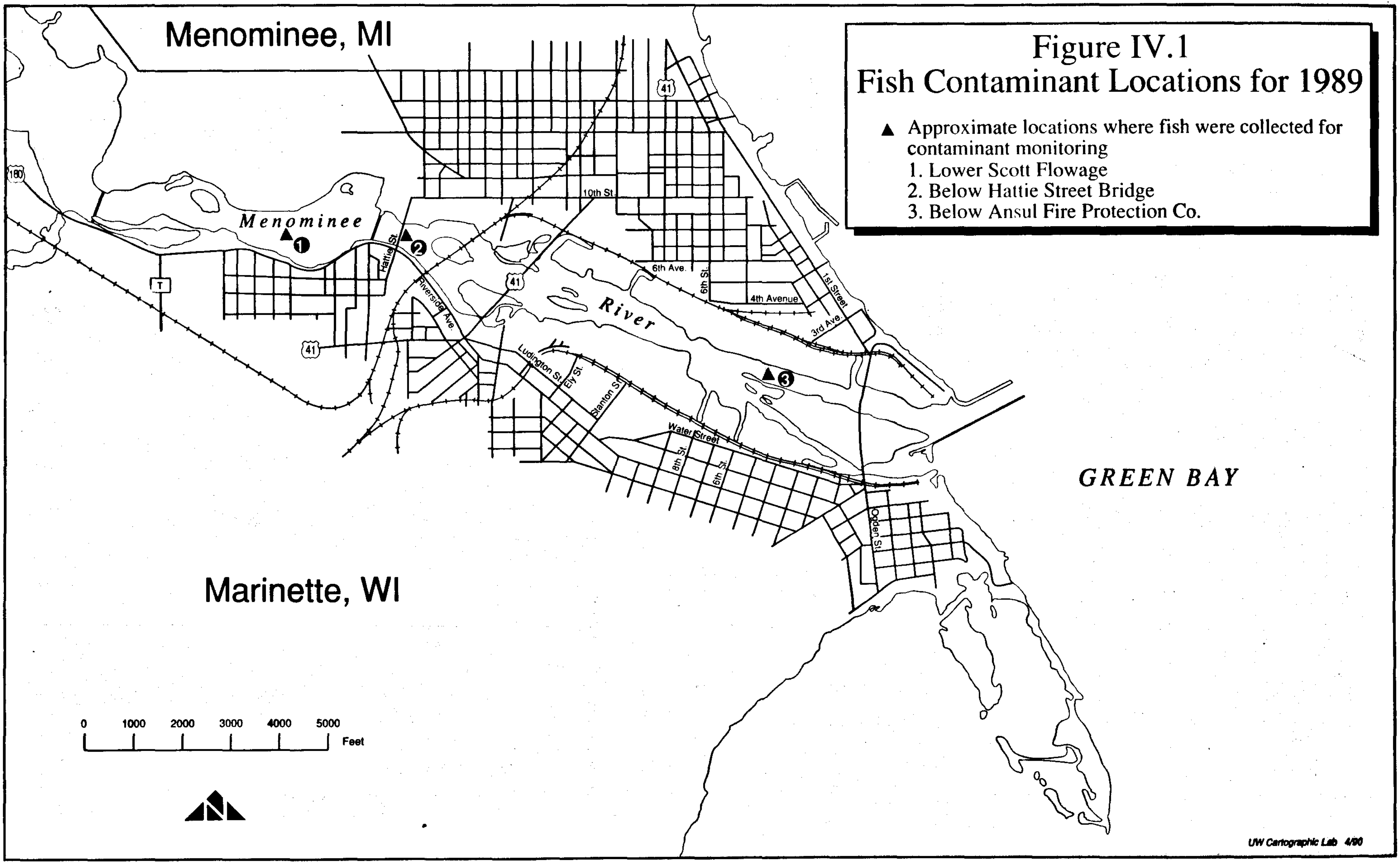
Note: Walleyes: 10 samples, length 10-27 inches, mean weight 2.2 pounds.
black bullheads: 10 samples, length 7.5-9.6 inches, mean weight 0.36 pounds.

The test results showed no statistically significant difference between upstream and downstream tissue concentrations for arsenic and cadmium for either species. Similar concentration levels for arsenic and cadmium in the muscle tissue were noted between the species. However, concentration levels for mercury were significantly higher in walleyes compared to the bullheads. The mean concentration in the walleyes above the second Scott Paper Dam (0.69 ppm) was above the FDA action level for mercury of 0.5 ppm. The average sample size for the walleyes was 11 inches and the average size for the bullheads was 5.5 inches.

Menominee River RAP Technical Advisory Committee Fish Contaminant Monitoring Recommendation (1989)

Based on Technical Advisory Committee recommendations, Wisconsin's fish contaminant monitoring program was expanded in the Menominee River in 1989. Sampling locations included the Lower Scott Flowage, below Ansul Fire Protection Company, at Hattie Street (26th Street), as well as several sites in the Menominee River above the AOC. Figure IV.1 shows the approximate location of the 1989 sampling sites in the AOC for the fish contaminant monitoring program.

Rock bass were collected as a representative resident species in the Menominee River and analyzed for PCBs, mercury, arsenic and cadmium. Sport fish (chinook salmon, splake, and walleye) and carp were also collected and are awaiting analysis for a number of toxic pollutants including PCBs, chlordane, dieldrin, DDT, furans and dioxins. Only the rock bass samples have been analyzed thus far. Table IV.5 provides a summary of the 1989 test results for the rock bass. High mercury levels in the rock bass (above the 0.5 ppm health advisory) were observed in two samples from the Lower Scott Flowage. The concentrations of mercury observed (0.53 ppm and 1.20 ppm) resulted in a health advisory for rock bass in Wisconsin's April, 1990 fish consumption advisory. Slightly elevated mercury levels (0.27-0.30 ppm) were also found in the rock bass at Hattie Street (26th Street) and below Ansul Fire Protection Company, which further substantiates that there is a mercury problem in certain fish species in the AOC.



Menominee, MI
Figure IV.1
Fish Contaminant Locations for 1989
▲ Approximate locations where fish were collected for contaminant monitoring
1. Lower Scott Flowage
2. Below Hattie Street Bridge
3. Below Ansul Fire Protection Co.
Menominee
River
10th St.
6th Ave.
6th St.
4th Avenue
1st Street
3rd Ave.
Hattie St.
Riverside Ave.
Ludington St.
Ely St.
Stanton St.
Water Street
8th St.
6th St.
Ogden St.
41
180
T
GREEN BAY
Marinette, WI
0 1000 2000 3000 4000 5000
Feet
UW Cartographic Lab 4/90

Table IV.5 Contaminant Test Results for Rock Bass Collected From the Menominee River in 1989.

Site	Size (inches)	PCB (ppm)	Hg (ppm)	Cd (ppm)	As (ppm)
Lower	4.60	<0.2	0.23	ND[1]	<0.5
Scott	4.34	0.7	0.23	ND	<0.5
Flowage	8.84	<0.2	1.20	ND	<0.5
	8.72	<0.2	0.53	ND	<0.5
Hattie	5.52	<0.2	0.27	ND	<0.5
Street	6.50	<0.2	0.30	ND	<0.5
	7.20	<0.2	0.29	ND	<0.5
Below	5.22	<0.2	0.20	ND	<0.5
Ansul	5.82	<0.2	0.18	ND	0.6
Chemical	7.14	<0.2	0.29	0.09	<0.5
	7.70	-	0.36	0.10	<0.5

(1) ND means no detection

Note: All results are in ppm (parts per million)
Hg is mercury
Cd is cadmium
As is arsenic

The rest of the data from the rock bass showed only one PCB test result above the detection limit in the Lower Scott Flowage. One arsenic and two cadmium test results were above the detection limit, both in samples collected below Ansul Fire Protection Company. Based on analyses of the test results for PCBs, arsenic and cadmium, concentrations of these contaminants in the rock bass indicate they are not present in this species at levels of concern to human health. Human health standards have not been established by the FDA for arsenic and cadmium as they have for mercury and PCBs. This is because arsenic and cadmium do not bioconcentrate in food chain, and consequently are not considered to pose a threat to human health as a result of fish consumption. Comparison of the rock bass data to the test results from the game fish will be made when that data becomes available.

In summary, the toxicants of concern in the Lower Menominee River for fish consumption are PCBs and mercury. Restrictions on fish consumption are considered an impaired use in the AOC because of the mercury contamination problem documented in the walleyes and rock bass. Restrictions on fish consumption with respect to PCBs is considered an impaired use in the AOC due to a regional contamination problem.

Wildlife Consumption

The State of Michigan has a general, waterfowl consumption advisory. This advisory applies statewide and recommends that the skin be removed and internal organs not be eaten. Wisconsin does not have a general waterfowl consumption advisory for the state nor is there an advisory in effect for the AOC. Waterfowl were collected for analyses in 1988 in the vicinity of Stephenson Island (2 mallards), Sixth Street slip (1 mallard), and Seagull Bar (2 mallards) by the Wisconsin DNR.

The five mallards were analyzed by the Wisconsin State Laboratory of Hygiene for PCBs, DDT, mercury, cadmium, and chromium. No detection in the tissue of the mallards was observed for DDT, cadmium and chromium. Three of the five mallards had detectable concentrations of PCBs in their tissue (0.46, 0.37, and 0.21 ppm) and two mallards had detectable levels of mercury (both at 0.06 ppm). FDA action limits for poultry, applied to waterfowl, are 3 ppm for PCBs and 0.1 ppm for methyl mercury. Based on these test results from the five mallards collected in 1988 by the WDNR, wildlife consumption is not considered an impaired use in the AOC.

Additional waterfowl were collected by the WDNR in 1989 below the Lower Scott Flowage at Stephenson Island (5 mallards) and at Red Arrow Park (2 mergansers and 2 goldeneyes). The tissue from these nine (mallards, mergansers and goldeneyes) ducks are still awaiting analyses for PCBs and mercury at the Wisconsin State Laboratory of Hygiene.

Tainting of Fish and Wildlife Flavor

In past years there have been infrequent complaints about fish flavor, particularly in walleye, informally noted by WDNR staff in the AOC. Walleye from the Lower Menominee River have a slightly different flavor than walleye from inland lakes (Belonger, 1989). Since walleyes from Green Bay eat alewife and smelt, the diet could account for some of the difference in flavor.

Because tainting of fish flavor in the AOC has not been noted in recent years, this is not considered an impaired use. No tainting of wildlife flavor has been noted by WDNR or MDNR in the Lower Menominee River.

Degradation of Fish and Wildlife Populations

Fish

Fish species that migrate up the Menominee River include rainbow and brown trout, lake sturgeon, emerald and spottail shiner, splake, chinook salmon, coho salmon, pink salmon, northern pike, walleye, alewife, smelt, smallmouth bass, perch, white suckers, long nose suckers, and carp. The diverse Lower Menominee River fishery is due to the presence of migratory species from Green Bay. Since 1984, smelt runs have been almost non-existent in the Menominee River. The discontinued use of the Menominee River by smelt has not been explained, however, river avoidance by the smelt is a Green Bay-wide phenomena. The University of Wisconsin-Stevens Point received funding in 1990 from the University of Wisconsin Sea Grant Institute to research why smelt are no longer using the Menominee River by determining if there are differences in lake and river smelt spawning populations. Preliminary data has been collected for the study which is expected to continue over the next few years.

The Menominee River is located close to sources of pollution in Lower Green Bay that include contaminants such as PCB's. Some fish and wildlife species may bioaccumulate and/or bioconcentrate toxic substances in one area and then move to other locations. Consequently, because of fish and wildlife mobility, it is sometimes difficult to separate degradation resulting from problems inside and outside the area of concern. Pollution within the AOC, nonetheless, causes some degradation to fish populations as indicated by recent fathead minnow ambient bioassay test results, (Tusler, 1989 and Masnado, 1989) (refer to Appendix IV.4).

The acutely toxic effect to fathead minnows which occurred at two of nine bioassay sampling sites--at the Eighth Street slip area and directly across the river (1,000 feet from the Menominee WWTP)--provides evidence of potential degradation to the forage fish species in these areas. Additionally, electrofishing surveys conducted by WDNR in various years from 1983 to 1987 demonstrated very low numbers of fish in the Eighth Street slip (Belonger, 1990). This electrofishing data, coupled with bioassay results, supports the conclusion that the fish populations in certain areas of the AOC are locally degraded.

There is also evidence of fish population impairment based on habitat loss or alteration. The bottom substrate has been significantly altered by historic discharges of wood fiber and wood by-products.

In spite of these impairments, fish populations are noted by both MDNR and WDNR to be very good and generally not degraded for the entire AOC. However, the localized degradation and habitat alteration warrant the impaired use designation.

Disclaimer

The MDNR does not support the conclusions of the Tusler bioassay study due to concerns with the field methods used to collect the samples. MDNR believes these methods have not been validated, and therefore may not be representative of conditions in the Lower Menominee River.

Wildlife

Limited documented information is available on wildlife populations in the AOC. Comparisons made between the original land survey of Wisconsin and more current U.S. Geological Survey topographic maps indicate that as much as 30 square miles of wetland habitat have been lost in the Peshtigo Township containing the southern half of the AOC (WDNR, 1976). A principal axiom of wildlife biology states that carrying capacity is dependent upon habitat availability, diversity and quality. Substantial reductions in waterfowl populations and wildlife diversity have occurred in and around the AOC in the last 25 years (Linteur, 1990). According to Linteur, the reductions in waterfowl populations and wildlife diversity were strongly tied to bay-wide rises in water depth and an increase in carp. The increase in water depth has resulted in massive die-offs of emergent macrophytes (aquatic plants). Subsequent to the rise in water levels, a significant increase in carp populations caused major losses in dormant aquatic macrophyte root stocks which severely limited the potential for recovery of these plant communities (Linteur, 1990).

Continent-wide declines in waterfowl populations have impacted waterfowl abundance in the AOC. Losses in habitat, resulting from both filling of wetlands and rises in water levels have limited the quality and abundance of wetland habitat in the area. Although waterfowl populations have substantially declined from historical levels, this is not considered to be an impaired use. A decline in wildlife population and diversity cannot be attributed to man-made occurrences at this time. Efforts to restore populations to historical levels in the AOC would be limited by the success of continental populations and natural changes in the bay. It should be noted however, that loss of wildlife habitat, as a result of wetland filling, has been identified as an impaired use (Table IV.I).

One snapping turtle (weighing 50.6 pounds) sampled from the Marinette area by WDNR in 1984 had a high concentration of PCBs (130 ppm) in its abdominal fat. Unfortunately, information on turtle's age was not collected routinely in 1984. Age classification of snapping turtles is necessary to evaluate contaminant levels with respect to environmental exposure since snapping turtles have very long life spans (~100 years) and may accumulate compounds such as PCBs throughout their lives (Hurley, 1990). Snapping turtle habitat may also cover a large area and therefore may not be indicative of conditions within the AOC. Nonetheless, contaminant monitoring for turtles will be addressed in Stage II of the RAP.

The Wisconsin DNR has sampled bald eagles, woodcock, and raccoons from Marinette County for a wide range of contaminants, including metals and organics. Data are presented in Appendix IV.5. The Michigan DNR has also sampled bald eagles. In addition, the Wisconsin DNR collected waterfowl species (mallards, mergansers, and goldeneyes) for analysis in 1988 and 1989 in the AOC as part of the wildlife contaminant monitoring program (refer to the section on "Wildlife Consumption" earlier in this chapter). Based on limited wildlife data collected by the MDNR and WDNR, impairment of wildlife populations from ingestation of toxic chemicals is not an identified problem in the Lower Menominee River.

Fish Tumors or Other Deformities

Studies conducted jointly, beginning in 1984, by the Great Lakes Fishery Laboratory and the Columbia National Research Laboratory of the U.S. Fish and Wildlife Service, investigated the incidence of tumors in near shore fish populations in the Great Lakes. The Menominee River and the Fox River were two of the tributaries selected for the study.

Walleyes and bullheads were collected for gross pathological examination, histological analyses, as well as whole chemical body concentrations for hydrocarbons, metals, chlorinated pesticides, dioxins, PCBs and furans. Unpublished results from the U.S. Fish and Wildlife Service (USFWS) (Mac, 1987) indicated that pathological examination of 40 walleyes from the Menominee River revealed no visible dermal or internal tumors. Histopathological examination of the livers revealed that two walleyes had subtle alterations or changes in the liver tissue. Of the 47 bullheads collected from the Menominee River, no gross tumors and no histological alterations were found.

Results of the contaminant analyses for whole fish are listed in Table IV.6. The results shown in Table IV.6 were based on analyses of 10 brown bullheads and 10 walleyes collected in 1984. The mean length of the bullheads was 10 inches with a mean length of 15 inches for the walleyes. Concentration levels for arsenic, nickel, and lead are higher in the whole fish in the Menominee River compared to other sites sampled by the USFWS for the National Contaminant Monitoring Program, including the Fox River.

Table IV.6 Average Contaminant Levels for Whole Body Samples of Walleyes and Bullhead Taken from the Menominee River by USFWS in 1984

Parameter	Walleye	Bullhead
PCBs (ppm)	3.0	0.75
Arsenic (ppm)	0.31	0.16
Lead (ppm)	-	0.34
Nickel (ppm)	-	0.82
DDT (ppm)	0.68	0.31
Chlordane (ppm)	0.09	0.04
Dieldrin (ppm)	0.05	0.01
Dioxin (ppt)	12	13
Furans (ppt)	52	13

Whole body chemical burdens for specific contaminants were correlated to the incidence of tumors in walleyes and bullheads in near shore populations in the Great Lakes. Results of these correlations are not available at this time. The USFWS will be publishing a report in 1990 on the information (Mac, 1989).

As a follow-up to the 1984 study, the USFWS collected additional fish for analyses in May and September 1988. Results of that study will be published in a separate report, which is not available at this time.

No other studies have been conducted to determine if tumors or other deformities exist in fish in the Menominee River. The results from the 1984 USFWS study indicate early changes in the liver tissue of a small number of sampled walleyes that may or may not progress to a cancerous tumor stage. However, the USFWS study indicated no evidence of actual tumors in the walleyes. Based on the limited data available, fish tumors or other deformities do not constitute an impaired use. Continued ambient monitoring of the fish for tumors in the AOC will likely occur as part of the recommendations in stage II of the RAP.

Bird or Animal Deformities or Reproductive Problems

There have been no recorded incidences in the AOC of bird or animal deformities. Evidence suggests that the abnormalities that occur are primarily confined to outside the AOC and the problems are not manifested in the Menominee River.

In areas such as Green Bay, where contaminants remain high, excessive deformities have been recorded in Forster's tern as well as other fish-eating bird colonies (Toxic Substances Task Force, 1983). The historic abnormalities recorded in Green Bay have been at least 50 times more prevalent than in normal populations, and five to ten times higher than in any other locations in the Great Lakes for any species to date (Fitchko, 1986).

Double crested cormorants with crossed-bill deformities have been found in the mid and upper portions of Green Bay (Green Bay Remedial Action Plan, 1987). The highest number of deformed cormorant sightings in Green Bay have been in the area where Green Bay meets Lake Michigan. Crossed bill cormorants were first seen in Michigan colonies on Upper Green Bay in 1980 (Ludwig, 1983). Since then, some 73 deformed cormorant sightings have been recorded in Green Bay (Ludwig, 1988). Abnormal thyroids in herring gulls were found in Lower Green Bay in 1983 (Moccia, et al., 1985).

The lack of any recorded incidences of deformities to birds or animals in the AOC indicates that this is not an impaired use in the Lower Menominee River.

Degradation of Benthos

Several studies have documented degradation of benthos (bottom dwelling organisms) in and around the turning basin in the Menominee River. Causes attributed to the lowered diversity and abundance have varied. Dames and Moore (1979) found a reduction in species diversity and abundance in the turning basin compared to the main channel. The dominant species found were identified as organisms tolerant to pollution. Dames and Moore (1979) reported that the densities of even these tolerant species appeared to be low based on the organic type sediments available. They found elevated levels of arsenic, cadmium, and mercury in the tissue of benthic organisms. Species diversities, concentrations of arsenic, cadmium, and mercury in benthic tissues, and sampling locations are presented in Appendix IV.6.

The U.S. EPA determined there was a virtual absence of benthic organisms in the turning basin and low benthic populations at the river's mouth. Heavy arsenic pollution was interpreted by U.S. EPA as the likely cause since there were substrate and nutrients available to support a diverse benthic population (U.S. EPA, 1975). Taxonomy and sampling locations are presented in Appendix IV.5.

A study conducted by WDNR (Ball, 1974) did not find benthic organisms within 150 yards of the Ansul Fire Protection Company outfall (located on the eastern shore of the turning basin near the river channel). Habitat in this area was described by the study as very poor, and the bottom was covered by a black, oily substance with a strong sulfur odor. Pollution tolerant benthic organisms were found, although not abundant, at the mouth of the river. At this location, the soft bottom was comprised of silt or muck, which was also described as poor habitat. This study found high levels of cadmium in the water column and sediments near the Ansul Fire Protection Company outfall. Aqua-Tech, in a subsequent study conducted in 1985, found no detectable levels of cadmium in the water column near the Ansul Fire Protection Company outfall.

Michigan DNR conducted a biological study of the Lower Menominee River in July, 1980 (Evans, 1980). River bottom samples from the five sample sites were collected using a six inch ponar dredge. Included in the analysis is a description of the sample site. Biota (phytoplankton, periphyton, filamentous algae, macrophytes, slimes, zooplankton, macroinvertebrates, fish) abundance was identified for each sample site according to the following categories: absent, sparse, moderate, abundant, profuse. At each sample site all biota types were categorized by MDNR as absent, sparse or moderate. Sampling site locations and data collected for this study are presented in Appendix IV.6.

Benthic habitat has been degraded in Green Bay just off shore of the Lloyd/Flanders Furniture Company. Paint sludge wastes cover the bottom of an estimated 22,500 square foot area for 1 to 2 feet in depth (GZA-Donohue, 1989). Benthic populations are likely degraded in this location; however, no data is available to identify any adverse impacts.

Recent WDNR bioassay results (August, 1989) confirm that acute toxicity does occur to Ceriodaphnia dubia and Daphnia magna (small water fleas commonly called daphnids) in the turning basin and Eighth Street Slip area (refer to Table IV.9); however, causes cannot be specifically determined at this time. The daphnids, although they are not benthic organisms, are indicative of the potential for acute toxic effects to the benthos (Mount et al.; 1984, 1985, 1986). The benthic community is suffering from the effects of poor habitat in the portion of the Menominee River below the Highway 41 Bridge, which is combined with the potential for an acute toxic effect in certain locations, such as the turning basin and the Eighth Street Slip.

As part of a long term benthic trends analysis for the Fox River and Green Bay a study was conducted by Integrated Paper Services in 1988-1989 (Rades, 1990). The intent of the long term study is to map the water quality and seasonal effects on benthos throughout Green Bay. One of the sampling sites for this recent study was position 130 located off Marinette-Menominee at the Green Island Bell Buoy (Lat. N45•04'20", Long. W87•32'30"). Position 130 was in sand substrate at a depth of 60 feet.

The dominant organisms at this site were scuds. The study found "outer bay" sampling sites such as site 130 generally were "inhabited by a moderately diverse and abundant benthic fauna" (Rades, 1990). It was noted by Rades that the "high probability of Lake Michigan water intrusions/exchange" as well as decreased effects from pollutants entering the bay from the south, probably accounted for composition variance between benthic communities in the lower bay and the outer bay. Rades suggested future trends in water quality at the outer bay sites would be influenced principally by Lake Michigan waters. No seasonal benthic quality changes were noted from 1987-1988 data for the outer bay sampling positions (Rades, 1990). Results from this study indicate that benthic communities in Green Bay off the Menominee River are healthy, particularly when compared to the condition of benthos in the turning basin area of the river.

Additionally, concentrations of PCBs in sediments and total benthic body burden were analyzed at selected sites in the Rades Study. Four of seven selected sites had total PCB sediment concentrations above the 0.05 ppm (dry weight) detection limit. Site 130 had a PCB sediment concentration of 0.05 ppm (dry weight). Total PCB body burden in benthic organisms was detected at six of seven selected sites. The body burden and sediment analyses were not necessarily conducted on samples from the same sampling positions. Site 130 was not sampled for benthic PCB total body burden. Based on the PCB total body burden analysis Rades states that "the PCB data obtained generally followed a concentration gradient based on the Lower Fox River as the primary source." Rades advises against further extrapolation using the sediment and body burden PCB concentrations.

Based on the benthic studies conducted decreased diversity and abundance of the benthos may be due to unsuitable habitat, toxic conditions, or a combination of the two. The Menominee River bottom has been clogged with saw mill wastes since the boom in the lumber industry in the late 1800's and early 1900's. During sediment sampling efforts, WDNR personnel noted the presence of a thick blanket of decayed wood chips and wood fiber on the river bottom. Both the saw mill wastes and ship activity decrease the habitat quality in the river.

A review of all the available data indicates that the benthic populations are degraded, particularly in the Eighth Street Slip area and turning basin, and consequently that the use is impaired.

Restrictions on Dredging Activities

Restrictions on dredging activities is an impaired use in the area of concern. The Lower Menominee River and Harbor is classified as a federal navigable harbor and is used as a diversified cargo port. It has a history of being a harbor for navigation as well as a history of dredging. The harbor has been dredged six times since 1961 (see Table VII.1, Chapter VII) and is scheduled to be dredged again in 1990. Dredge spoils have been disposed of in open water within Michigan's Lake Michigan boundary. Wisconsin does not allow open water disposal of dredged sediments in State of Wisconsin waters.

The last time the shipping channel was dredged was in 1982; at that time, the turning basin was not dredged because of high levels of arsenic contamination. Currently, ships using the river are equipped with bow thrusters and no longer need the turning basin to leave the river. A study to assess future navigational dredging of the Menominee River will be conducted by the U.S. Army Corps of Engineers (COE) in 1990. Because the contaminated sediments limit dredging and disposal options, the restrictions on navigational dredging constitute an impaired use.

Some of the arsenic contaminated sediment is concentrated enough that, should it be dredged, it could be classified as a hazardous waste (Baker, unpublished). Refer to the "Sediment Quality Assessment" section later in this chapter for a discussion of the arsenic contamination problem. Since Wisconsin does not have a hazardous waste disposal facility, these sediments would have to be treated on site and/or disposed of out of state. The degree of arsenic contamination limits the range of available environmental restoration options for this area.

Eutrophication or Undesirable Algae

Eutrophication is a process by which waterbodies are enriched with nutrients. While the process is natural, human activities (from both point and non-point sources) greatly accelerate the rate by adding phosphorus and nitrogen. As nutrients are added to waterbodies, they become more fertile over time resulting in what is termed a eutrophic lake or stream.

No eutrophication problems have been documented in the Menominee River. Ambient monitoring data collected by the Michigan DNR at the Hattie Street (26th Street) bridge from the early 1970's through the present indicates low levels of nutrients present in the river. Additional monitoring was initiated in 1989 by the WDNR in the Menominee River AOC (based on Technical Advisory Committee recommendations) with one of the goals being to assess if there was, or was not, a eutrophication problem. Appendix IV.12 provides water chemistry test results from monitoring conducted on the Menominee River in 1989-90.

Table IV.7 Concentrations of Key Parameters Used to Assess Eutrophication

Parameter	Mouth of the Menominee River[1]	Hattie Street Bridge (26th Street)	Eutrophic Levels[4]
Dissolved phosphorus (ppm)	0.0047	0.008[3]	
Total phosphorus (ppm)	0.03	0.02[2]	0.05[5]
Total kjeldahl nitrogen (ppm)	0.55	0.45[2]	
Chlorophyll-a (ppb)	6.4	2.4[3]	14[6]

(1) Mean values based on approximately 20 samples taken in 1989.

(2) Mean values based on 60 samples collected from 1985-89.

(3) Mean values based on 100 samples collected from the early 1970s through 1984. No data were available for dissolved phosphorus and chlorophyll-a over the last five years (1985-89).

(4) Concentration levels commonly associated with eutrophic conditions.

(5) Average phosphates (as total phosphorus) should not exceed 0.05 ppm at the point where a stream enters a lake (U.S. EPA, 1976).

(6) Chlorophyll-a levels above 14 ppb are generally associated with eutrophic conditions in lakes.

NOTE: ppm is parts per million, ppb is parts per billion.

As part of this monitoring effort, water quality data have been collected each week since March, 1989, at the mouth of the Menominee River by the U.S. Geological Survey (USGS) in conjunction with the Green Bay mass balance study. Sampling was discontinued at this site in April, 1990. Based on the data analyzed thus far from this location, the results are similar to the monitoring data from the Hattie Street (26th Street) bridge. The conclusion, after examining all the information available, is that eutrophication is not a problem in the AOC. Average concentrations for several parameters, frequently used as indicators of eutrophication, are summarized in Table IV.7.

The average values for phosphorus, nitrogen and chlorophyll-a in the Lower Menominee River are below concentration levels normally considered to result in eutrophication problems. Of the parameters listed in Table IV.7, only total phosphorus has recommended criteria. U.S. EPA suggests total phosphates (as phosphorus) should not exceed 0.05 ppm in any stream at the point where it enters a lake or reservoir (U.S. EPA, 1976). The phosphorus concentration at the mouth of the Menominee River averaged 0.03 ppm and 0.02 ppm at the Hattie Street (26th Street) bridge, both of which are below the 0.05 ppm U.S. EPA criterion.

Eutrophication may also negatively impact water supplies, recreational and aesthetic uses, and water quality needed to sustain fish and other aquatic life. Table IV.8 describes potential water quality problems which may occur as a result of excessive primary producer (algal) growth (U.S. EPA, 1983). Based on limited data and verbal contact with the Health Departments in the Cities of Marinette and Menominee, negative water quality impacts to the water supply systems, because of algal production, has not been a problem in the Menominee River. Occasionally, some algae has been observed on the south shore of the Menominee River in Marinette. However, it has not been documented that nuisance algal conditions occur in either the Menominee River or in Lake Michigan in the vicinity of the AOC.

Reduction in nutrient loadings (especially phosphorus) to the Great Lakes is a key IJC Management Objective as stated in Annex 3 of the 1978 Great Lakes Water Quality Agreement. Additional water quality data has been gathered by USGS and WDNR at upstream (above the AOC) and downstream (mouth of the river) sites to document nutrient loadings from the Menominee River to Green Bay. Preliminary results from the analytical tests show low nutrient levels at both the upstream and downstream locations.

Restrictions on Drinking Water Consumption, or Taste and Odor Problems

The water supplies for the Cities of Marinette and Menominee are from Green Bay and meet drinking water standards. There have been no restrictions on drinking water consumption. Isolated taste and odor problems occurred in the early 1970's in the City of Menominee's water supply and were traced to blue green algae (Stuppnig, 1989). There have been no reported taste and odor problems since 1973. The City of Marinette has not had any reported taste and odor problems (Mann, 1989).

Based on available information, there are no restrictions on drinking water consumption or associated taste and odor problems that would designate this as an impaired use.

Beach Closings

The City of Marinette has only one designated swimming area (Red Arrow Park) along the riverfront and bay shore. The water at Red Arrow Park is not monitored for bacteria. Pine Beach is a private swimming beach on the shore of Green Bay across from Sea Gull Bar. The City of Menominee has two designated swimming areas (Henes Park and Tourist Park) and the water is monitored for bacteria levels. No closings of designated swimming areas have occurred as a result of this monitoring. Therefore, beach closings is not considered to be an impaired use in the AOC.

Table IV.8 **Assessment of the Water Quality Impairment Associated with Eutrophication**

Type of Use - Use Impairment	Comment on Menominee AOC
Water Supply - Taste and odor impairments - Filter clogging - Turbidity - Increased chlorine demand - Algal growth in distribution system - Blockage of intake screens	No problems are known to exist with the City of Marinette Water Supply. The City of Menominee experienced some taste and odor impairments at one time (1970-73). However, no taste and odor problems have been experienced recently, nor any other problems with the water supply.
Aesthetics - Floating mats - Surface scums - Turbidity - Rooted aquatic plants	No documented problems are known to exist.
Swimming/Boating/Water Contact Sports - Excessive macrophyte and filamentous algae in shallow areas	Some algal growth has been observed along the south shore of the Menominee River in Marinette, but nuisance conditions have not been documented.

Total and Partial Body Contact

Elevated bacterial levels, exceeding Michigan and Wisconsin water quality standards in localized areas of the Menominee River, have been associated with wet weather events. Wisconsin recently concluded a sanitary sewage rehabilitation and combined sewer separation program to eliminate a sewage by-passing problem on its side of the river. Michigan's CSO policy states that the discharge of raw sewage from CSO's is unacceptable and must be adequately treated. The City of Menominee is currently under a court order to control all CSO discharges by addressing both short-term and long-term conditions specified in the order, including the implementation of a CSO correction program by August 1, 1990. New language will be incorporated in the

NPDES permit to be issued later this year that will specify additional actions to be taken. Elevated levels of bacteria limit total and partial body contact in localized areas of the Menominee River in the vicinity of the CSOs during certain times of the year. Therefore, total and partial body contact is considered to be an impaired use in the AOC.

In 1989, the City of Menominee and the Delta-Menominee District Health Department indicated that fecal coliform levels inside the Menominee Marina wall (666 counts/100 mL and 364 counts/100 mL) and just outside the wall (204/100 ml) exceeded Michigan's water quality standards (200 counts/100 mL). Fecal coliform is an indicator organism used to indicate the presence of sewage in water. The marina is located north of the mouth of the Menominee River on the shore of Green Bay (Figure III.2). Although this is not an officially designated swimming area and swimming is strictly prohibited, signs were posted in the marina to prevent unlawful swimming and warn the public about the related bacterial hazard during the 1989 boating season. Two suspected sources of fecal coliform bacteria are the marina's large duck population and the possible leakage or dumping of boat holding tanks within the marina's walls (Leslie, 1989). Michigan law strictly prohibits the practice of dumping of boat holding tanks. Pump out service, however, is available at the marina. There are storm sewer outfalls to Green Bay in the vicinity of the marina; however, the frequency of discharge is considered by the City of Menominee to be low (Leslie, 1990). The Menominee Town Council will form a task force to study this water quality problem during the 1990 boating season. Because of these elevated bacteria levels, total body contact is considered to be an impaired use in the marina area.

Degradation of Aesthetics

There is no evidence to suggest that water quality aesthetics are degraded in the AOC. Consequently, degradation of aesthetics is not considered to be an impaired use in the Lower Menominee River. Shoreline aesthetics are being addressed separately by the Citizen's Advisory Committee as part of the RAP process.

Added Cost to Agriculture or Industry

There is no agriculture in the AOC that uses water from the Menominee River; the immediate drainage area is entirely in a metropolitan setting. Pretreatment of intake water is not required by most industries on the Menominee River for use as process or cooling water. Menominee Paper Company uses river water in its production process. Approximately 0.5 million gallons per day (MGD) is treated in a conventional water treatment plant to remove color and turbidity. However, the company has not noticed any degradation in river water quality. Since there are no added costs to industry in the AOC, this is not considered an impaired use.

Degradation of Phytoplankton and Zooplankton Populations

Phytoplankton and zooplankton form the basis of food chains in the aquatic environment. Changes in their abundance or diversity may adversely affect the animals that depend on them. A healthy aquatic ecosystem depends on the phytoplankton and zooplankton populations and on the balance of these populations.

A study conducted by WDNR (Ball, 1974) found that arsenic entering the river from the Ansul Fire Protection Company site was tied up by algae or adsorbed by suspended particles and then was precipitated out almost immediately. The study found that plankton (phytoplankton and zooplankton) populations collected by plankton tows from just below the Highway 41 bridge and near the turning basin were essentially the same (see Figure III.2 for locations). Therefore, phytoplankton, and zooplankton populations are not believed to be degraded. Recent bioassay results from August 1989 (Tusler, 1989 and Masnado, 1989) indicate potential adverse impacts to the zooplankton populations in the turning basin and at the Eighth Street Slip due to acute toxic effects. However, additional testing, especially of the water column in these areas (only "sediment water" was tested in the bioassay), is necessary to determine if toxicity is a persistent problem and whether it represents in situ conditions.

Based on review of the available data, phytoplankton and zooplankton populations are not considered to be impaired in the AOC.

Loss of Fish and Wildlife Habitat

Habitat loss in the Menominee River AOC is difficult and nearly impossible to quantify due to historic use of the river. Wetlands and other fish and wildlife habitat, once common on the river's edge, were largely eliminated by the practices of the lumber industry from the mid 1800's to about 1917. Log jams from the lumber industry clogged the river. Wood chips, bark, and other saw mill wastes were dumped along the shoreline. The river bottom still contains the remains of these wastes. The Marinette river's edge remained a disposal site for a period of years for other materials as well. The City of Marinette used the river's edge as a municipal dump site which was eventually filled to provide land for industrial development.

Plant communities found in present day wetlands in the AOC are the result of reestablishment of aquatic plant species in undeveloped parcels of land on the south shore of the turning basin and between the Sixth and Eighth Street Slips. Other small wetland areas are located between the Sixth Street Slip and Waupaca Foundry, and between Red Arrow Park and Seagull Bar Natural Area (Figure III.3). Upland habitat is only found west of the Waupaca Foundry, in Red Arrow Park and in Seagull Bar Natural Area (Figures III.2 and V.1). Some of the islands in the Menominee River also provide small areas of wildlife habitat. Green Island, located in the bay several miles from the mouth of the river, contains additional wildlife habitat. The Citizen's Advisory Committee has recommended that Green Island be included in the AOC because it is functionally connected to the AOC. Additional acreage between Red Arrow Park and the former M & M Box Company may also have limited value as wildlife habitat.

As described above, habitat reduction and fragmentation has occurred primarily because of the destruction and development of wetland sites and development of upland sites. Carp populations have also contributed to alteration of the wetland habitat by uprooting underwater plants and stirring up sediments, thereby increasing turbidity.

Due to substantial losses in habitat resulting from both filling of wetlands and rises in water levels (refer to the section on "Degradation of Fish and Wildlife Populations"), the abundance and quality of fish and wildlife habitat have declined significantly from historical levels. Wildlife habitat is considered to be impaired due to loss of wetlands resulting from urbanization. Loss of wetlands has not resulted from water quality problems. Water level fluctuations are a natural occurrence and will continue to cause variations in emergent wetlands.

Water quality contamination has resulted in the loss of fish habitat in the AOC, specifically in the Eighth Street Slip and South Channel areas. Sediments in these areas have affected the water quality through release of toxic pollutants (i.e., arsenic) as described in the Sediment Quality Assessment Section of this chapter. In addition, transport of toxic pollutants into the river via groundwater has adversely affected the water quality. Evidence of toxic water quality conditions in the river was observed in the bioassay conducted on sediment water (water collected from just above the sediments, see Table IV.9) from the Eighth Street Slip sampling location which resulted in fathead minnow (Pimephales promelas) mortality. Contaminated sediments and the toxic effect observed in the sediment water indicate a loss of fish habitat due to water quality problems. Electrofishing survey information also supports this conclusion. Data gathered through electrofishing by Brain Belonger in 1983 and 1987 showed very low numbers and diversity of fish in the Eighth Street Slip area which further substantiates that habitat for these fish is degraded.

MAJOR POLLUTANTS

Biota Quality Assessment

Benthos

Elevated levels of arsenic have been detected in benthic organisms by Dames and Moore (1979), an environmental consulting firm retained by Ansul Fire Protection Company. Dames and Moore reported arsenic concentrations in benthic tissue (wet weight) that ranged from <10 ppm to 13,900 ppm for fourteen sites in the river (Appendix IV.6) The concentrations from the turning basin sites were the highest reported values: 13,900 ppm, 752 ppm, and 1,880 ppm. The average arsenic concentration in benthic tissues from the remaining sites was reported as <55.0 ppm. Three Green Bay sites had benthic tissue concentrations of 40.2 ppm, 21.4 ppm, and <10 ppm. These concentrations were much higher than the average arsenic concentration in Lake Michigan benthos of 2 ppm as reported by Copeland and Ayers (1972). According to the Dames and Moore study, cadmium and mercury were also detected in the benthos. Wet weight concentrations of cadmium in benthos ranged from <10 ppm to 480 ppm. An average background concentration of cadmium in Lake Michigan aquatic invertebrates was not found in the literature. Wet weight mercury concentrations in benthos ranged from <6.0 ppm to 120 ppm (refer to Appendix IV.6). Typical mercury concentrations in aquatic invertebrates from Lake Michigan range from 0.03 to 0.05 ppm (Huckabee, 1979). Comparing the tissue levels for arsenic and mercury in benthos from the turning basin to average concentrations from Lake Michigan invertebrates indicates that these two pollutants are elevated in the benthos from the Lower Menominee River.

A more recent Wisconsin DNR bioassay study (Tusler, 1989 and Masnado, 1989) showed mortality to test organisms. Bioassays were performed on two zooplankton species: Ceriodaphnia dubia and Daphnia magna. Sediment water for bioassays was collected at nine different locations (Figure IV.2) in the Menominee River using a sediment/water sampler. The water collected from the sampler is referred to as sediment water (see the footnote in Table IV.9 for a description). A description of the sampler, the methodology of the sample collection, and a discussion of the bioassay results are contained in Appendix IV.4. Several dilutions of the water from the samplers were made with river water, and the bioassays were performed with the resulting test water. The results showed daphnia mortality even at large dilutions (6.25% sediment water) at two sites: the turning basin and the Eighth Street Slip. The bioassay results, presented in Table IV.9, identified acute toxicity for both species of daphnids at the two locations. Since benthic macroinvertebrates are relatively sedentary organisms which live in the sedimentary environment, they may be similarly affected.

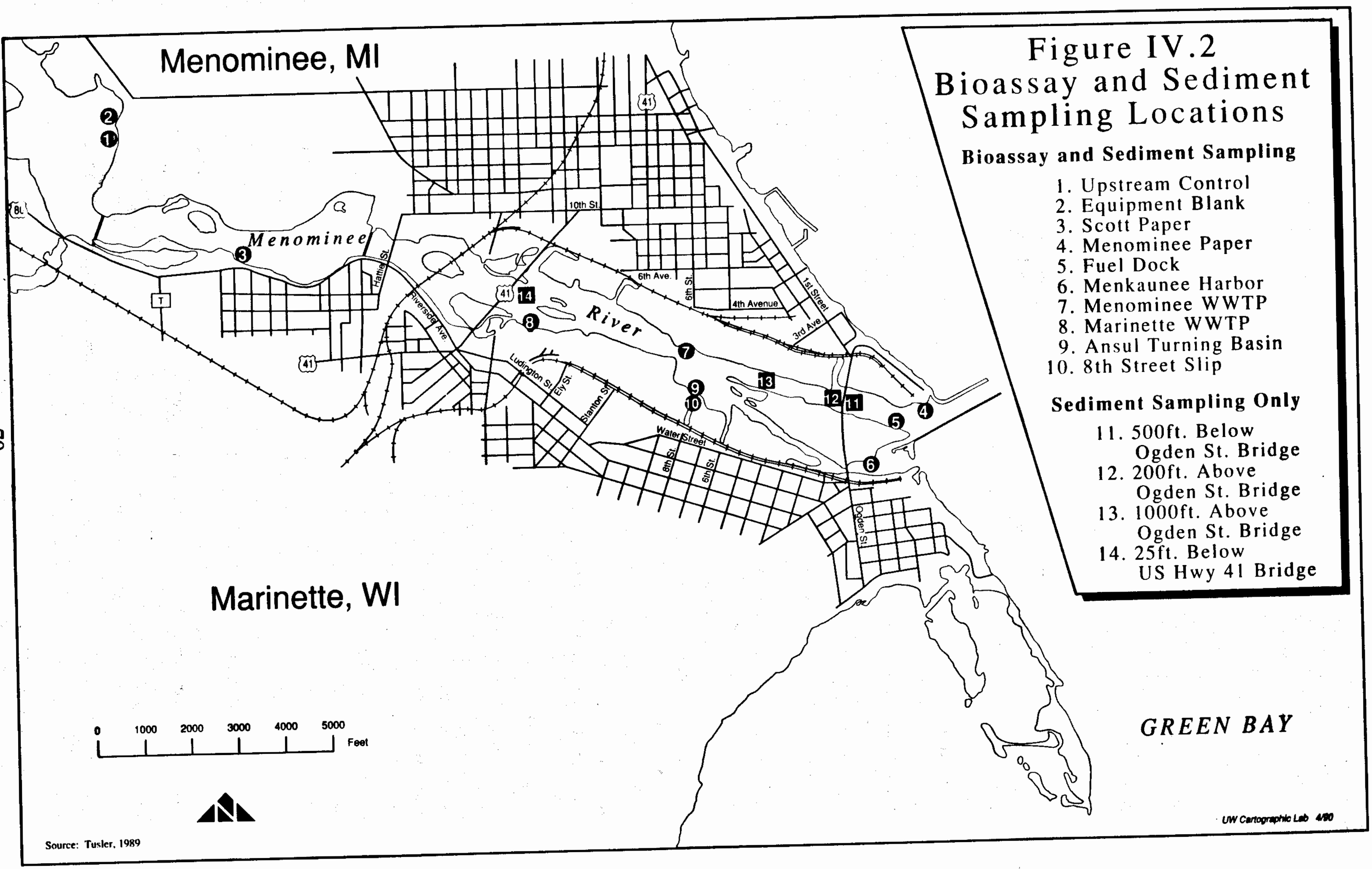


Figure IV.2
Bioassay and Sediment Sampling Locations
Bioassay and Sediment Sampling
1. Upstream Control
2. Equipment Blank
3. Scott Paper
4. Menominee Paper
5. Fuel Dock
6. Menkaunee Harbor
7. Menominee WWTP
8. Marinette WWTP
9. Ansul Turning Basin
10. 8th Street Slip
Sediment Sampling Only
11. 500ft. Below Ogden St. Bridge
12. 200ft. Above Ogden St. Bridge
13. 1000ft. Above Ogden St. Bridge
14. 25ft. Below US Hwy 41 Bridge
Menominee, MI
Marinette, WI
Menominee River
GREEN BAY
10th St.
6th Ave.
6th St.
4th Avenue
1st Street
3rd Ave.
Hattie St.
Riverside Ave.
Ludington St.
Ely St.
Stanton St.
Water Street
8th St.
6th St.
Ogden St.
41
T
0 1000 2000 3000 4000 5000 Feet
Source: Tusler, 1989
UW Cartographic Lab 4/90

Table IV.9 Mortality Rates (Percent of Test Organism Population) for Menominee River Water Samples.

Site	Species	6.25%	10.0%	12.5%	25.0%	50.0%	100% (@ 24-h)	100%
		Sample Concentration (v:v)						
LC	C. dubia							5
	D. magna							0
	FH Minnow							0
UC	C. dubia							0
	D. magna							0
	FH Minnow							0
EB	C. dubia							0
	D. magna							0
	FH Minnow							0
A1D	C. dubia		0					5
	D. magna		0					0
	FH Minnow		0					0
MR WWTP	C. dubia	0		0	0	0	0	0
	D. magna	0		0	0	0	0	0
	FH Minnow	0		0	0	0	0	0
MN WWTP	C. dubia		0				0	0
	D. magna		0				0	0
	FH Minnow		0				100	100
ATB	C. dubia	25		20	35	100	100	100
	D. magna	40		65	95	100	100	100
	FH Minnow	0		0	0	0	0	0
8ST	C. dubia	100		100	100	100	100	100
	D. magna	100		100	100	100	100	100
	FH Minnow	25		45	80	100	100	100
MEN PPR	C. dubia		0				0	0
	D. magna		0				0	0
	FH Minnow		0				0	0
FD	C. dubia		0				0	0
	D. magna		0				0	0
	FH Minnow		0				0	0
MKN HBR	C. dubia		0				0	0
	D. magna		0				0	0
	FH Minnow		0				0	0

Sites:
Laboratory Control (LC),
Upstream Control (UC)
Equipment Blank (EB)
Above 1st Dam (A1D)
Marinette WWTP (MR WWTP)
Menekaunee Harbor (MKN HBR)
Menominee WWTP (MN WWTP)
Ansul Turning Basin (ATB)
Eight Street Slip (8ST)
Menominee Paper (MEN PPR)
Fuel Dock (FD)

Note: Samples for the bioassay tests were collected from sediment water. Sediment water was collected by placing samplers on the river bottom. These samplers held river water over the sediments for one week. This one week period allowed any mobile contaminants that migrate from the sediments to be trapped by the sampler. After the one week period, the sediment water was removed from the sampler and transported to the laboratory for analytical and bioassay testing. See Appendix IV.4 for the entire report.

Additional studies are needed to determine the effect on the benthos from arsenic, cadmium, mercury and oil and grease which may be present in the turning basin, the Eighth Street slip, and possibly the south river channel sediments.

Fish

Several species of fish present in the Menominee River are included in the WDNR and the WDHSS PCB and Pesticide Consumption Advisory for fish (Table IV.2) and the Michigan Department of Public Health (MDPH) fish consumption advisory. These are discussed in the section on "Restrictions on Fish and Wildlife Consumption".

The Food and Drug Administration (FDA) has established action levels for contaminants present in fish that may constitute a health risk to humans who eat them. Fish species which have been sampled (based on a composite of several fillets for Wisconsin and individual fillets for Michigan) and determined to have contaminants above action levels are added to the consumption advisory by location according to where the species was caught. Fish consumption advisories are discussed in depth in the "Impaired Use" section in this chapter. Table IV.10 lists action levels (FDA action levels, WDHSS and MDPH action levels) for contaminants commonly found in sport fish, and the levels present in fish sampled from the Menominee River. Table IV.10 provides a summary of the mean and range of concentration values for major pollutants found in coldwater and warmwater species (refer to Appendix IV.2 for contaminant levels for individual fish species).

Table IV.10 Summary of Major Pollutants in Warmwater and Coldwater Fish Based on Wisconsin Fish Contaminant Monitoring Data From 1976-88.

Parameter	Action Level	Warmwater Fish Species (1) Mean	Warmwater Fish Species (1) Range	Coldwater Fish Species (2) Mean	Coldwater Fish Species (2) Range
PCB (ppm)	2 (4),(5),(6)	3.30	0.2-20.3	2.18	0.75-5.1
Mercury (ppm)	0.5 (5),(6), 1 (4)	0.32	0.02-0.76	ND (3)	--
Toxaphene (ppm)	5 (4),(5),(6)	ND (3)	--	ND	--
Chlordane (ppm)	0.3 (4),(5),(6)	ND (3)	--	ND	--
Dieldrin (ppm)	0.3 (4),(5),(6)	0.02	--	0.03	--
Dioxin (ppt)	25 (4), 10 (5),(6)	ND (3)	--	ND	--
DDT (ppm)	5 (4),(5),(6)	0.06	--	ND	--

(1) Smallmouth Bass, Northern Pike, Perch, Walleye, Bullhead, White Sucker, White Bass, Carp

(2) Rainbow Trout, Chinook Salmon, Brook Trout, Brown Trout, Splake

(3) ND means no detection; for toxaphene the detection limit is 1.0 ppm; for chlordane (isomers) the detection limit is 0.05 ppm; and for dioxin the detection limit depends on the instrument, but it can be reported as low as 0.2 ppt.

(4) FDA action level

(5) WDHSS level

(6) MDPH level

Listing of a waterbody on the Wisconsin fish consumption advisory for mercury is based on the mean of all the sample values for mercury concentrations > 0.5 ppm; for PCBs it is based on the percent of samples with PCB concentrations > 2 ppm as follows:

Percent (%) of PCB Samples > 2 ppm	Consumption Advisory Fish Group	
< 10%	Group 1:	These fish pose the lowest health risk.
10-50%	Group 2:	Women of child bearing age and children should not eat these fish. Others should limit consumption.
> 50%	Group 3:	No one should eat these fish.

In 1984, as part of a joint research project, the U.S. Fish and Wildlife Service and the Great Lakes Fishery Laboratory examined the incidence of tumors in various near shore fish populations in the Great Lakes. This study is discussed in detail in this chapter in the section on "Fish Tumors or Other Deformities".

The Wisconsin DNR has collected fish for contaminant analyses since 1976 in the Menominee River. Samples have been analyzed for organics (PCB, dieldrin, DDT, chlordane, pentachlorophenol) and metals (mercury, cadmium, chromium, arsenic, and lead). The majority of analyses are for PCBs and mercury because these pollutants tend to bioaccumulate the most in fish and pose the greatest health risk to humans. Analyses for other contaminants are performed less frequently and concentrations have been very low or below the detection limits. Complete results from the fish monitoring data from 1976-88 are presented in Appendix IV.2. Fish consumption advisories are discussed in detail in the "Impaired Use" section in this chapter.

Bioassays, conducted at the Eighth Street slip area and directly across the river (1,000 feet from the Menominee WWTP), showed fathead minnow mortality (Table IV.9). The sediment water collected 1000 feet from the Menominee WWTP (undiluted) produced 100 percent mortality in the fathead minnows after just 24 hours. By comparison, the daphnia did not show mortality in this test water. Fathead minnows also showed a mortality response at the Eighth Street Slip site with 100 percent mortality of the test organisms at 50 percent dilution. Mortality decreased to 25 percent when the test water was at 6.25 percent (Table IV.9). These studies document an acute toxic effect on fathead minnows and potential impacts to fish populations at these test sites. Samples from the other sites in the study (Table IV.9) did not result in mortality of the fathead minnows.

Wildlife

The Wisconsin DNR has historically sampled various species of wildlife in Marinette County, but not necessarily within the AOC. The parameters analyzed varied, but generally included mercury and other heavy metals, PCBs and other organic chemicals. Bald eagles made up the majority of samples, but raccoon and woodcock were also sampled.

In order to increase the data available on wildlife contamination and also for the purpose of issuing waterfowl consumption advisories, waterfowl have been collected for analyses from the AOC by the WDNR. Mallard ducks were collected in 1988 in the vicinity of Stephenson Island and mergansers and goldeneye ducks were obtained from Red Arrow Park in 1989 (results are presented in Appendix IV.5). Wildlife consumption advisories are discussed in detail in the "Impaired Use" section.

Summary Comments

Pollutants of concern to biota in the AOC have been identified, in some cases, and are summarized as follows:

- analyses conducted by Dames and Moore indicate mercury and arsenic concentrations are elevated in tissue of benthos,

- bioassay results from the Eighth Street Slip and turning basin identified acute toxicity to two daphnid species which suggest possible adverse impacts to zooplankton populations due to contaminants in the sediment water,

- acute toxicity shown in the daphnid bioassay results (based on data in the literature) and poor habitat conditions suggest potential adverse impacts to benthic macroinvertebrates,

- levels of PCBs and mercury in fish from the AOC exceed FDA action levels for human consumption, as well as MDPH and WDHSS levels resulting in restrictions on fish consumption, and

- bioassay results for fathead minnows showed an acute toxic effect at the Eighth Street Slip area and directly across the river (1,000 feet from the Menominee WWTP) in the AOC resulting from contaminants in the sediment water.

Water Quality Assessment

There is a lack of recent background water quality data in the AOC. Ambient water quality data exists for three locations on the Lower Menominee River:

1) The USGS gaging station at McAllister (Figure III.1) which is approximately 20 miles upstream of the City of Marinette (1981-86 monitoring data),

2) The Upper Scott Paper Company Dam (Figure III.2) in Marinette/Menominee which was the site of a WDNR ambient monitoring station (information was collected from 1977-79), and

3) The Hattie Street (26th Street) bridge in Marinette/Menominee (Figure III.2) which has been a Michigan DNR ambient monitoring station since the early 1970s.

The historical data from the above locations are summarized in Table IV.11. The water chemistry data presented in Table IV.11 are divided into two categories:

1. Conventional parameters, including nutrients and other compounds, and

2. Non-conventional parameters, including metals and organics.

Table IV.11

Historical Water Chemistry Information from the Menominee River From The Early 1970s through 1988

	McAllister Gaging Station			Upper Scott Paper Co. Dam			Hattie (26th Street) Street			
Conventional Parameters	Avg.	Std. Dev.	# of Tests	Avg.	Std. Dev.	# of Tests	Avg.	Std. Dev.	# of Tests	Range
Conductivity (umhos)	207	40	38				243	33	63	
Hardness (mg/L)	102	15	34				118	15	52	74-154
Alkalinity (mg/L as $CaCO_3$)	89	13	35				105	14	105	97-203
Total Phosphorus (mg/L)	0.025	0.02	34	0.3	0.02	18	0.025	0.016	128	.005-.150
Dissolved Phosphorus (mg/L)	0.01	0.01	23	.008	.008	18	.008	.02	103	.001-.176
Total Barium (ug/L)	0.79	27	7				15	7.2	5	5-24
Total Nitrogen (mg/L)	0.72	0.3	6							
Total Kjeldahl Nitrogen (mg/L)							0.45	0.14	76	0.23-1.3
Total Ammonia (mg/L)	0.04	0.02	6				0.02	0.016	121	0-.076
Nitrite & Nitrate-N (mg/L)	0.13	0.08	6				0.14	0.093	125	0.01-49
BOD_5 (mg/L)				2.6	1	16	1.7	0.9	134	0.3-4.6
COD (mg/L)							22	8.9	56	5-40
pH (S.U.)							7.8	0.09	109	6.7-8.7
Total Solids (mg/L)							157	37	128	93-440
Total chloride (mg/L)							4.4	3	128	0.5-14
Sulfate (mg/L)							14	2.8	58	7-20
Chlorophyll-a (ug/L)							2.4	2.2	112	0.2-11
Fecal coliform (count/100 mL)							102	274	44	5-1800

Table IV.11 Continued

Non-Conventional Parameters	McAllister Gaging Station Avg.	Std. Dev.	# of Tests	Upper Scott Paper Co. Dam Avg.	Std. Dev.	# of Tests	Hattie (26th Street) Street Avg.	Std. Dev.	# of Tests	Range
Metals & Organics										
Total cyanide (ug/L)							3.3	4.1	8	0.7-10
Total phenols (ug/L)							3.2	2.1	39	0.5-11
Total Arsenic (ug/L)	1.6	.5	7				1.3	0.67	12	0.5-3
Suspended Arsenic (ug/L)	.4	.5	7							
Dissolved Arsenic (ug/L)	1.1	.4	23				<1		1	
Total Cadmium (ug/L)	1.3	.7	7				0.48	0.75	61	0.2-4
Total Chromium (ug/L)	11	6	7				2.7	0.93	61	1-5
Total Cobalt (ug/L)	1.9	1.6	7				13.8	7.5	4	5-20
Total Copper (ug/L)	7	3	7				2.9	1.6	61	1-10
Total Iron (ug/L)	350	100	7				285	133	36	110-685
Total Lead (ug/L)	2.6	2	7				2.8	3.8	61	1-21
Total Manganese (ug/L)	53	24	7				70	19	9	47-110
Total Mercury (ug/L)	.1	.08	7				<0.5		12	0.1-1.0
Total Nickel (ug/L)	3	2.6	7				<4.5		61	2-16
Total Selenium (ug/L)	<1		7							
Total Silver (ug/L)	<1		7				<0.85		11	0.2-2
Total Zinc (ug/L)	41	19	7				17	21	61	2-170

Note: mg/L is the same as parts per million, ug/L is the same as parts per billion, and std. dev. refers to standard deviation.

Water chemistry information indicates that the Menominee River is a hard water stream with alkaline waters (average hardness of 118 mg/L (ppm) with a mean pH of 7.8 at Hattie Street (26th Street)) and has low levels of nutrients -- both total and dissolved phosphorus as well as nitrogen. The average flow at the USGS gaging station at McAllister (based on data from 1946-61 and 1981-86) is 3580 cubic feet per second (cfs). Based on extrapolation of the flow data at the McAllister Station, the average flow at the mouth of the Menominee River is 3980 cfs (Holmstrom, 1990). This is compared to a low flow value in the Menominee River of 1,260 cfs (based on the lowest flow that occurs over a 7 day period once every 10 years ($Q_{7,10}$)). The $Q_{7,10}$ flow value is used in calculating effluent limits for wastewater dischargers.

Water quality information in the AOC focuses on the Michigan ambient monitoring station data from the Hattie Street (26th Street) bridge, which is located above the majority of the point sources (except the Scott Paper Company discharge). The reason for concentrating on the Hattie Street (26th Street) bridge data is because it contains significantly more test results for more parameters and is located within the AOC.

For a complete listing of all the data available from the Hattie Street (26th Street) bridge, refer to Appendix IV.7.

Test results over the last five years from 1985-89 (both mean values and ranges) from the Hattie Street (26th Street) bridge have been compared to fish and aquatic life criteria for Michigan, Wisconsin, and IJC. The comparison of the ambient water quality data to the criteria values are shown in Table IV.12.

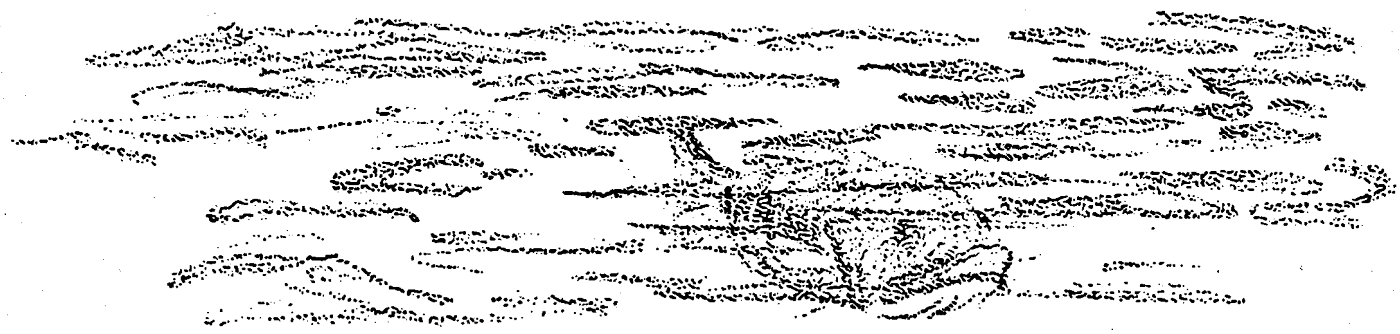


Table IV.12

Comparison of Applicable Water Quality Standards for the Menominee River to Ambient Conditions at the Hattie Street (26th Street) Bridge (1985-1989)

Water Quality Parameters	Wisconsin Criteria Acute	Wisconsin Criteria Chronic	Michigan Criteria Rule 57(2) Value	IJC Criteria	Ambient Water Quality in the Menominee River at the Hattie Street (26th Street) Bridge: Mean Values	Range	Criteria Exceedance(s)
Metals							
Arsenic (ug/L)	364	153	184	-	<3	<3	No
Cadmium (ug/L)	34.9	0.57	0.47	0.2	0.2	<0.2-0.7	No
Chromium (ug/L)(1)	14.2	9.7	3.0	-	<3	<3	No
Copper (ug/L)	19.4	13.4	12.5	5.0	2.8	<1-10	No
Cyanide (ug/L)	46.2	4.96	4.0	-	-	-	Unknown
Iron (ug/L)	-	-	-	300	263	140-685	No
Lead (ug/L)	208	12.5	3.8	25.0	5.0	<1-130	No
Mercury (ug/L)	1.53	-	0.0006	0.2	<0.5	<0.5	No
Nickel (ug/L)	1240	76	39	25.0	2.4	<2-16	No
Selenium (ug/L)	58	7.1	20	-	<2	<1-2	No
Silver (ug/L)	2.4	2.4	0.10	-	<0.5	<0.5	No
Zinc (ug/L)	119	57	57	30	14	<4-39	No
Conventionals							
Total phosphorus (mg/L)		-	-	-	0.25	0.005-.150	No
pH (S.U.)		6.0-9.0	6.5-9.0	6.5-9.0	7.8	6.7-8.7	No
Fecal coliform (counts/100 mL)(2)		200	200	-	-	-	Unknown
Ammonia (mg/L)		0.04	0.05	0.02	0.02	0-.076	No

(1) The criteria values are based on the toxicity of hexavalent (+6) chromium and the ambient water quality results from the Menominee River are values based on total chromium (it should be noted that the hexavalent form is more toxic than either the triavalent form or total chromium).

(2) Compliance is determined on the basis of the geometric mean of any series of five or more consecutive samples taken not over more than a 30 day period.

NOTES:

- ug/L are equivalent to parts per billion and mg/L are equivalent to parts per million.
- Wisconsin's criteria is based on numbers contained in NR 105 of the Wisconsin Administrative Code, Michigan's criteria on levels in Michigan Administrative Code Rule 57(2) Guidelines, and IJC criteria on guidelines contained in the revised Great Lakes Water Quality Agreement of 1978.
- For those parameters where water quality hardness affects toxicity -- cadmium, copper, lead, nickel, silver and zinc -- the calculations were based on a hardness value of 118 ppm in the Menominee River (from Table IV.11).
- For determining criteria exceedances, the Wisconsin chronic value, the Michigan Rule 57(2) value, and the IJC criteria were compared to the mean values in the Menominee River and the Wisconsin acute criteria was compared to the upper range of values observed at the Hattie Street (26th Street) bridge.
- For the Michigan Criteria Rule 57(2) values, the majority of the parameters are based on the aquatic chronic value. However, for mercury (as methyl mercury) it was based on the human life-cycle safe concentration (HLSC) and for selenium it was based on the terrestrial life-cycle safe concentration (TLSC).

None of the metals that were analyzed at this site exceeded fish and aquatic life criteria (Table IV.12). Unfortunately, some parameters, such as arsenic, had very limited test results over the last five years (3 samples).

River sampling for fecal coliform data conducted during a wet weather overflow from CSO #2, located on the Menominee shore (Figure V.4), is presented in Appendix IV.8. The sampling was done as part of the McNamee, Porter and Seeley Combined Sewer Overflow Study (1988). Three samples out of 105 were above 200 counts/100 mL for fecal coliform bacteria (220 count/100 mL, 201 counts/100 mL, and 210 counts/100 mL). However, the geometric mean of all the samples did not exceed the Michigan and Wisconsin Criteria of 200 counts/mL.

In a combined sewer overflow study conducted by McNamee, Porter and Seeley (1986), dissolved oxygen (DO) concentrations were recorded from a continuous monitor in the Menominee River during the summer of 1985 (Appendix IV.9). Dissolved oxygen concentrations, in general, were above the Wisconsin and Michigan standard of 5 ppm. However, on two separate occasions, over a period of several days, the minimum DO dropped below the standard. The first occurrence was between July 14 and 19, 1985, and the second was on August 4 and 5, 1985. The minimum DO levels observed during these periods were 3.37 ppm on July 15, 1985, and 3.82 ppm on August 5, 1985.

In most cases, the DO concentrations corresponded to the river flow (i.e., lower DO levels were observed when river flows were low). However, the river flow was not the only cause of the DO sags according to the McNamee, Porter, and Seeley study. Some declines in the DO can be attributed to BOD loadings from upstream point sources, and, to some extent, from the combined sewer overflows from the City of Menominee. The McNamee, Porter and Seeley study recommended additional studies to further investigate contributing causes for the DO depletions. More recent DO data than 1985 data are not available on the Menominee River.

In 1985, a water quality survey was conducted by Aqua-Tech, Inc. (for Ansul Fire Protection Company). The sampling was conducted in the Menominee River in the vicinity of the turning basin. Appendix IV.10 provides a summary of the water quality analyses conducted at each sampling site, as well as a map showing the sampling locations. In addition to the field parameters tested (pH, temperature, dissolved oxygen and conductivity), lab analyses were run for turbidity, total dissolved solids, chloride, total arsenic, and total sodium. From water samples collected at mid-depth, analytical test results showed no arsenic concentrations above detection limits (10 ppb).

Because of the lack of recent water chemistry data on the Menominee River, the Technical Advisory Committee (TAC) recommended (in the spring of 1989) that additional data be collected in the AOC. Details of the 1989 water quality monitoring plan for the Menominee River, as developed by the TAC, is provided in Appendix IV.11. Sampling was conducted semi-monthly from May to October by University of Wisconsin students with supervision by WDNR personnel. With the

the exception of the continuous monitoring for DO (which was not initiated), the majority of the monitoring has been completed as detailed in the TAC plan.

The data collection efforts in the Lower Menominee River were completed in November 1989, for the upstream site (above the second Scott Paper Dam) and in March, 1990 for the downstream location (at the mouth of the river). Preliminary results from the water chemistry tests are listed in Appendix IV.12. When the water chemistry data analyses are completed by the Wisconsin State Laboratory of Hygiene, the 1988 -'90 results will be evaluated to determine current water quality conditions in the Lower Menominee River. Sample results on water quality should be available mid-to late summer of 1990 and will be incorporated in Stage II of the RAP. In addition, the water quality concentrations for the various parameters will be compared to existing water quality criteria and to the ambient monitoring data from the Hattie Street (26th Street) bridge for the purpose of assessing water quality trends.

As part of the TAC recommendations, bioassays were also conducted in 1989 (Tusler, 1989 and Masnado, 1989). Results of the bioassay tests are contained in Table IV.9 and Appendix IV.4. Impacts to the test organisms -- Ceriodaphnia dubia, Daphnia magna, and Pimephales promelas (fathead minnows) -- from nine sampling sites in the Menominee River are discussed in this chapter under the section on "Biota Contamination". Figure IV.2 shows the location of the samplers used to collect water samples for the laboratory bioassay tests.

At the time the bioassay sampling was conducted, water chemistry test analyses were run at the same locations. Water samples used in the bioassay tests were analyzed for biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), cyanide, arsenic, chromium, copper, lead, phenol, and ammonia (total). Samples for these analytical tests were collected from sediment water in the samplers (refer to the footnote in Table IV.9 for a description of the sediment water). Two sets of field measurements were also taken for DO, pH, temperature, and specific conductance. One sample for the field measurements was collected from the ambient river water (one to three feet below the surface) and the second sample was collected from the water in the sampler. Results from the field measurements and the analytical test results of the water samples from the laboratory are shown in Appendix IV.4 (see Tusler's report).

Sediment samples were also taken several weeks prior to the bioassay testing. The sediment sampling sites were used to locate the samplers for the bioassay testing. Some of the sediment sites were selected in downstream depositional areas from below the key industrial and municipal discharges in the AOC. There was also an upstream control site selected (above the second Scott Paper Company Dam) and an equipment blank, in order to establish that background conditions of the sampler itself was not causing a toxicity problem. Analytical results from the sediment sampling are discussed in this chapter in the section on "Sediment Quality Assessment".

Mortality occurred to the test organisms at three of the nine bioassay sampling sites on the Menominee River. Wisconsin State Laboratory of Hygiene water chemistry test results documented the potential cause of the toxicity as follows:

1. **One Thousand feet from the Menominee Wastewater Treatment Plant** - Toxic effects were observed only to juvenile fathead minnows; no mortality occurred to the daphnid species. Un-ionized ammonia concentrations detected in the water sampler at this site were elevated (0.19 mg/L (ppm) compared to ambient levels for this parameter of 0.02 mg/L (ppm) total ammonia at the Hattie Street (26th Street) bridge (refer to Table IV.11). However, the chemical data did not identify the cause of the mortality or the source of the toxicity problem. The observed mortality to the fathead minnows could not be explained by the ammonia concentration and pH, because the un-ionized ammonia levels in the test water were below Wisconsin's acute criterion and Michigan's Rule 57(2) criterion. More data gathering will probably be necessary and will likely be recommended in Stage II.

2. **Eighth Street Slip** - Mortality occurred to both the fathead minnows and the daphnid species. Suspected cause of the toxicity was due to extremely high arsenic levels (18,000 ppb) of the sediment water within the sampler. The arsenic concentrations exceeded the acute criterion (364 ppb) by about 50 times. All the rest of the toxic pollutants measured in the sediment water were below detection. High conductivity levels (2350 umhos/cm) at this location, compared to background levels in the river, indicate that dissolved salts are entering the river via the groundwater.

3. **Turning Basin** - Mortality occurred only to the daphnid species. Arsenic levels of the sediment water within the sampler (3900 ppb) exceeded the acute criterion for arsenic by more than 10 times at this site. The other toxic pollutants measured were at less than detection levels. High conductivity levels were also observed in the turning basin (1100 umhos/cm) compared to background concentrations in the Menominee River.

The acute toxic effect observed in the turning basin and Eighth Street slip needs to be better defined. Arsenic concentrations greatly exceeded Wisconsin's acute criterion and Michigan's Rule 57(2) criterion for that substance. However, cadmium and mercury (both substances that were not measured in the sampler) could be contributing to the toxicity problem at these sites. Additional sampling at the Eighth Street slip and turning basin will be recommended in Stage II of the RAP in order to better define the cause and extent of the toxicity.

Summary Comments

In summary, conditions/pollutants of concern that have been identified in the Menominee River from water quality sampling efforts are as follows:

- Occasional dissolved oxygen levels below the Wisconsin and Michigan standard of 5 ppm in the main channel of the Menominee River during times of low flow in the summer,

- Extremely high arsenic concentrations, above Wisconsin and Michigan criteria levels, in the sediment water collected from the bioassay samplers in the turning basin and the Eighth Street slip, and

- Elevated ammonia levels in the sediment water approximately 1,000 feet from the Menominee WWTP that exceeded Wisconsin's chronic criteria and Michigan's Rule 57(2) criteria value.

Sediment Quality Assessment

In-place pollutants are present in the sediments of the Menominee River and Harbor in parts of the Area of Concern (AOC). Arsenic is found at elevated concentrations in the turning basin area of the river, adjacent to the Ansul Fire Protection Company property. Other in-place pollutants found at elevated concentrations in the AOC include oil and grease, phosphorus, ammonia-nitrogen, Kjeldahl-nitrogen, chemical oxygen demand (COD), cyanide, lead, manganese, cadmium, mercury, copper, and zinc. To facilitate summarizing the sediment data, the Lower Menominee River and near shore area at the mouth of the river in the AOC have been divided into six reaches based on landmark points along the river. The six reaches are shown in Figure IV.3. In addition, Table IV.13 describes each of the reaches and the key point source discharges in each reach.

Table IV. 13 **River Reach and Point Source Dischargers**

Reach	Extent	Point Source or Other Discharger
1.	Upper to Lower Scott Paper Co. Dams	Scott Paper Company
2.	Lower Scott Paper Co. Dam to Ansul Fire Protection Co.	Menominee WWTP Marinette WWTP
3.	Ansul Fire Protection Co. to Ogden St. Bridge (main channel)	Waupaca Foundry
4.	Ogden St. Bridge to end of Navigational Channel in Green Bay	Menominee Paper Company
5.	Turning Basin and the Adjacent Eighth Street Slip	Ansul Fire Protection Company, SpecialtyChem Products Corporation
6.	South Channel of River Extending from Eight Street Slip to the Menekaunee Harbor on Green Bay (includes Sixth Street Slip)	

To provide a perspective on the relative degrees of contamination of the sediments in the Menominee River, Table IV.14 summarizes the ranges in concentrations of the in-place pollutants found in each river reach and compares the maximum values with U.S. EPA's Region V guidelines (1977) for the pollutional classification of Great Lakes Harbor sediments and the International Joint Commission (IJC) sediment quality guidelines (Table IV.15).

Table IV.14

Lower Menominee River Sediment Pollution Data 1980 - 1989

Minimum (min.) and maximum (max.) pollutant concentrations by river reach (Figure IV.3). Comparison of maximum pollutant concentrations to U.S. Environmental Protection Agency (EPA) and International Joint Commission (IJC) sediment classification guidelines(1). Units are in parts per million (ppm).

Metals and Organics

Stream Segment		Arsenic	Cadmium	Chromium	Copper	Cyanide	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Zinc	Polycyclic Aromatic Hydrocarbons (PAH)	Total PCBs
Reach No. 1	(min)	0.5					-	-	-	-					-
Range in ppm	(max)	4.0	<1	-	-	-	7,700	43	170	1.2	-	-	-	-	0.12*
EPA/IJC Guidelines(2)		M/B	U/B	-	-	-	U/B	M/B	U/B	H/E	-	-	-	-	U/E
Reach No. 2	(min)	0.1	<0.01	7.5	<0.55	<0.05	7,100	<1.2	105	<0.04	<4		18.5	-	0.03
Range in ppm	(max)	37	13	16	26.5	<1.6	13,000	240	490	0.44	17	<1	70	-	2.0
EPA/IJC Guidelines(2)		H/E	U/E	U/B	M/B	M/-	U/B	H/E	M/B	U/E	U/B	-/B	U/B	-	U/E
Reach No. 3	(min)	0.5	<0.02	7.3	0.29	<0.05	4,180	<0.88	124	<0.05	<4	<0.2	20.8	-	0.04
Range in ppm	(max)	37	0.4	16	26.5	<1.6	13,000	337	660	2.6	17	<1	70	27	0.30
EPA/IJC Guidelines(2)		H/E	H/E	U/B	M/B	M/-	U/B	H/E	H/B	H/E	U/B	-/B	U/B	-	U/E
Reach No. 4	(min)	0.7	0.02	7.3	<0.38	<0.05	6,000	<1.1	160	<0.02	5.1		33.9		.05
Range in ppm	(max)	25	6	27	35	0.1	16,000	51	920	0.46	27	<1	106	-	0.18
EPA/IJC Guidelines(2)		H/E	H/E	M/B	M/B	M/-	U/B	M/E	H/B	U/E	M/B	-/B	M/E	-	U/E
Reach No. 5	(min)	0.5	<1.0	17.1	10.7	<0.3	6,370	4.2	244	0.17	6.93	<0.02	22.5		<0.03
Range in ppm	(max)	32,300	5.4	826	47	0.41	41,990	110	933	1.0	32.7	0.05	190	-	0.49*
EPA/IJC Guidelines(2)		H/E	U/E	H/B	H/E	H/-	M/B	H/E	H/B	H/E	M/B	-/B	M/E	-	U/E
Reach No. 6	(min)	4.3	<1	16.3	18.0	0.21	9.2	0.38	43	0.032	7.37	-	59.1		<0.05
Range in ppm	(max)	102	3.3	59	113	45.7	10,000	237	290	0.13	28.8	-	429	0.3	1.60
EPA/IJC Guidelines(2)		H/E	U/E	M/B	H/E	H/-	U/B	H/E	U/B	U/B	M/B	-	H/E	No Criteria	U/E

(1) U.S. EPA pollutional classification of Great Lakes Harbor sediments and IJC values are guidelines for in-water disposal of dredged materials.

(2) For the U.S. EPA guideline abbreviations, "U" means unpolluted, "M" means moderately polluted, and "H" means heavily polluted. For IJC abbreviations, "E" means exceeds and "B" means below the open water disposal guidelines. The comparison with each guideline is made with the upper end of the range of the sediment values only. Refer to Table IV.15. for the EPA guideline and IJC criteria values.

* PCBs reported as Aroclor 1254/1260.

NOTE: This table is a summary of available sediment chemistry data from 1980-1989. Refer to Appendix IV.13 for data sources.

Table IV.14 Continued

	Conventional and Other Pollutants				
Stream Segment	Ammonia-Nitrogen	Chemical Oxygen Demand (COD)	Total Kjeldahl Nitrogen	Oil and Grease	Phosphorous
Reach No. 1 (min) Range in ppm (max)	-	-	-	6,300	-
EPA/IJC Criteria(2)	-	-	-	H/E	-
Reach No. 2 (min) Range in ppm (max)	109	4,490 / 107,000	187 / 962	137 / 19,000	- / 55
EPA/IJC Criteria(2)	M/E	H/-	U/B	H/E	U/B
Reach No. 3 (min) Range in ppm (max)	109	39,000 / 107,000	55 / 1,090	234 / 19,000	- / 55
EPA/IJC Criteria(2)	M/E	H/-	M/B	H/E	U/B
Reach No. 4 (min) Range in ppm (max)	498	33,000 / 720,000	130 / 3,480	120 / 14,000	160 / 940
EPA/IJC Criteria(2)	H/E	H/-	H/E	H/E	H/E
Reach No. 5 (min) Range in ppm (max)	1,600	5,830 / 23,000	83 / 4,950	$\leq$290 / 5,830	-
EPA/IJC Criteria(2)	H/E	U/-	H/E	H/E	-
Reach No. 6 (min) Range in ppm (max)	50 / 1,600	- / -	120 / 16,020	177 / 37,900	100 / 2,600
EPA/IJC Criteria(2)	H/E	-	H/E	H/E	H/E

(1) U.S. EPA pollutional classification of Great Lakes Harbor sediments and IJC values are guidelines for in-water disposal of dredged materials.

(2) For the U.S. EPA guideline abbreviations, "U" means unpolluted, "M" means moderately polluted, and "H" means heavily polluted. For IJC abbreviations, "E" means exceeds the criteria and "B" means below the criteria. The comparison with each criteria is made with the upper end of the range of the sediment values only. Refer to Table IV.16 for the EPA guidelines and IJC criteria values.

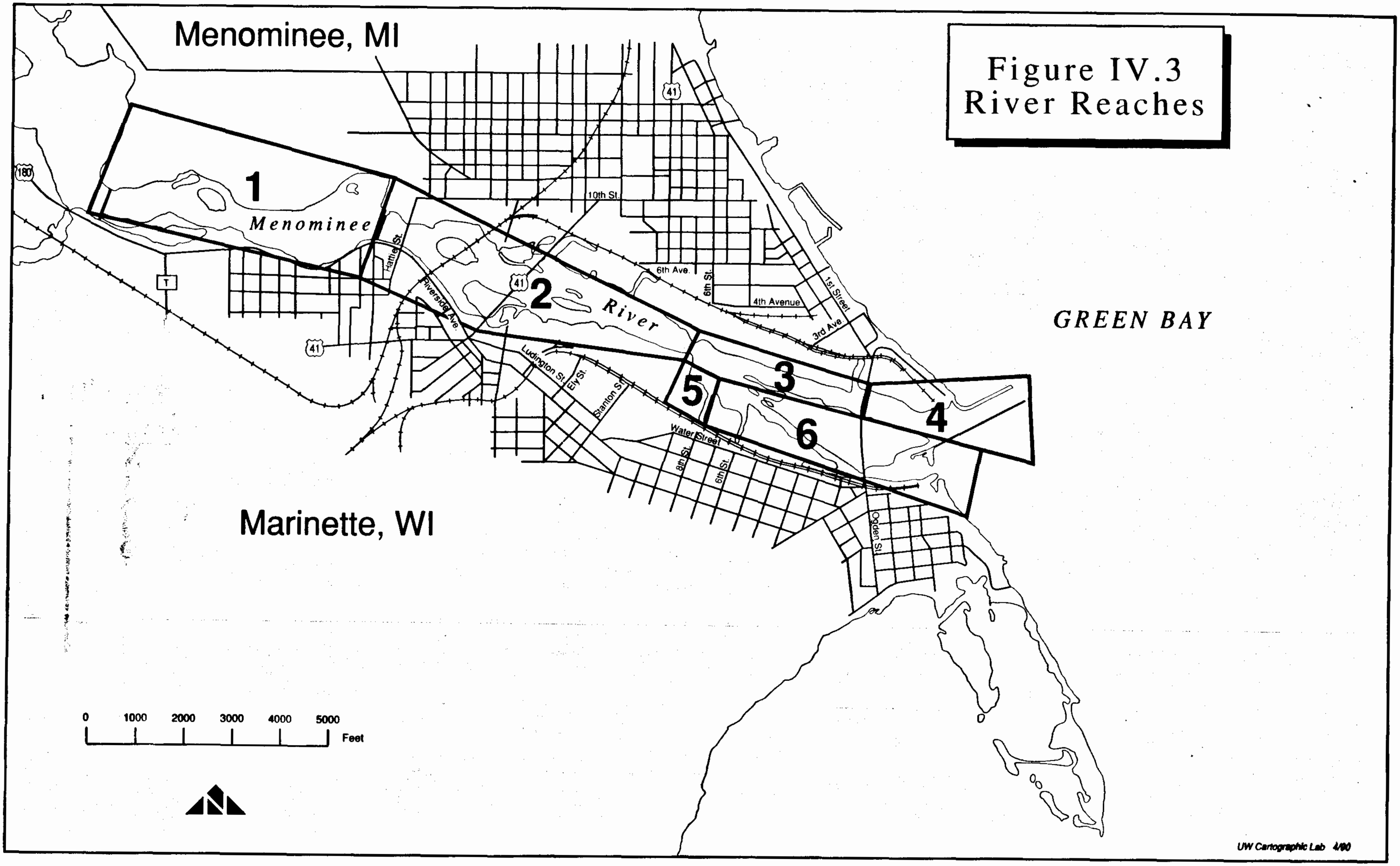


Figure IV.3
River Reaches
Menominee, MI
Marinette, WI
GREEN BAY
Menominee
River
1
2
3
4
5
6
10th St.
6th Ave.
6th St.
4th Avenue
1st Street
3rd Ave.
Hattie St.
Riverside Ave.
Ludington St.
Ely St.
Stanton St.
Water Street
8th St.
6th St.
Ogden St.
41
180
T
0
1000
2000
3000
4000
5000
Feet
UW Cartographic Lab 4/90

The in-place pollutant concentration ranges listed in Table IV.14 are based on all available sediment sampling data in each reach over the last ten years from 1980-1989 as summarized from the sources in Appendix IV.13. There is variation in sediment depths sampled, sampling locations, and study purposes depending on the data sources used. Table IV.14 summarizes and classifies each in-place pollutant present in each stream reach based on the maximum concentrations found from all available data sources. The designation (i.e., M for "moderately polluted", H for "heavily polluted" or U for "unpolluted" in the U.S. EPA system; and E for "exceeds" and B for "below" based on the IJC guidelines) does not mean all the sediments in a stream reach have in-place pollutants at elevated levels. However, the designations provide an indication that at least certain areas within a stream reach have elevated in-place pollutants in the sediments based on available data. Figures IV.4, IV.5, and IV.6 present approximate locations of contaminated sediment within the reaches. Sediment depositional areas with high concentrations of in-place pollutants may serve as a source for the transport of contaminated sediments to downstream reaches. Additional sampling and assessments of all existing sample results may be needed to determine the extent and degree of contamination in each reach for some pollutants. Guidelines for contaminated sediment cleanup decisions to be developed for Stage II of the RAP will determine any additional sampling and assessment needs for each in-place pollutant.

In addition to the numeric concentration guidelines, U.S. EPA's sediment pollutional classification system also outlines additional factors to be considered when classifying a sediment (e.g., elutriate test results, sources of contamination, particle size distribution, color, odor, and benthic invertebrate populations). However, it should be noted that there are several limitations to using the EPA guidelines. The U.S. EPA's pollutional classification system for harbor sediments was developed in 1977 to facilitate decisions regarding disposal of dredged material. The guidelines, which are based on a large number of harbor sediment samples, were not adequately related to the impact of the sediments on lake quality or the aquatic biota. The guidelines do not indicate bioavailability of contaminants nor do they consider natural background concentrations of sediment constituents that may exceed the guidelines (Laskowski-Hoke and Prater 1981). They were considered to be interim guidelines until more scientifically defensible criteria could be developed. The 1977 guidelines do not consider more recent contaminants that may be a cause for concern nor were they designed to protect the environment and public health adequately. Despite these drawbacks, the EPA guidelines remain a common method used by many states (including Michigan and Wisconsin) for evaluating the relative degree of contamination of sediments. Currently, U.S. EPA is developing new sediment quality criteria. WDNR has recently received funding for In-place Pollutant Program staff within the Bureau of Water Resources Management. The staff is in the process of developing a strategy for the in-place pollutant program strategy and has initiated reviews of methodologies for sediment assessment and development of relevant, scientifically defensible, and biological effects-based sediment criteria.

Figure IV.4

Menominee River Sediment Data, 1980-1990

(Reaches 1 & 2)

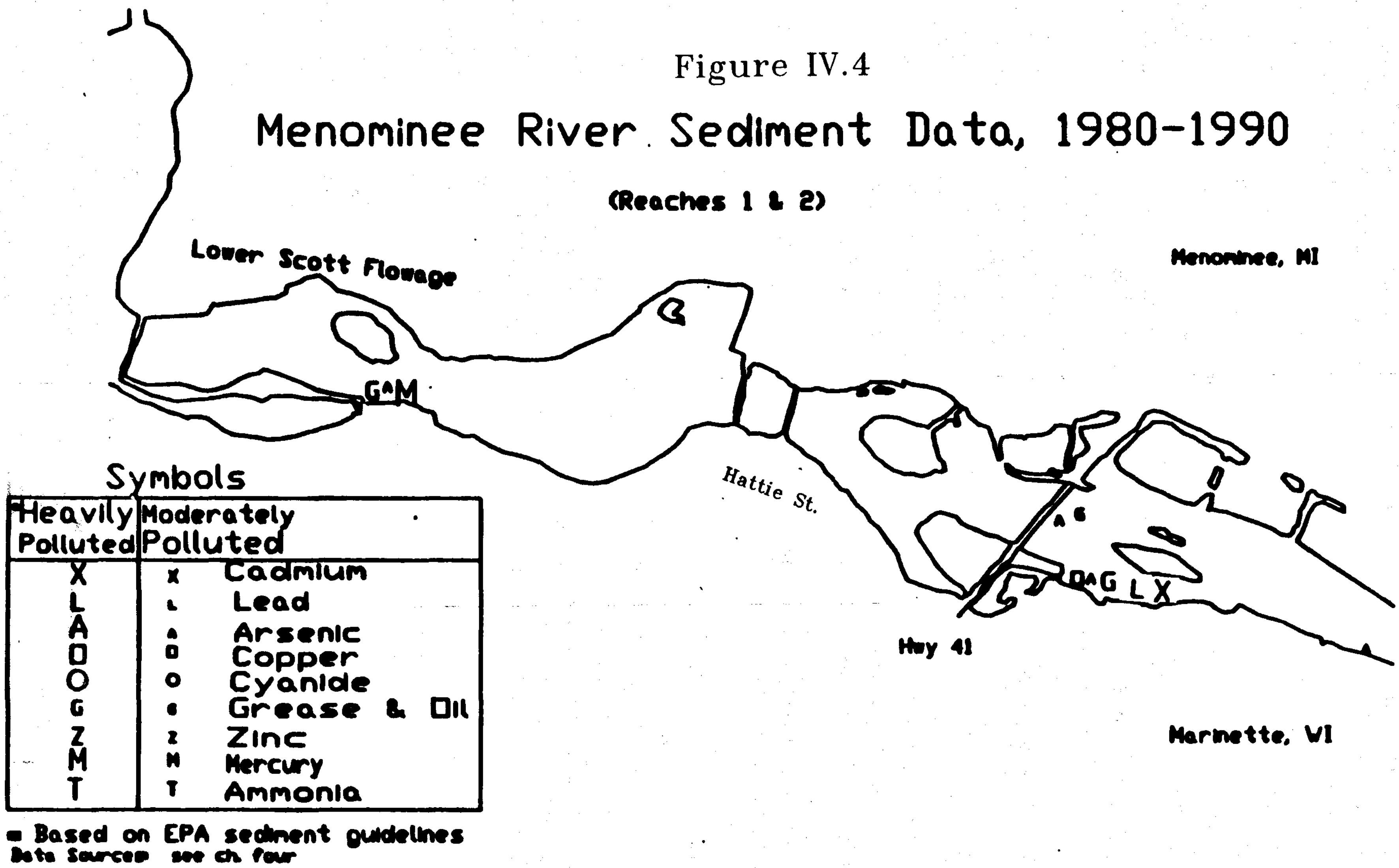


Figure IV.5

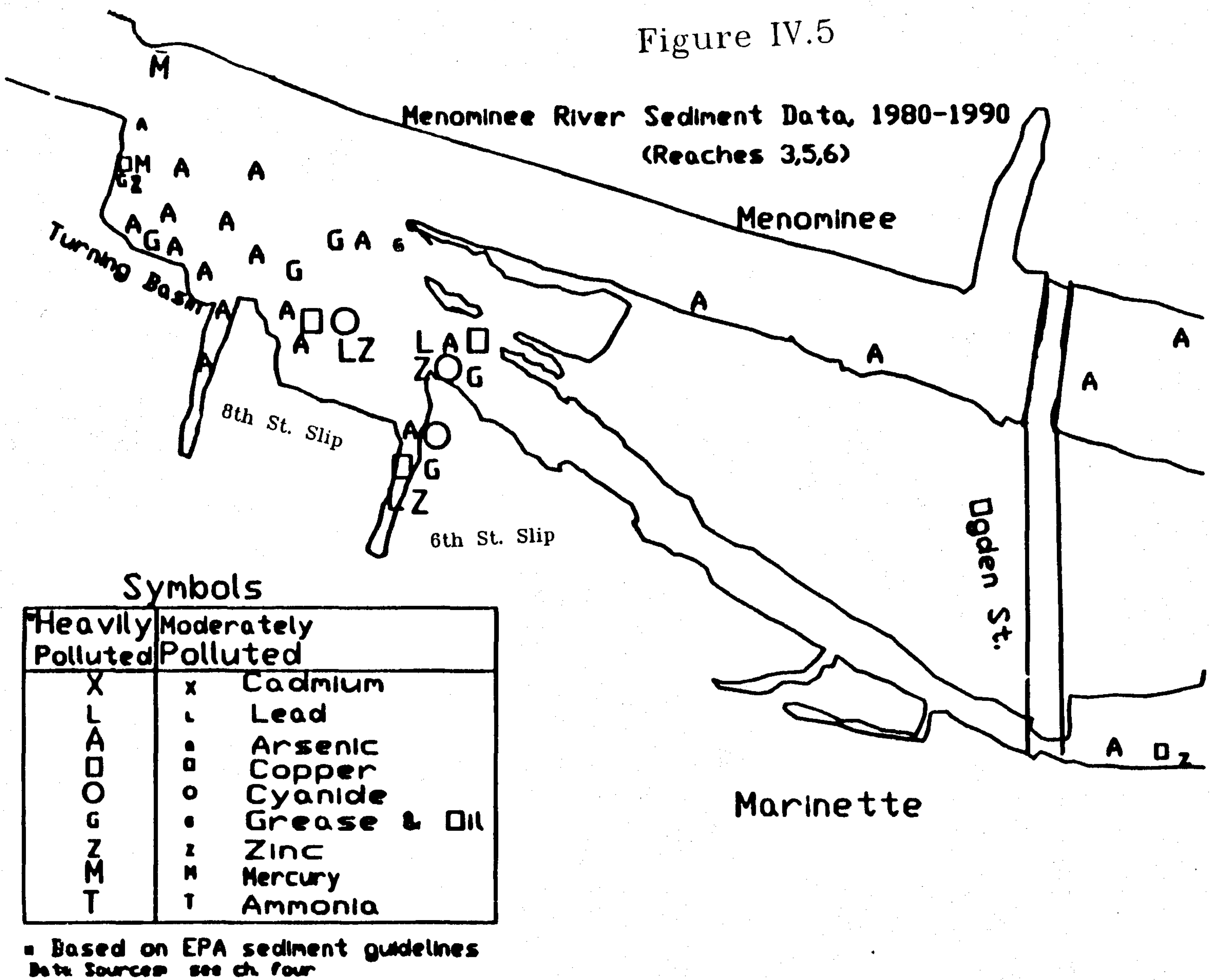

Menominee River Sediment Data, 1980-1990
(Reaches 3,5,6)
Menominee
Turning Basin
8th St. Slip
6th St. Slip
Ogden St.
Marinette
Symbols
Heavily Polluted
Moderately Polluted
Cadmium
Lead
Arsenic
Copper
Cyanide
Grease & Oil
Zinc
Mercury
Ammonia
Based on EPA sediment guidelines
Data Sources see ch. four

Figure IV.6

Menominee River Sediment Data, 1980-1990

(Reaches 4,6)

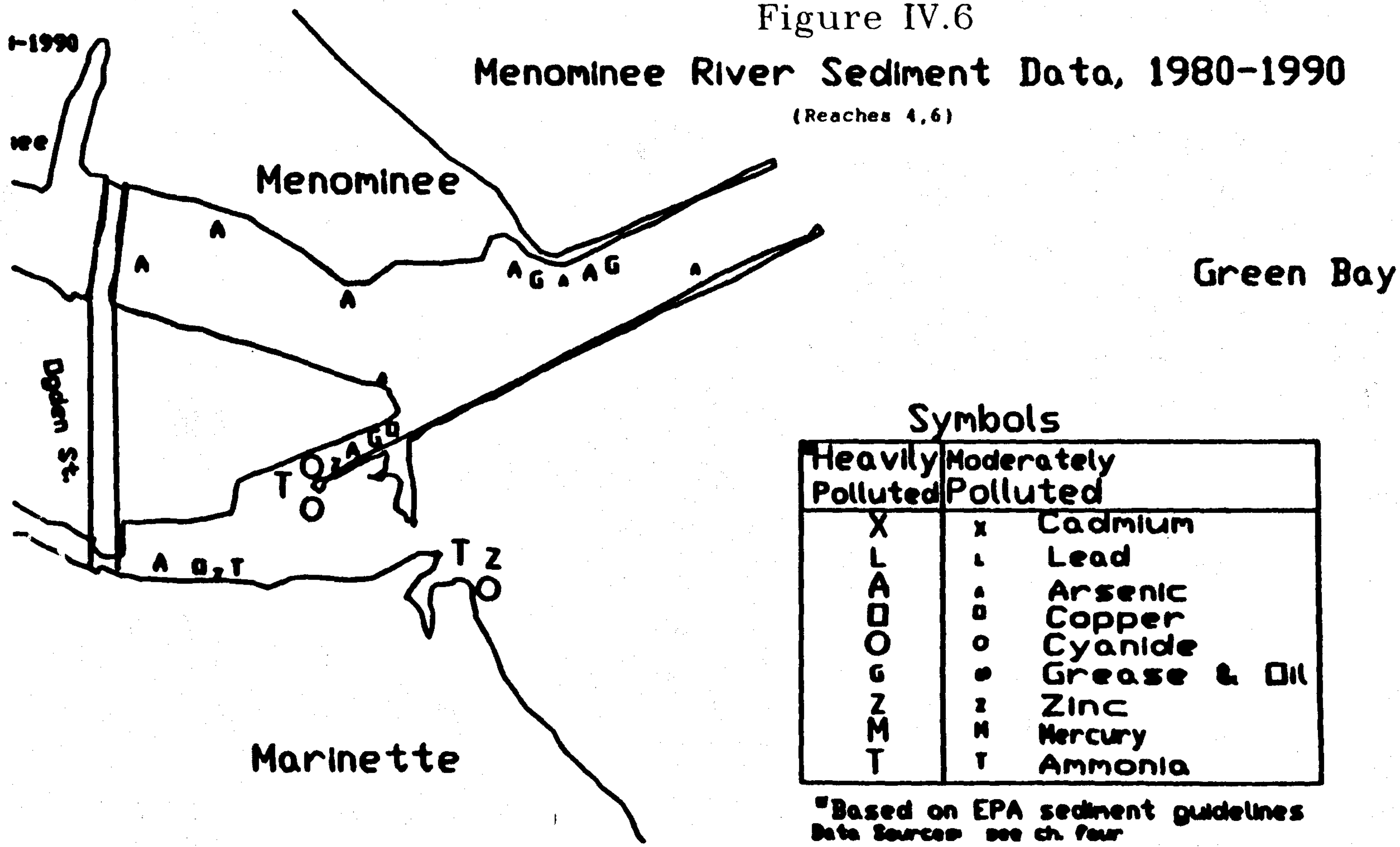


Table IV.15 Sediment Quality Assessment Guidelines for Disposal of Dredged Material

	EPA Sediment Classification Guidelines[1][2]			IJC Guidelines[1]
	Nonpolluted	Moderately Polluted	Heavily Polluted	Open Water Disposal Guidelines
Volatile Solids	<5%	5% - 8%	>8%	-
Chemical Oxygen Demand	<40,000	40,000 - 80,000	>80,000	-
Total Kjeldahl Nitrogen	<1,000	1,000 - 2,000	>2,000	2,000
Oil & Grease (Hexane Soluble)	<1,000	1,000 - 2,000	>2,000	1,500
Lead	<40	40 - 60	>60	50
Zinc	<90	90 - 200	>200	105
Ammonia	<75	75 - 200	>200	100
Cyanide	<0.10	0.10 - 0.25	>0.25	-
Phosphorus	<420	420 - 650	>650	1,000
Iron	<17,000	17,000 - 25,000	>25,000	45,500
Nickel	<20	20 - 50	>50	90
Manganese	<300	300 - 500	>500	1,625
Arsenic	<3	3 - 8	>8	8
Cadmium	Lower Limits Not Established		>6	1.5
Chromium	<25	25 - 75	>75	120
Barium	<20	20 - 60	>60	-
Copper	25	25 - 50	>50	45
Mercury	>1 is unacceptable for Open Lake Disposal		>1	0.3
Total PCBs	(3)	(3)	>10	0.05

Note: All values in ppm dry weight unless otherwise noted.

(1) Sources: U.S. EPA. 1977 Guidelines for the Pollutional Classification of Great Lakes Harbor Sediments. U.S. EPA, Region V. Chicago, IL. April 1977.

International Joint Commission guidelines for open water disposal of dredged materials.

(2) Additional factors such as elutriate test results, sources of contamination, particle size distribution, benthic macroinvertebrate populations, color, and odor are also considered in the classification.

(3) Pollutional classification of sediments with total PCBs between 1.0 and 10.0 ppm dry weight determined on case-by-case basis.

The State of Michigan uses the EPA guidelines and International Joint Commission (IJC, 1982) guidelines for evaluating disposal options for dredge material. Wisconsin does not presently allow in-water disposal of dredged materials but does have sediment quality guidelines that are applied to beach nourishment projects (Appendix IV.14). Beach nourishment (restoration) is the disposal of clean sediments with the appropriate particle size distribution in eroded beach areas. The Wisconsin guidelines are generally based on background concentrations for substances established from lake sediment coring and analysis of bluff materials.

Arsenic

Nature and Extent of Arsenic Problem

Past leaching from stored by-product waste salts from arsenical herbicide manufacturing at the Ansul Fire Protection Company contaminated the underlying groundwater. Contaminated groundwater flow and surface releases to the river have resulted in severe arsenic contamination of sediments in the adjacent turning basin area. This corresponds to River Reach 5 (refer to Figure IV.3). Extensive sediment sampling, conducted by the U.S. Army Corps of Engineers in 1986 in the turning basin, showed high levels of arsenic contamination in this area (Appendix IV.15). Arsenic levels of 1,000 parts per million (wet weight) were found at depths of 15 feet and greater in the sediment cores with surficial concentrations in the 1,000 to 2,000 parts per million range at some sample sites. The highest concentrations of arsenic were found in cores (two to seven feet deep in the sediment) taken closest to the Ansul Fire Protection Company property where the waste salt storage piles were located. (To find corresponding dry weight concentrations, the wet weight values above would need to be multiplied by a factor of 1.5 to 2.5.)

Forms of Arsenic

Sediment sampling sites in the turning basin in proximity to the former waste salt pile storage sites on the Ansul Fire Protection Company property, were found to have the highest total arsenic concentrations. Iverson, Anderson, Holm and Stanforth (1980) found that at these proximal sites, 90% of the arsenic was in the form of monomethylarsonic acid (MMAA) and is reflective of the arsenic species at the waste salt pile source. A sampling site approximately 300 feet away and toward the river channel had a lower total arsenic concentration which was approximately 70% inorganic). The Iverson study suggested that the MMAA at the outer sites was converted to the inorganic arsenic form through a demethylation process. The study observed that one possibility why demethylation was not observed in the sediments in proximity to the former waste salt piles was because the higher arsenic concentrations were toxic to the organism responsible for the demethylation. The demethylation process may release the more toxic trivalent arsenite and pentavalent arsenates to the sediments and water column. Dames and Moore (1979) found that inorganic arsenic levels were greater than organic arsenic concentrations in surficial sediments at eight of the twelve Menominee River and Green Bay sampling locations. At these eight river and bay locations, inorganic arsenic comprised 65% of the total arsenic measured.

Toxicity of Various Arsenic Forms

Arsenic metabolism and toxicity vary greatly among aquatic species. The availability and effects of arsenic on organisms depends on various of physical, chemical, and biological factors in the water column and sediments (Eisler, 1988). Just as important as direct mortality to aquatic organisms, resulting from exposure to high concentrations of arsenic, is the long term effects of exposure to sublethal concentrations that may limit development, growth, reproduction, metabolism and other physiologic processes (NAS, 1977).

The relative ordering of the toxicity of arsenic species from the most toxic to least toxic forms is as follows: arsines > inorganic trivalent arsenites > organic trivalent compounds (arsenoxides) > inorganic pentavalent arsenates > organic pentavalent compounds > arsonium compounds > elemental arsenic (Eisler, 1988).

Arsenic has been identified as being extremely mobile in the aquatic environment and it cycles through several components (i.e. the water column, the sediments, the biota, and the atmosphere) (NTIS, 1979). Biological reduction of arsenate to the more toxic arsenite form in natural waters causes an increase in the ratio of arsenite to arsenate. Extreme reducing conditions can form arsine gas (AsH_3) in the sediments that volatilizes and is released to the atmosphere when sediments are disturbed.

Arsine gas is toxic and has a characteristic garlic-like odor. Other organic arsenical compounds that are less toxic also apparently give off a garlic-like odor. Garlic-like odors were noted during core samplings in the turning basin by some investigators (Anderson, 1981, and U.S. Army Corps of Engineers, 1983). Baker (unpublished) noted the unquantified release of gaseous arsenic during sampling in 1983 and 1985 and confirmed the microbial transformation of arsenic (sodium cacodilate) to the volatile alkyl arsines and arsenic hydride. Baker noted that gaseous release of arsenic must be addressed in any management scheme proposed for the sediment in the turning basin.

The odor threshold for arsine gas is in the range of 0.21 to 0.50 ppm. The threshold limit value - time weighted average (TLV-TWAs) for human exposure is 0.05 ppm (0.2 mg/m^3) (ACGIH, 1988). The human exposure value (0.05 ppm) serves as a measure of fume toxicity in the workplace to which workers may be repeatedly exposed, over an eight hour workday and a forty hour work week, without adverse effect. Application of the TLV-TWAs for open air core sampling is a very conservative application. Arsine is probably oxidized rapidly when exposed to the atmosphere.

However, the extreme acute toxicity of arsine to humans is well documented. Exposure rates from 3 to 10 ppm can cause poisoning symptoms in a few hours (ACGIH, 1971). Animals exposed three hours a day to concentrations between 0.5 and 2 ppm developed blood changes in a few weeks (ACGIH, 1971).

Procedures for Evaluating Availability of Arsenic

The turning basin is part of a federal navigable harbor project that is maintained by the U.S. Army Corps of Engineers (COE). The COE contracted a study (Baker, unpublished) to evaluate treatment and disposal alternatives for sediments dredged from the navigational channel of the Menominee River and harbor area. According to the Baker study conducted in 1985, the project area (Figure IV.7) covered 120,000 square feet and involved 40,000 cubic yards of arsenic contaminated sediment. Approximately 28,900 cubic yards are highly contaminated sediments with an average arsenic concentration of 1,055 parts per million (dry weight). It should be noted that the boundary drawn along the southeast portion of the navigational project area does not encompass all the arsenic contaminated sediments that are possibly present in the vicinity of the Eight and Sixth Street Slip areas and south channel. Baker applied the extraction procedure (EP) toxicity test (as established in the Federal Resource Conservation Recovery Act regulations [RCRA] and corresponding NR 181, Wis. Adm. Code) to determine if the sediment in the turning basin would be classified as hazardous waste based on the arsenic concentrations. Any arsenic in the leachate extracted from sediments that exceeds the EP toxicity criteria of 5 ppm would be classed as a RCRA hazardous waste. Baker established that, based on the EP toxicity leachability of the turning basin sediments, any sediments that contain total arsenic concentrations of 278 parts per million dry weight or greater would yield a leachate containing greater than 5 ppm of arsenic. Of the eight cores taken in the turning basin of the project area, Baker found that four of them contained segments where the arsenic concentrations exceeded 278 parts per million. The disposal of such hazardous waste requires a special confined facility permitted by U.S. EPA under the RCRA regulations. EP toxicity tests conducted on arsenic contaminated sediments in the Sixth Street Slip yielded an arsenic leachate concentration of 19.78 ppm which exceeds the 5 ppm criteria for determining if the material is hazardous waste (Swiantek, 1984).

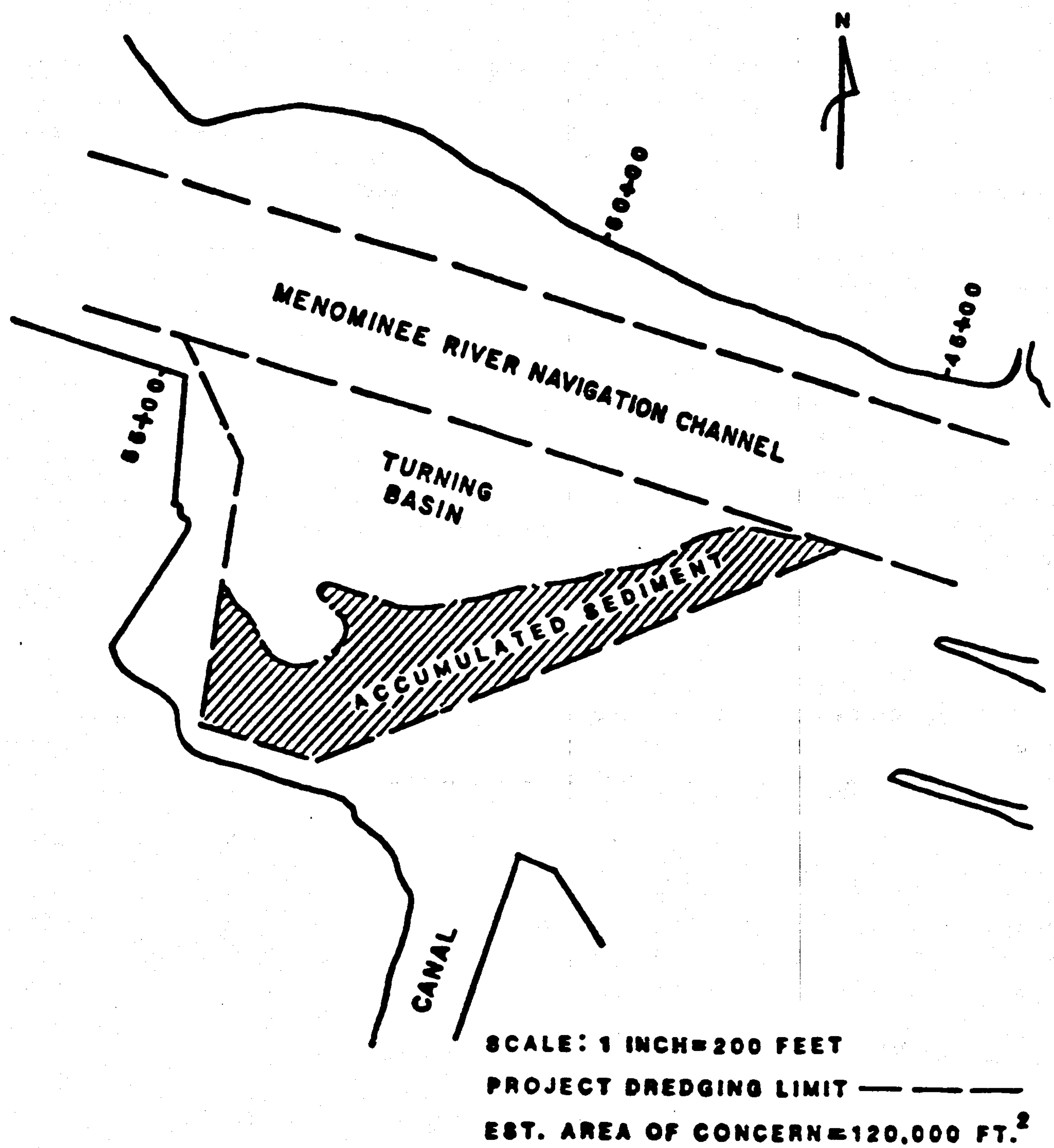
The following expression from the Baker study was used to predict the possible movement of arsenic from sediments to water under dredging conditions:

$$\ln E_{AS} = 1.38 \ln S_{AS} - 5.55$$

where: E_{AS} = extracted or leached arsenic concentration expressed in ppm.
S_{AS} = sediment arsenic concentration in parts per million (mg/Kg dry weight)

(Refer to the original document for development of this relationship.) Based on the above equation, preliminary indications are that any sediments containing 26.8 ppm or greater of arsenic have the potential to leach or release arsenic to the water column in amounts exceeding Wisconsin's acute water quality criteria of 363.8 ppb under a dredging situation. The above sediment and water quality values assume arsenic is in the form of total recoverable trivalent arsenite. It is also assumed that the Baker study

FIGURE IV.7
BAKER ENGINEERING STUDY AREA



Source: Baker Engineering, unpublished

linear regression model fits for the lower concentrations of arsenic in the sediments. Leachability testing (Baker, unpublished) of arsenic in the turning basin using the EP Toxicity Test, ASTM-A procedure D-3987-81 and a modification of the ASTM-A procedure where river water was used instead of deionized water, leached 40 percent, 44 percent, and 58 percent respectively of sediment arsenic. Potential sources of leaching and release in-situ are: disturbances and dispersion of sediments to the water column, release of interstitial water, and groundwater flows out of the sediment.

Analyses of sediment pore water from samples in the turning basin taken during the Baker study showed concentrations of arsenic as high as 3,720 ppm at a sediment depth of 27 feet.

A federal Resource Conservation Recovery Consent Order is being negotiated between the U.S. EPA, the WDNR, and the Ansul Fire Protection Company. The consent order will include a RCRA Facility Investigation (RFI), and corrective measures study. The order will require Ansul Fire Protection Company to reenter order negotiations if the corrective measures investigation finds that remediation is necessary.

The U.S. EPA sediment pollutional classification guidelines that establish concentration ranges for arsenic may be set too low to accommodate the natural geochemical abundances of arsenic in the soils and substrates of the Menominee River watershed. Based on the WDNR sediment quality guidelines for beach nourishment projects, (Appendix IV.14), which is derived from arsenic levels in lake sediments and bluff material from Lake Michigan, the "unpolluted" designation might more appropriately be set at 10 ppm or the IJC guideline value of 8 ppm. The "moderately" and "heavily" polluted classification ranges for arsenic should possibly be set at ranges greater than this, e.g., 10-15 ppm, and greater than 15 parts per million, respectively. While these proposed changes do not alter the pollutional classification of the heavily polluted turning basin and Eighth Street slip areas (River Reach 5), the pollutional classification for arsenic in River Reaches 1, 3 and 4 would be affected.

After River Reach 5, the most elevated levels of arsenic in the sediments are found in Reach 6 in the South Channel (refer to Figure IV.3). Sampling has shown levels ranging from 102 ppm in the area of the Sixth Street slip to 17.7 ppm in the Menekaunee Harbor area. The sediment samples in River Reaches 3 and 4, below the turning basin in the main river channel, show moderate levels of arsenic contamination (15 ppm).

One sample result upstream from the turning basin in River Reach 2 (WDNR, 1989) showed an arsenic concentration of 37 ppm in the sediments. The sample site was 10 feet from the Marinette wastewater treatment plant (WWTP) outfall. A possible source of arsenic in the sediment at this site is the effluent from the WWTP. Other pollutants, such as cadmium, lead, oil and grease, and volatile solids were also at elevated concentrations at this site compared to 14 other sediment sites sampled from the Lower Menominee River by WDNR in August 1989 (Appendix IV.16). The levels for cadmium and lead at this site are among the highest concentrations found in samples collected from all sediment studies for all reaches of the river (refer to Table IV.14).

Other Pollutants of Concern

Based on the U.S. EPA pollutional classification guidelines, a synopsis of all sediment sampling presented in Table IV.15 indicates that areas in all river reaches are heavily or moderately polluted with at least one pollutant. The river reaches having the most pollutants in the "heavily polluted" classification are the following reaches (in parentheses are the number of pollutants classified as heavily polluted within that reach): 5(10), 6(9), 4(8), 3(5), 2(4), and 1(2).

Pollutants meeting the U.S. EPA guideline for the heavily polluted classification in at least one sample in two or more river reaches are (the total number of reaches are in parentheses): arsenic (5), oil and grease (6), chemical oxygen demand (3), cadmium (2), lead (4), mercury (3), ammonia-nitrogen (3), total Kjeldahl nitrogen (3), volatile solids (3), copper (2), cyanide (2), manganese (3), and phosphorus (2).

Pollutants meeting the moderately polluted classification in two or more river reaches are (the total number of reaches are in parentheses): nickel (3), lead (2), copper (3), cyanide (3), zinc (2), ammonia-nitrogen (2), and chromium (2).

All river reaches have at least 3 or more in-place pollutants that exceeded the IJC sediment quality guidelines. The order of the river reaches having the most to the least number of pollutants exceeding the IJC guidelines (followed by the number of pollutants that exceed the guidelines in that reach) are as follows: 5(7), 6(6), 4(6), 2(5), 3(5), and 1(2). This river reach ordering is the approximate ordering found in applying the U.S. EPA pollutional classification system. Some significant levels of pollutants in the sediments associated with particular stream reaches are provided in Table IV.16.

From the data in the Table IV.16 the sample sites with the most elevated concentrations of pollutants in the sediments were found predominately in River Reaches 4, 5 and 6.

Mercury

Based on the U.S. EPA pollutional classification guidelines, mercury levels at sites in three river reaches are classified in the heavily polluted category. The mercury levels in the sediments exceed the WDNR guidelines for beach nourishment projects of 0.1 ppm in all six reaches and the IJC guideline value of 0.3 ppm in five reaches. Maximum sediment concentrations for mercury in ppm (followed by river reach in parenthesis) are as follows: 2.6 (3), 1.2 (1), 1.0 (5), 0.46 (4) and 0.44 (2). The higher levels of mercury in the sediments are typical of areas that have received or presently receive discharges from municipal and industrial sources that contain mercury in their effluent (Lake

Michigan Enforcement Conference, 1972). Konrad (1971) related comparable elevated levels of mercury in sediments to discharges from municipal wastewater treatment plants and paper mills.

Table IV.16 Significant Exceedances (1980-1989) of U.S. EPA Concentration Guidelines Designating Heavily Polluted Sediments

Pollutant	Maximum Concentration Levels (ppm)[1]	River Reach	Amount in Exceedance EPA Heavily Polluted Guideline
1. Arsenic[2]	32,300	5	4,037X
2. Arsenic	5,473	5	687X
3. Arsenic	4,626	5	578X
4. Cadmium	13	2	2.2X
5. Copper	113	6	2.3X
6. Cyanide	45.7	6	183X
7. Lead	240	2	4X
8. Lead	237	6	4X
9. Manganese	933	5	1.9X
10. Mercury	2.6	3	2.6X
11. Zinc	439	6	2.2X
12. Ammonia-Nitrogen	1,600	5	8X
13. Ammonia-Nitrogen	1,600	6	8X
14. Chemical Oxygen Demand	107,000	2	1.3X
15. Chemical Oxygen Demand	189,000	3	2.4X
16. Chemical Oxygen Demand	226,000	4	2.8x
17. Total Kjeldahl N	5,400	5	2.7X
18. Total Kjeldahl N	10,400	6	5.2X
19. Oil & Grease	6,300	1	3.2X
20. Oil & Grease	19,000	2	9.5X
21. Oil & Grease	19,000	3	9.5X
22. Oil & Grease	14,000	4	7X
23. Oil & Grease	5,830	5	2.9X
24. Oil & Grease	37,900	6	19X
25. Phosphorus	1,200	5	1.9X
26. Phosphorus	2,600	6	4X

(1) The maximum concentrations for these pollutants are expressed as ppm dry weight.

(2) Sixteen of 100 samples taken in 1986 (U.S. Army Corps of Engineers) had arsenic concentrations exceeding 278 ppm and would be classified as a hazardous waste (Baker, unpublished).

Konrad (1971) found the major source of the mercury contamination in sediments to be associated with mercury cell process for the production of chlorine and caustic soda and the use of phenyl mercuric acetate as a slimicide by the paper industry. In 1970, a letter was sent by WDNR to each pulp and paper mill advising them that the use of mercury compounds should be discontinued. Menominee Paper Company reports that there has never been a detectable level of mercury present in its wastewater discharge. Some examples of mercury values found in the sediments by Konrad in the Menominee River and other Wisconsin rivers are shown in Table IV.17. A comparison of the mercury content in the sediments to water column concentrations for these rivers (the Menominee, Peshtigo, Oconto, and Fox Rivers) is shown in Table IV. 18.

Even if man-made sources of mercury to aquatic ecosystems are removed, the mercury content in sediments, fish, and in other aquatic organisms appear to decrease slowly. In the NAS (1978) and the Forstner and Wittman (1983) reviews of the literature, there are discussions of the importance of biologically mediated reactions that produce mercury-organic compounds that have the potential to bioaccumulate with toxic properties. Organisms in sediments have the ability to biosynthesize methyl mercury compounds. The biosynthesis and production of methyl mercury is a normal part of the mercury cycle. Man-made sources of mercury in the sediments result in methyl mercury above natural cycle steady-state conditions. The literature reviews cite evidence that bioaccumulation of methyl mercury into the tissues of higher organisms may be controlled by diffusion. Extremely low concentrations of methyl mercury in water may bioaccumulate rapidly. The rate of methyl mercury formation and bioaccumulation is a function of: a) the degree of contamination, b) the chemical form, c) the physical-chemical-biological characteristics of the system, d) the water residence time, and e) the rate at which the mercury is either removed (bed load transport) or buried in the sediments.

Eisler (1987) indicates that among the metals tested, mercury was the most toxic to aquatic organisms, and organomercury compounds showed the greatest biocidal potential. The acute toxicity criteria for aquatic organisms for mercury (+2) in NR 105, Wis. Adm. Code, is 1.53 ppb in the water column. The availability and presence of the mercury (+2) form in the sediments and interstitial waters cannot be predicted from the total mercury levels in the Menominee River sediments reported above. A number of factors related to mercury levels in the sediments needs to be further investigated including sources, biosynthesis of methyl mercury by microorganisms, bioconcentration and biomagnification, and lethal and sublethal levels that impact benthic organisms.

Sediment Quality Assessment for Metals

Arsenic and mercury concentrations in the Menominee River sediments are discussed above. The other metals such as copper, zinc, selenium, chromium, lead, and nickel can also demonstrate various levels of toxicity depending on the form of the metal, presence of other metals, physical conditions in the sediment, condition of the organism, and behavioral response of the organism (Forstner and Wittman, 1983). Toxicity to benthic organisms by these metals adversely affects the basis of the food chain upon which birds, fish and other aquatic organisms depend.

Table IV.17 Mercury Concentrations In The Menominee River and Other Wisconsin Rivers (Adopted from Konrad 1971)

River	Location of Deposit (number corresponds to sample number in Table IV.18)	Source of Deposit	Average Mercury Content (ppm)	Average Alkalinity (ppm)	Average pH	Fish Accumulation (ppm)
Baraboo	1. Below Wonewoc	Sewage Treatment Plant Effluent	0.5	-	7.6	N.A.
Chippewa	2. Chippewa Falls-Eau Claire	Paper Mill	1.2	33	7.1	0.60
Flambeau	3. Below Park Falls	Paper Mill	0.6	20	6.9	0.41
	4. Ladysmith Area	Paper Mill	1.4	25	7.2	1.07
Fox	5. Below Portage	Sewage Treatment Plant Effluent	0.8	-	7.6	N.A.
	6. Neenah-Menasha to Mouth	Paper Mills and Sew. Trt. Plt. Eff.	2.0	139	7.8	0.36
	7. Lower Green Bay	Paper Mills	1.5	-	7.2	0.21
Menominee	8. Marinette Area	Paper Mills	1.2	81	7.6	0.45
Milwaukee	9. Above Mouth and Milwaukee Harbor	Unknown	1.5	168	7.8	0.13
Rock	10. Below Janesville	Unknown	0.4	225	8.3	0.11
	11. Below Madison Sewage Outfall - Badfish Creek	Sewage Treatment Plant Effluent	11.5	-	7.5	N.A.
Wisconsin	12. Rhinelander-Tomahawk	Paper Mills	1.5	20	6.7	0.95
	13. Stevens Point-Wis. Rapids	Paper Mills	2.7	30	6.8	0.51
	14. Port Edwards-Nekoosa	Chlorine Plant	684	36	6.8	1.24
Wolf	15. Below Shawano	Paper Mills	0.8	92	7.8	N.A.

Note: N.A. means no available data.

Table IV.18 Mercury Content of Sediments and Water from the Menominee, Peshtigo, Oconto, and Lower Fox Rivers (adopted from Konrad, 1971)

*Sample No.	Miles	Location	Mercury Content, ppm Sediment	Water
		Menominee River		
	114	Mouth of Brule River		
1		0.25 miles below Niagara Paper Mill	0.28	------
2		1 mile below Niagara Paper Mill	0.14	------
3	3.5	200 yds. above Upper Dam - Marinette	<0.10	<0.0005
4	3.4	Upper Dam - Marinette	----	<0.0005
5	2.3	300 ft. below Scott Paper - Marinette	1.15	<0.0005
6	1.0	100 ft. below Ansul Chemical	0.30	<0.0005
	0	Lake Michigan		
		Peshtigo River		
7	10.5	200 yds. above Dam - Peshtigo	<0.10	<0.0005
8	9.8	Hwy. "41" Bridge - Peshtigo	----	<0.0005
9	7.0	3.5 miles below Badger Paper	<0.10	<0.0005
	0	Green Bay		
		Oconto River		
10	19.8	300 yds. above Upper Dam - Oconto Falls	0.10	<0.0005
11	15.1	1.5 miles above Stiles Dam	0.23	<0.0005
12	3.1	U.S. "41" Bridge - Oconto	----	<0.0005
	0	Green Bay		
		Lower Fox River		
	39.9	Lake Winnebago		
14	31.9	0.25 miles above Hwy. "47" Bridge-Appleton	0.34	<0.0008
15	27.4	Below Kimberly-Clark - Kimberly	0.97	------
16	24.4	0.4 miles above Kaukauna Dam	3.3	------
17	7.5	0.25 miles above DePere Dam	3.6	------
18	2.3	Mason St. Bridge - Green Bay	2.5	0.0045
19	1.4	East River	2.0	<0.0005
20	0	Mouth of Fox River - Green Bay	1.25	<0.0005
		Lower Green Bay		
21		(a) ½ mile West of Grassy Island	1.80	<0.0005
22		(b) 2 miles East and 1.5 miles North of Fox River Mouth	1.70	------
23		(c) 2 miles out in Ship Channel	1.35	------
24		(d) Off Long Tail Point	0.25	------
25		(e) 0.4 miles West of Sable Point	0.14	------
26		(f) 2 miles SW of Red Banks	0.60	------
27		(g) 400 yds. NE of Red Banks	0.25	------

(1) Sample number corresponds to the location number noted in Table IV.17.

At the present time, an acceptable methodology has not been developed to derive sediment quality criteria for metals that can be applied to different sediment types. Biological availability and contaminant mobility of metals in sediments, interstitial waters, and the overlying water column are related to a number of variables in the aquatic environment: organic matter content, pH, iron and manganese complexes, type and amount of clays, and oxidation/reduction states. Prediction of these variables makes it difficult to derive sediment quality criteria related to protecting benthic and epibenthic species (the latter spend all or part of their life cycles on the surface of deposited sediment). Also the embryos of fish and larval forms of other aquatic organisms that come in close contact with the sediments and sediment pore water need to be protected from adverse levels of metals in the sediments. Development of sediment quality criteria for metals (i.e., related to protecting benthic aquatic life and addressing human health concerns) is an area that both U.S. EPA and WDNR are currently reviewing. U.S. EPA has indicated that the development of sediment criteria for metal contaminants, using an equilibrium partitioning approach,will be the focus of future efforts in this area.

The high cyanide reading of 45.7 ppm reported in Table IV.14 above from River Reach 6 could be a reporting error and needs to be verified. EPA's pollutional classification establishes a level of <0.10 ppm as being unpolluted. The 45.7 ppm value is several orders of magnitude above the 0.25 ppm value for a heavily polluted sediment in EPA's pollutional classification. Sulfide, if present in the sample, can interfere with cyanide analysis resulting in elevated readings.

In assessing the pollution levels in the Menominee River sediments for metals, application of the U.S. EPA pollutional classification system has to be qualified. The WDNR sediment quality guidelines (Appendix IV.14) attempt to establish background levels for metals in Lake Michigan sediments. It should be noted that the background levels established in Appendix IV.14 for lead, zinc, nickel, chromium, and copper all exceed the levels established for unpolluted sediments in EPA classification with chromium being as much as 3 times higher. Applying the U.S. EPA pollutional classification scheme creates the situation of having WDNR's guidelines for "clean" sediment (based on background levels for those metals), being classified as moderately polluted and, in some cases, even heavily polluted. Consequently, this can lead to misinterpretation or misrepresentation of the sediment quality.

In addition, WDNR sediment guidelines (Appendix IV.14) do not establish values for manganese and iron; however, the EPA classification does establish pollutional ranges for these parameters. There are indications that background concentrations for manganese and iron in the sediments may be categorized by the U.S. EPA classification as being moderately or heavily polluted, which, like other metals mentioned above, may be a misleading indication of the pollutional condition. The pollutional classification categories established by EPA need to be investigated further to determine how they relate to state guidelines.

Based on water quality criteria established by U.S. EPA (1986) for iron (1000 ppb), iron toxicity to aquatic organisms (and comparably to benthic organisms) is of less concern compared to any of the other heavy metals. Although not directly toxic, high concentrations of ferric and ferrous ions in water can kill fish introduced in the solution by coating the gills with iron hydroxide precipitates. Iron oxidizing bacteria are dependent on iron in solution for growth. These bacteria can form slimes that affect the aesthetic values of water bodies (U.S. EPA, 1978).

No water quality criteria for manganese have been published related to possible toxic effects to freshwater aquatic life which indicates there is less concern about the potential impact on aquatic organisms. However, U.S. EPA has published water quality criteria related to human ingestion of water and fish containing manganese.

Beak Consultants Limited has done sediment guideline development work for the Ontario Ministry of the Environment. Utilizing Great Lakes benthic surveys and in-place pollutant data, they have developed Screening Level Concentrations (SLCs) for a variety of in-place pollutants (Hart, 1989). The SLC approach estimates the highest concentration of a contaminant that can be tolerated by 95% of benthic species. As the SLC is exceeded, the percentage of benthic species that can tolerate the increased concentration will decrease. The Ontario Ministry of Environment (MOE) has incorporated the SLC approach as one of the approaches in developing their Sediment Quality Guidelines (Persaud et al, 1990). The Beak SLCs are compared with the minimum and maximum metal concentrations found in the sediments of the Menominee River stream reaches (Table IV.19). For comparison, the MOE Lowest Effect Level concentrations for metals contained in their Sediment Quality Guidelines is also included at the bottom of Table IV.19. The SCLs are being used as a preliminary assessment tool to identify if there may be any potential effects from elevated concentrations of various metals in the Lower Menominee River sediments.

Table IV.19 indicates that the following metals exceed the Beak Consultants-derived SLCs (followed by the number of stream reaches where the levels were exceeded in the sediments): arsenic (5), mercury (4), cadmium (3), lead (2), copper (1), and chromium (1). Actual impacts to benthic organisms and the benthic community structure indigenous to the Lower Menominee River would have to be verified from field studies and laboratory bioassays.

Polychlorinated Biphenyls (PCBs)

The PCB concentrations from sediment samples collected by WDNR in the six river reaches did not exceed the 10 ppm total PCB guideline established by U.S. EPA for the heavily polluted classification. Where detected in the sediment samples, PCB levels do routinely exceed the WDNR sediment quality value of 0.05 ppm (Appendix IV.14) related to beach nourishment projects. U.S. EPA Region V has stated (1987 and 1988 correspondence, Sutfin to Hochmuth) that preliminary results indicate the 10 ppm PCB guideline recommended in their 1977 pollutional classification system may not be restrictive enough. EPA Region V further states that additional preliminary data indicate a level of 1 ppm for a sediment guideline may not be restrictive enough to prevent bioaccumulation of PCBs in the food chain, and toxic impacts to aquatic life, fish and wildlife, and human health concerns.

Table IV.19 Comparison of the Ranges of Metal Concentrations in the Menominee River Stream Reaches with Screening Level Concentrations[(1)(2)] to Determine Potential Impacts to Benthic Organisms (all values in ppm)

Stream Reach	Arsenic	Cadmium	Chromium	Copper	Lead	Manganese	Mercury	Nickel	Zinc
No. 1 Min.	0.5	-	-	-	-	-	-	-	-
No. 1 Max. 4.0	<1	-	-	-	43	170	1.2*	-	
No. 2 Min.	0.1	<0.01	7.5	<0.55	<1.2	105	<0.04	<4	18.5
No. 2 Max.	37*	13*	16	26.5	240	490	0.44*	17	70
No. 3 Min.	0.5	<0.02	7.3	0.29	<0.88	124	<0.05	<4	20.8
No. 3 Max.	37*	0.4	16	26.5	337*	660	2.6*	17	70
No. 4 Min.	0.7	0.02	7.3	<0.38	<1.1	160	<0.02	5.1	33.9
No. 4 Max.	25*	6*	27	35	51	920	0.46*	27	106
No. 5 Min.	0.5	<1.0	17.1	10.7	4.2	244	0.17	6.93	22.5
No. 5 Max.	32,300*	5.4*	826*	47	110	933	1.0*	32.7	190
No. 6 Min.	4.3	<1	16.3	18	0.38	43	0.032	7.36	59.1
No. 6 Max.	102*	3.3	59	113*	237*	290	0.13	28.8	429
Beak[(1)] Screening Level Concentrations	17	3.5	134	93	118	1,100	0.44	92	563
MOE[2] Screening Level Conc.	6	1	31	25	31	460	0.2	31	120

(1) Screening Level Concentrations developed by Beak Consultants Limited Brampton Ontario, 1989, D. R. Hart and J. Fitchko, for Ontario Ministry of Environment. The SLC is an estimate of the highest concentration of a contaminant that can be tolerated by approximately 95% of benthic species. SLCs based on total organic carbon-normalized sediment concentrations and adjusted to a bulk sediment basis assuming an average 4% total organic carbon.

(2) Screening Level Concentrations from Ontario Ministry of Environment Provincial Sediment Quality Guidelines. (Persaud et al., 1990). The value used is the Lowest Effect Level Concentration which is a level of sediment contamination that can be tolerated by the majority of benthic organisms.

* Notes Beak Screening Level Concentrations exceeded.

U.S. EPA has indicated that their PCB guidelines may be modified in the future as it promulgates specific numerical sediment quality criteria.

U.S. EPA currently has a number of activities ongoing to identify, coordinate, and develop guidance relating to the assessment and management of contaminated sediments. They are reviewing several approaches to developing sediment quality criteria based on biological effects.

U.S. EPA has undertaken a significant research effort aimed at verifying and refining an equilibrium partitioning (EQP) approach for deriving national sediment criteria. The EQP is just one of about twelve approaches for developing sediment criteria that U.S. EPA is currently examining. It is probably the farthest along of any of the other approaches in its development, but it should be stressed that the values developed using this method as cited in the RAP are preliminary and to be used for screening purposes only and should not be regarded as definitive numbers. The values derived from this initial application of the EQP approach will be referred to as sediment quality assessment values (SQAV) in the discussions below. An explanation of the method and assumptions that underlie the use of the EQP-based approach to establish SQAVs and the advantages and limitations of the approach are listed in Appendices IV.17 and IV.18. Based on the EQP approach, U.S. EPA (1988, 1989) has developed interim sediment quality criteria for 11 nonpolar hydrophobic compounds which include PCBs (Aroclor 1254). Water quality criteria for toxic substances are used to derive sediment quality criteria by applying the EQP approach to the following formula:

$$SQC = WQC \times K_{oc} \times F_{oc}$$

where: SQC = sediment quality criteria
WQC = water quality criteria for the pollutant of concern
K_{oc} = organic carbon (OC) partition coefficient for the pollutant of concern
F_{oc} = particle organic carbon (OC) weight fraction Kg OC/Kg sediment

Chapman et al. (1987) and Pavlou (1987) indicate the equilibrium partitioning approach holds much promise for establishing biologically safe levels of contaminants in sediments. The Science Advisory Board to U.S. EPA has completed a review of the EQP approach for establishing sediment quality criteria and has issued a favorable report. The EQP approach is based on the chemical characteristics of each compound to partition between sorption sites in the sediment particles and the surrounding water media at a constant and characteristic ratio. The key to the approach is the determination of a representative sediment/water partition coefficient for each contaminant of concern. To date, the EQP approach has been used with nonpolar (non-ionic) hydrophobic organic compounds and relating their concentrations in the sediment to organic carbon content. As with all approaches there are limitations that need to be recognized in its application. Supplemental studies may need to be used to refine the approach and provide further chemical and biological verification.

The above EQP approach has been applied to the sediment monitoring data for PCBs obtained by WDNR in August 1989 (refer to Tables IV.20 and IV.21). The sediment quality assessment values (SQAV) in Table IV.20 are driven by the water quality criteria in NR 105 of the Wisconsin Administrative Code that address human cancer criteria. The water quality criteria are designed to prevent bioaccumulation of PCBs (1254/1260) in fish tissue below a cancer risk level of 1 in 100,000 for people that consume fish. The SQAV for PCBs (refer to Table IV.20) range from approximately 1 to 22 ppb. The calculated SQAV are exceeded at each of the five sample sites.

Table IV.20 Development of Sediment Quality Assessment Values for PCBs at Five Sites in the Menominee River (based on Human Cancer Criteria) Using the **Sediment-To-Water Equilibrium Partitioning Approach**

Site[1]	Water Quality Standards (WQS) For PCBs[2]		Koc For PCB-1254[3]		foc[4]		Sediment Quality Assessment Value (SQAV) ppb (ug/Kg)
5	1.5×10^{-4} ppb	x	1.38×10^{6}	x	0.04	=	8.90
10	1.5×10^{-4} ppb	x	1.38×10^{6}	x	0.11	=	21.74
11	1.5×10^{-4} ppb	x	1.38×10^{6}	x	0.03	=	6.36
14	1.5×10^{-4} ppb	x	1.38×10^{6}	x	0.05	=	10.18
15	1.5×10^{-4} ppb	x	1.38×10^{6}	x	0.008	=	1.59

Site	SQAV ppb (ug/Kg)	Sediment[1] Concentration ppb (ug/Kg)
5	8.9	80
10	21.7	490
11	6.4	70
14	10.2	120
15	1.6	800

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(1) From WDNR August 1989 samples, See Figure IV.2 for locations. PCBs reported as Arclors 1254/1260.
(2) Based on NR 105.09 Human Cancer Criterion, Great Lakes Sport Fish Community, PCBs 1254 and 1260.
(3) Mean Organic Carbon Partition Coefficient for PCB 1254 from U.S. EPA (1988).
(4) Particle Organic Carbon Weight Fraction (Kg OC/Kg sediment) at sample site.

The state of Indiana's review (IJC, 1988) of the literature, which was aimed at developing interim sediment criterion for PCBs, found ranges of approximately 100 to 500 ppb established in various studies as acceptable total PCB concentrations in the sediment. The concentrations were based on sediment-to-fish partitioning of PCBs. One study cited used the sediment/water partitioning (EQP approach) to establish "permissible" sediment concentrations of 0.27 to 21 ppb (it assumes a 3% organic carbon content in the sediments) depending on the PCB isomer. A study by Newell (1989) established sediment quality criteria for total PCBs of 2.4 ppb based on the EQP approach and from 0.6 to 6 ppb based on a sediment-to-fish bioaccumulation method (values were converted from one in a million risk basis to one in 100,000 risk basis and assumes a 3% organic carbon content in the sediment). Chapman (1987) calculated a safe sediment level for PCBs based on the ratio between observed tissue levels and sediment concentrations at a site. Using the Federal Food and Drug Administration (FDA) action level of 2 ppm of PCBs in fish tissue, a sediment quality criteria of 26 ppb was derived.

The range of PCB values detected in the Menominee River sediments, based on the WDNR August 1989 sampling, was from 0.07 ppm to 0.80 ppm. PCBs were detected in five of the 14 sediment samples. The COE has stated in past correspondence (1982) that the PCB levels they found in the Menominee River sediments (from 0.03 to 0.4 ppm with a mean level of 0.1 ppm) are in the range of background levels for Lake Michigan sediments. The Frank, et al. (1981) study cited by the COE showed the mean concentration of PCBs in sediments for Lake Michigan was 0.009 ppm. The nondepositional zones of Lake Michigan contained an average of 0.0063 ppm and the depositional zones averaged 0.017 ppm. The highest mean concentration (0.075 ppm) and maximum reading (0.19 ppm) occurred in the Fox River basin. The second highest average concentration of PCBs in the sediments was found in the Milwaukee River Basin (0.029 ppm). PCB sampling data for the Lower Fox River and the lower portion of Green Bay Harbor in the 1976-1986 period (Lohr, 1988) showed that the average concentration of PCBs in 14 reaches ranged from 2.06 to 48.99 ppm with a maximum individual value of 250 ppm. This suggests that the PCB levels at some sites in the Menominee River are above the Lake Michigan average background concentration, but much less than concentrations found in the Fox River sediments. This also suggests that the above SQAV in Table IV.21 are comparable to the Lake Michigan average background PCB concentration (0.001-0.022 ppm SQAV versus 0.009 ppm for an average "background" concentration in Lake Michigan).

PCBs were found at only some locations in the Menominee River sediments (detected at five of 14 sample sites by WDNR in August 1989) and at low concentrations (average 0.14 ppm; this assumes that the reported detection level equals the quantified amount). Compared to these values, the average PCB concentrations in the 14 reaches of the Lower Fox River ranged from 2.06 to 48.99 ppm, with widespread sediment contamination.

Based on the above numbers, it would appear that any elevated PCB levels in the tissues of migratory fish species, that spend their life cycles in Green Bay and its tributaries, would most likely be caused by the high concentrations in the sediments from the Lower Fox River system. The Lower Fox River system has a large sediment reservoir of PCBs for continuous release to the overlying water column for possible bioconcentration/bioaccumulation into fish species.

The rock bass, which is considered a resident species of the Lower Menominee River showed no detectable levels of PCBs in nine of the ten fish sampled (refer to Table IV.5). One of the fish sampled did have detectable levels and may be a reflection of the area sampled in the river that contained detectable levels of PCBs in the sediments.

Application of U.S. EPA's EQP approach to derive SQAVs to protect and maintain fresh water aquatic life is shown in Table IV.21. The fresh water chronic criteria used in the formula is based on a total PCB value of 0.014 ppb (U.S. EPA, 1980).

The concentration of the PCBs in the sediments at four of the sites are below the calculated SQAV value derived from the water quality criteria to protect aquatic biota. This potentially means that benthic organisms in contact with sediment interstitial waters into which the PCBs have partitioned will potentially not suffer any toxic effects if exposed over a long period of time. A basic assumption in applying the EQP approach is that the availability of an organic compound to aquatic organisms is controlled by the amounts partitioning to water.

The concentration of PCBs at Site 15 exceeds the calculated SQAV for the site based on the organic carbon in the sediments. The concentration of PCBs in the sediments at this site has the potential to partition into the interstitial water of the sediments and impact benthic organisms or be released to the water column which could impact fish or other aquatic organisms.

Polycyclic Aromatic Hydrocarbons (PAHs)

One sediment sample in River Reach 3 had a total PAH concentration of 27 ppm. PAHs are formed as a result of incomplete combustion of organic compounds due to insufficient oxygen (oil and wood heating, vehicle emissions, burning of wastes). PAHs are also associated with oils and greases and other components derived from petroleum products which may end up in sediments and be measured as a component of oil and grease. The PAH grouping may include such compounds as benzo (a) anthracene, benzo (b) fluoranthene, benzo (a) pyrene, chrysene, phenanthrene, and pyrene. Several polycyclic aromatic hydrocarbons are among the most potent carcinogens known to exist (Eisler, 1987). PAHs may reach aquatic environments in domestic and industrial sewage effluents, urban stormwater runoff, deposition of airborne particulates, and combustion derived PAHs.

Application of the U.S. EPA equilibrium partitioning approach (as done for PCBs above) to derive a SQAV for PAHs is given in Table IV.22.

Table IV.21 Development of Sediment Quality Assessment Values for PCBs at Five Sites in the Menominee River (Based on Protecting Fish and Aquatic Life) Using the Sediment-to-Water Equilibrium Partitioning Approach

Site[(1)]	WQS For PCBs[(2)]		Koc For PCB-1254[(3)]		foc[(4)]		Sediment Quality Assessment Values (SQAVs) ppb (ug/Kg)
5	1.4×10^{-2} ppb	x	1.38×10^{6}	x	0.04	=	817
10	1.4×10^{-2} ppb	x	1.38×10^{6}	x	0.11	=	2030
11	1.4×10^{-2} ppb	x	1.38×10^{6}	x	0.03	=	593
14	1.4×10^{-2} ppb	x	1.38×10^{6}	x	0.05	=	950
15	1.4×10^{-2} ppb	x	1.38×10^{6}	x	0.008	=	148

Site	SQAV ppb ug/Kg	Sediment[1] Concentration ppb (ug/Kg)
5	817	80
10	2030	490
11	593	70
14	950	120
15	148	800

(1) From WDNR August 1989 samples. See Figure IV.2 for locations. PCBs reported as Aroclors 1254/1260.
(2) Based on U.S. EPA (1980) Water Quality Criteria to protect freshwater aquatic life.
(3) Mean Organic Carbon Partition Coefficient for PCB 1254 from U.S. EPA (1988).
(4) Particle Organic Weight Fraction (Kg OC/Kg Sediment) at sample site.

Table IV.22 Development of Sediment Quality Assessment Value for Polycyclic Aromatic Hydrocarbons (PAHs) At One Site in the Menominee River (Based on Human Health Concerns) Using the Sediment-To-Water Equilibrium Partitioning Approach

Site[1]	Water Quality Standards (WQS) For PAHs[(2)] ppb (ug/L)	Koc For PAHs[(3)]	foc[(4)]	Sediment Quality Assessment Value (SQAV) ppb (ug/Kg)	Sediment Concentration ppb (ug/Kg)[(1)]
Reach 3	0.023	8.9×10^5	0.026	532	27,000

(1) From Table IV.14
(2) Based on NR 105.09 Human Cancer Criterion
(3) Organic Carbon Partition Coefficient for Benzo(a)pyrene. Assumes PAHs all in the form of Benzo(a)pyrene.
(4) Particle Organic Carbon Weight Fraction (Kg OC/Kg Sediment) from a site in River Reach 6 (See Appendix IV.16)

Comparison of the calculated SQAV value with the actual concentration of PAHs in the sediment for River Reach 3 indicates the SQAV derived through this approach are extremely elevated. To verify this detection and insure there are no potential problems at other sediment depositional sites in the AOC for PAHs, additional sampling will be recommended in Stage II.

It should be noted that in the calculations in Table IV.22, an assumption is made that only one carcinogenic PAH (benzo(a)pyrene) was measured in the sediment sample. The EQP approach can be applied to a class of compounds such as a group of carcinogenic PAHs for which a water quality criterion has been developed only if the organic carbon partition coefficient for each individual PAH in the group is considered.

Fabacher et al. (1988) studied sediments from four in-shore industrial sites and a reference site in the Great Lakes to chemically characterize the PAHs. The study found that the PAH concentrations in three of the river systems sampled, which include the Fox and Menominee Rivers in Wisconsin, were 10-fold higher than sediment concentrations reported from the open waters of the Lower Great Lakes (Lakes Michigan and Erie), but consistent with the concentrations reported for Hamilton Harbor, a heavily industrialized embayment on Lake Ontario. The sediment sample taken in the Fabacher study was collected on the south side of the navigational channel in the Menominee River, about 0.75 miles upstream from the mouth of the river. The sample had a total PAH concentration of 27 ppm. Fabacher characterized the PAHs in the sample as being predominantly unsubstituted PAHs with molecular weights of 166 (grams per mole) or greater, which suggest PAHs derived from combustion sources rather than petroleum sources. More data is needed about the quantity and quality of PAH compounds in the sediments of the Lower Menominee River before any complete assessment can be made about the potential impacts of these compounds.

Oil and Grease

As shown in Table IV.16, elevated levels of oil and grease were present in all the stream reaches with a maximum value of 37,900 ppm found in River Reach 6. The analytical method normally used for measuring oil and grease is Standard Method 503A (Standard Methods For the Examination of Water and Wastewater, 17th edition).

The pollution potential of oil and grease should be qualified because of the diversity of substances that could possibly be measured by the Standard Method. An absolute quantity of a specific substance related to the more commonly thought of forms of oil and grease is not always measured (DiSalvo et al., 1977). Any compounds with common solubility in the organic solvent extract used in the Standard Method are quantitatively determined. This includes biological lipids and petroleum hydrocarbons and also such compounds as gasoline, waxes, phenols, organosulfur compounds, and other organic matter in solution which may also be extracted from the sample and are measured as "oil and grease". It may be important to characterize the types of materials in the sediments being quantified as to the types of oil and grease.

Oil and grease of petroleum origin, once incorporated into the bottom sediments below an aerobic surface layer, persist for a long period of time because microbial degradation of these compounds is very slow. If PAHs are given off by petroleum oils, they are potentially toxic to benthic and water column organisms. Oil and grease may cause heavier partitioning or concentration of nonpolar hydrophobic organic compounds in the sediments.

Oily substances that precipitate to the bottom sediments may destroy benthic organisms, degrade fish spawning areas, and potentially have long term effects on the benthic community. Oils of petroleum origin, when discharged, can exist as a sheen on the water surface, emulsified in the water column, dissolved in the water column, or settle to the bottom sediments. Due to the great variability in the chemical and physical properties of oil and the difficulty in determining related toxic properties, it is hard to establish threshold values for oil and grease in sediments related to environmental harm.

Oils and greases of a biological nature, if present in sediments, are more readily biodegradable, are less toxic, and generally are less persistent. This may not be the case if the oils are mixed in the sediments or become covered with deposited sediment material and are below a surficial aerobic layer. While degrading, oil and grease have may create an oxygen demand that could result in a decrease in the available oxygen required for survival of benthic organisms. Non-petroleum oils can also cause the same problem to benthic communities as petroleum oils if deposited in a layer over the bottom. As with petroleum oils, establishing threshold values for non-petroleum oils is difficult. The EPA pollutional classification system and the WDNR sediment quality guidelines for beach nourishments establish a level of 1000 ppm for a background or unpolluted situation. It would appear that more investigation needs to be done on a site specific basis to determine the impact oil and grease on overall sediment conditions and on benthic organisms. In addition, further characterization of the form of oil and grease present is necessary:

(1) Are oil and grease present in the form of petroleum or non-petroleum (animal or vegetable origin) components?

(2) Are only petroleum, and/or non-petroleum oil and grease forms being measured in the standard analytical method used, or are other organic components being extracted resulting in artificially higher oil and grease readings?

(3) Are the oil and grease present as a surficial covering over the bottom sediments or in buried strata or are they mixed with the bottom sediments?

Pesticides

Data collected in August 1989 by the COE is the most current and extensive sampling for pesticides in the Menominee River. Twelve stations along the Menominee River navigational channel were sampled and analyzed for 20 pesticides. None of the pesticides were found above the limit of detection achieved by the COE contract laboratory. Generally, with the exception of endosulfan, endosulfan sulfate, and toxaphene, the COE reported level of detection for pesticides is five times higher than the level of detection achieved by the Wisconsin State Laboratory of Hygiene (SLOH) (Table IV.23). The SLOH method of detection limits are not available for aldrin, endrin aldehyde, mirex, methoxychlor, and Gamma-BHC (Lindane). The U.S. EPA pollutional classification guidelines does not include ranges for pesticide concentrations. Frank, et al. (1981) sampling of surficial sediments of Lake Michigan for organochlorine insecticides showed the following results:

Maximum concentrations of organochlorine insecticides in 286 sediment samples are listed below (ppm):

DDE	0.054
DDT	0.026
Chlordane	0.0056
Dieldrin	0.0030
Heptachlor Epoxide	0.0056

Application of the U.S. EPA equilibrium partitioning approach (EQP) to develop SQAVs for pesticides is shown in Table IV.24. SQAVs were derived for those pesticides for which water quality standards are available in NR 105, Wisconsin Administrative Code for the protection of fish and aquatic life.

Based on a comparison of the SQAVs in Table IV.24 and COE method of detection limits in Table IV.23, the reported COE detection limits for the samples demonstrate SQAV are being met. The exceptions are toxaphene, and the samples with the minimum organic carbon content for gamma-BHC and endrin. Because the reported detection limit for these three compounds is greater than the calculated SQAV, it cannot be demonstrated that the SQAV are being met. The SQAV for toxaphene is relatively stringent because of the small organic carbon partition coefficient for this compound. A small partition coefficient means it is not readily absorbed to sites on the sediment particles and that it partitions heavily to the interstitial waters. Similarly, the SQAV for parathion is low because the partition coefficient is relatively low; the water quality criteria established for this compound is the lowest of all the pesticides for which there are criteria in NR 105, Wisconsin Administrative Code for the protection of fish and aquatic life.

Application of the EQP approach, based on water quality standards in NR 105 to protect the public health and welfare (human threshold and human cancer criteria), are shown in Table IV.25. The calculated SQAV values in Table IV.25, are below the method of detection limits achieved by either the COE contract laboratory or the SLOH.

Most uses of the above listed chlorinated hydrocarbon pesticides have been prohibited or restricted beginning in the early 1970s. Their characteristic long persistence in soils and sediments is measured in years. Thirteen pesticides have FDA action levels established for fish consumption.

Chlorinated hydrocarbons degrade more rapidly under anaerobic conditions in stream and river bottom sediments. Substantial amounts of intermediate metabolites accumulate in anaerobic soils. The concentration of the parent compound may decrease in the sediments through degradation, but the metabolite formed could be equally or more toxic and persistent than the parent compound (Rao, P. S. and J. M. Davidson, 1981).

Additional Observations

Some of the higher concentrations for pollutants such as COD, organic carbon, and total Kjeldahl nitrogen may, in some cases, be related to historical depositions on the river bottom of bark, chips, sawdust, and other wood related components from the lumbering era.

Dames and Moore (1979) found that the turning basin and the south channel act as deposition or settling areas for sediments transported in the Menominee River. The sediments in these areas consist of silt with some organic detritus and sand, which is indicative of a reduced stream flow.

Table IV.23 Comparison of Method of Detection Limit Attained By U.S. Army Corp of Engineer's Contract Laboratory and Wisconsin State Lab of Hygiene

	COE Contract Laboratory	Wisconsin State Laboratory of Hygiene
Aldrin	0.05	-
Chlordane	0.05	0.01
DDD	0.05	0.01
DDE	0.05	0.01
DDT	0.05	0.01
Dieldrin	0.05	0.01
Endosulfan	0.05	0.10
Endosulfan Sulfate	0.05	0.10
Endrin	0.05	0.01
Endrin Aldehyde	0.05	-
Heptachlor	0.05	0.01
Heptachlor Epoxide	0.05	0.01
Toxaphene	0.50	1.0
Mirex	0.05	-
Methoxychlor	0.25	-
Gamma-BHC (Lindane)	0.05	-

Note: All values are in parts per million (ppm).

Table IV.24 Sediment Quality Assessment Values (SQAVs) for Pesticides in the Menominee River to Protect Fish and Aquatic Life (based on Minimum, Maximum, and Mean Total Organic Carbon Content of Sediments) using the Sediment-To-Water Equilibrium Partitioning Approach

	Minimum Total Organic Carbon Content (1.2%)	Maximum Total Organic Carbon Content (14%)	Mean Total Organic Carbon Content (4.9%)
Aldrin	2.234	26.074	9.126
Gamma-BHC(2)(4)	0.008	0.092	0.032
Chlordane(2)	0.316	3.685	1.290
Dieldrin(4)	1.104	12.882	4.509
4,4'-DDT(4)	4.292	50.072	17.525
Endosulfan(3)	-	--	
Endrin(4)	0.028	0.323	0.113
Heptachlor(4)	0.137	1.599	0.560
Toxaphene(2)	0.00012	0.0013	0.00047
Parathion(2)(4)	0.0010	0.012	0.004

Note: All values are in parts per million (ppm).

(1) Based on total organic carbon content from 12 sediment samples taken along the Menominee River navigational channel in August, 1989 by U.S. Army Corps of Engineers.

(2) For these compounds, the chronic water quality criteria in NR 105, Wis. Adm. Code, was used to derive the interim sediment quality criteria based on U.S. EPA's Equilibrium Partitioning Approach. For the remainder of the parameters, only acute water quality criteria from NR 105 was available.

(3) No Organic Carbon Equilibrium Partitioning Coefficient was available to calculate SQAVs.

(4) Mean Organic Carbon Partition Coefficient used to derive the SQAV for these pesticides from U.S. EPA (1988). Partition coefficients for the remainder of the pesticides taken from U.S. EPA Superfund Public Health Evaluation Manual (October, 1986).

Table IV.25 Sediment Quality Assessment Values (SQAVs) for Pesticides in the Menominee River to Address Human Health Concerns based on a Minimum, Maximum, and Mean Total Organic Content of Sediments using the Sediment-To-Water Equilibrium Partitioning Approach

	Minimum Total Organic Carbon Content (1.2%)	Maximum Total Organic Carbon Content (14%)	Mean Total Organic Carbon Content (4.9%)
Aldrin	0.00020	0.0023	0.00080
Gamma-BHC[(3)]	0.0016	0.019	0.0065
Chlordane	0.0022	0.025	0.0089
Dieldrin[(3)]	0.00014	0.0016	0.0006
Endrin[(3)]	0.0058	0.067	0.024
4,4, DDT	0.0004	0.005	0.0018
Heptachlor[(3)]	0.0002	0.017	0.0006
Toxaphene	0.000019	0.00022	0.00008

Note: All values are in parts per million (ppm).

(1) Based on total organic carbon content from 12 sediment samples taken along the Menominee River navigational channel in August, 1989 by U.S. Army Corps of Engineers.

(2) Based on Water Quality Standards in NR 105 to protect human health and welfare (human threshold and human cancer criteria)

(3) Mean Organic Carbon Partition Coefficient used to derive the SQAV for these pesticides from U.S. EPA (1988). Partition Coefficient for the remainder of the pesticides taken from U.S. EPA Superfund Public Health Evaluation Manual (October, 1986).

V. SOURCES OF POLLUTION

This chapter provides an analysis of all currently identified sources of pollution within the AOC. Sources of pollutants which do not result in specific use impairments but which do result in some type of contamination in the AOC are also included. Table V.1 presents a summary of the impaired uses in the area of concern (AOC) and their likely cause(s) and source(s).

Table V.1 Summary of Sources and Causes of Impaired Uses

Impaired Use	Likely Cause	Source of Pollution or Problem
Restriction on Dredging	Elevated levels of arsenic, cadmium, mercury, lead, and oil and grease	Former arsenic salt storage areas, (contaminated groundwater), storm sewers, and other in-place pollutants
Loss of Fish and Wildlife Habitat	Over development of shoreline	Filling of wetlands contaminated sediments, unbalanced food chain
Degradation of Benthos	Acute toxic effect, poor habitat conditions, contaminated sediment	Former arsenic salt storage areas, (contaminated groundwater), build up of wood fibers in sediment, paint sludge, and other in-place pollutants
Degradation of Fish and Wildlife Populations	Decreased habitat, others unknown, water quality problems	In-place pollutants, point sources, filling of wetlands
Restriction on Fish Consumption	PCB and Mercury levels above Wisconsin and Michigan action levels	Regional sources outside the AOC, in-place pollutants, atmospheric deposition, unknown
Total and Partial Body Contact	Bacterial Contamination	Combined sewer overflows and other undetermined sources in Menominee Marina area

Primary Sources

Primary sources are those which manufacture, use, or produce materials which subsequently become pollutants (SAIC, 1987). The Menominee River AOC has several primary pollutant sources. Their locations within the AOC are presented in Figure V.1. Toxic pollutants such as arsenic, cadmium, cyanide, mercury, lead, and oil and grease are present in the AOC.

Pollution sources outside the AOC also contribute to contamination found within the AOC. The Fox River contributes an estimated 60 percent of the total tributary loading of PCBs to Lake Michigan (Marti, 1984)(see Figure III.1). Fox River PCB loads to Green Bay were estimated to range from 367 to 1360 pounds per year with an average between 1100-1320 pounds per year. Conventional parameters discharged to the AOC includes substances such as a biochemical oxygen demand (BOD), suspended solids, phosphorus, nitrogen, pH, and fecal coliform. The key sources of these pollutants are described below. Loadings from these sources are discussed in Chapter VI.

Whole effluent biomonitoring is required of several dischargers in the AOC. The whole effluent toxicity test is a method used to directly determine the toxic effect of an industrial or municipal effluent. The acute toxicity test is designed to measure toxicity severe enough to rapidly induce a response (within 96 hours). The chronic toxicity test is designed to measure toxicity that lingers or continues for a longer period of time (typically one-tenth of the organisms life span) (USEPA, 1985). Specific procedures for whole effluent biomonitoring, pass and fail conditions, and compliance measures (required when effluents fail the test) are detailed in each facility's discharge permit.

Marinette Wastewater Treatment Plant

The Marinette Wastewater Treatment Plant (WWTP) provides secondary treatment of wastewater for domestic, commercial, and industrial facilities. In 1986, the condition of the WWTP and collection system required bypassing of waste water from the treatment plant during periods of wet weather. Due to the bypassing, the City of Marinette was placed under a sewer service moratorium by WDNR and Wisconsin Department of Industry Labor and Human Relations. The moratorium prohibited sewer expansion until corrections were made in the collection and treatment systems to prevent bypassing. The City of Marinette has upgraded its collection system, resulting in separation of the combined sewers and renovation of the treatment system. The moratorium on new sewer connections was lifted in 1989. The upgraded wastewater

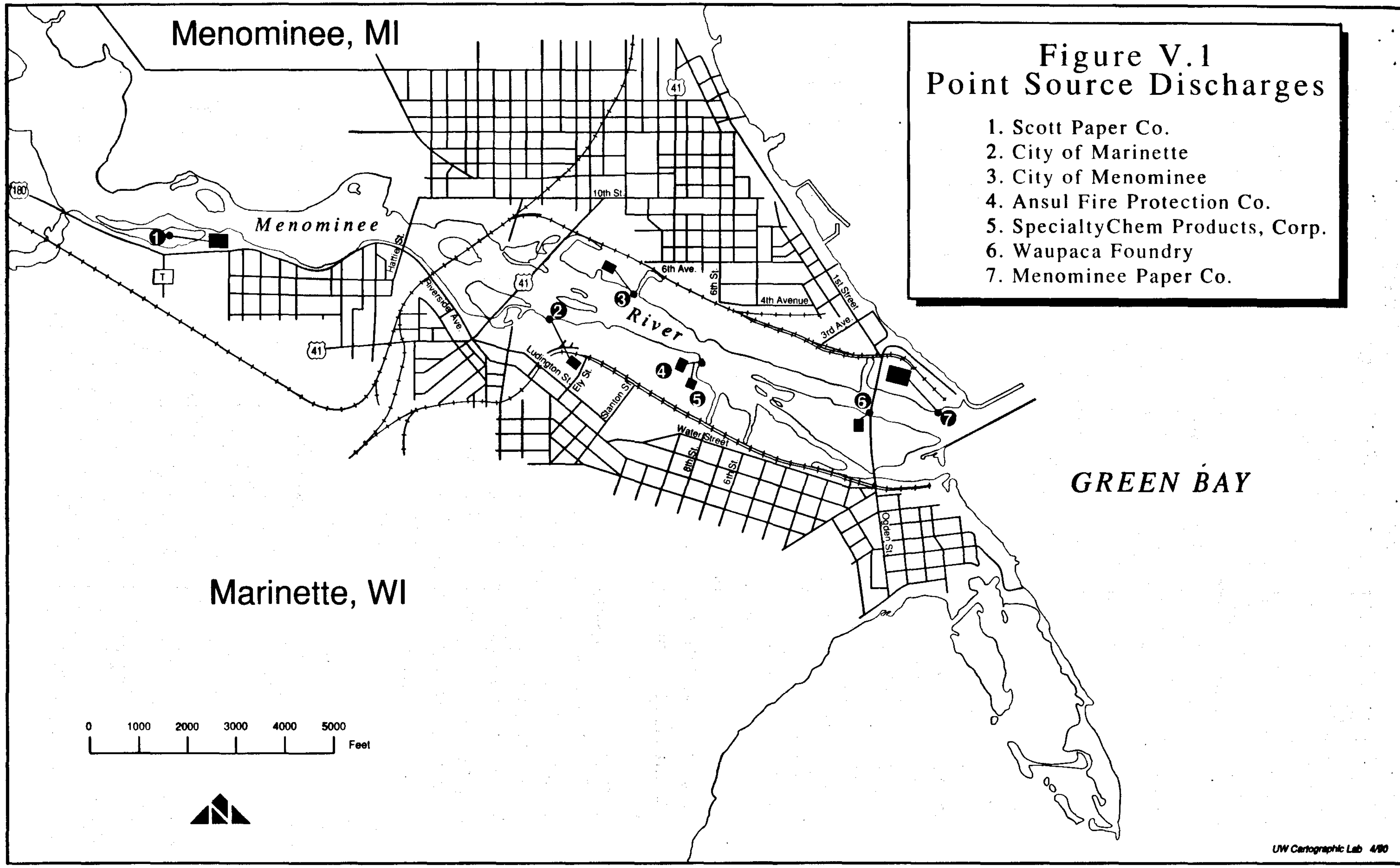


Figure V.1
Point Source Discharges

1. Scott Paper Co.
2. City of Marinette
3. City of Menominee
4. Ansul Fire Protection Co.
5. SpecialtyChem Products, Corp.
6. Waupaca Foundry
7. Menominee Paper Co.

treatment plant can now treat up to 5.1 MGD (average dry weather flow), 8360 pounds of five day biochemical oxygen demand; 10,150 pounds of total suspended solids; and 290 pounds of total phosphorus per day.

The City of Marinette WWTP discharge is monitored for the following parameters: pH, BOD, suspended solids, fecal coliform, residual chlorine, phosphorus, cyanide, heptachlor and aldrin. An industrial pretreatment program and biomonitoring are required in the Wisconsin Pollution Discharge Elimination System permit (WPDES) issued September 29, 1989.

Biomonitoring will not begin until June 30, 1991, due to the ongoing construction at the WWTP. The biomonitoring will be conducted when the new system is operating under normal conditions. During the following two years (1992, 1993) the city is required to conduct two acute and one chronic bioassay each year. The City of Marinette will also be required to conduct one acute and one chronic bioassay during the last year of its permit which expires September 30, 1994. In April, 1988 the U.S. EPA laboratory in Chicago ran an acute bioassay on the City of Marinette's effluent (Oman, 1990). The bioassay results are summarized in Table V.2.

TABLE V.2 **City of Marinette Effluent (Outfall 001) Biomonitoring Results**

Lab	Date	Test Organism	Test Type	Pass/Fail
USEPA	April 88	Pimephales promelas	Acute	Pass
		Ceriodaphnia dubia	Acute	Pass
		Daphnia pulex	Acute	Pass

Note: Pimephales promelas are fathead minnows. Ceriodaphnia dubia and Daphnia Pulex are waterfleas.

Menominee Wastewater Treatment Plant and Combined Sewer Overflow

The Menominee Wastewater Treatment Plant (WWTP) provides secondary treatment for domestic, commercial, and industrial wastewater. The City of Menominee is currently addressing two major problems. In 1978, Menominee Paper Company began discharging to the City of Menominee WWTP. However, the WWTP failed to adequately treat the increased wastewater and violated its permit. In response to the permit violations a 1989 EPA Consent Decree ordered the City of Menominee to comply with the established effluent limits and control existing combined sewage overflows to the Menominee River. The treatment deficiency was essentially resolved when Menominee Paper Company completed construction of a new treatment facility in August, 1989, and eliminated their discharge to the City of Menominee. Minor renovations returned the City of Menominee plant to compliance. The combined sewer overflows are presently being addressed through the development of a long term correction program that has recently been established. Pending approval by EPA, the correction program calls for complete separation of the City of Menominee collection system, which will eliminate all combined sewer overflows.

Loadings from Menominee River CSO's are discussed in detail in Chapter VI. The City of Menominee WWTP, according to its permit issued September, 1985, monitors its discharge for pH, suspended solids, phosphorus, cadmium, mercury, fecal coliform, residual chlorine, and carbonaceous BOD. An industrial wastewater pretreatment program has been in place since 1985..

Ansul Fire Protection Company

The Ansul Fire Protection Company (Ansul) produces fire extinguishing equipment and spill clean-up chemicals. The discharge to the river consists of treated metal finishing wastes. As part of their WPDES permit, Ansul must analyze their discharge for: pH, metals (beryllium, thallium, mercury, arsenic, cadmium, chromium, nickel, zinc, copper, lead, and silver), suspended solids, cyanide, oil and grease, hardness, and total toxic organics (methylene chloride, toluene, and 1,1,1-trichloroethane). In addition, their permit, issued September 30, 1988, requires biomonitoring of their effluent three times during the first year of the permit and annually until permit expiration (June 30, 1993). Ansul has performed the first three bioassays (results are summarized in Table V.3), and will complete the others in 1990, 1991, and 1992 (Oman, 1990). In January, 1987 the USEPA laboratory in Chicago ran a bioassay on metal finishing effluent (an in-plant sampling point not the outfall to the river). The test produced a failure; however, the test report was issued as "Ansul Oil Co.", and quality control procedures were not available from EPA (Rogers, 1990).

Table V.3 Ansul Fire Protection Co. Effluent (Outfall 001) Biomonitoring Results

Lab	Date	Test Organism	Test Type	Pass/Fail
Midstate Associates	Dec 88	Pimephales promelas	Acute	Pass
		Ceriodaphnia dubia	Acute	Pass
		Daphnia magna	Acute	Pass
		Daphnia pulex	Acute	Pass
Midstate Associates	Feb 89	Pimephales promelas	Acute	Pass
		Ceriodaphnia dubia	Acute	Pass
		Daphnia magna	Acute	Pass
Midstate Associates	Jun 89	Pimephales promelas	Acute	Pass
		Ceriodaphnia dubia	Acute	Pass
		Daphnia magna	Acute	Pass

Note: Pimephales promelas are fathead minnows. Ceriodaphnia dubia, daphnia magna, and daphnia pulex are waterfleas.

SpecialtyChem Products Corporation

SpecialtyChem Products Corporation (SpecialtyChem) is a chemical manufacturer. The Company's wastewater discharge was through a shared outfall with Ansul Fire Protection Co. and included noncontact cooling water and treated wastewater from sulfur dioxide production. In 1989 the sulfur dioxide process was discontinued. Production of specialty (organic) chemicals will continue with wastes pretreated and discharged to the City of Marinette WWTP.

The City of Marinette WWTP had disruptions in 1987 which were traced to SpecialtyChem. Increased monitoring and pretreatment alleviated these problems (Oman, 1989). SpecialtyChem has subsequently modified its noncontact cooling water to a closed loop system through cooling towers. The next WPDES permit will address only emergency discharges of noncontact cooling water.

A new SpecialtyChem permit was issued February 12, 1990. The Company monitors its discharge for chemical oxygen demand and phenols. SpecialtyChem has started construction of an on site wastewater pretreatment plant which will be ready for use in late 1990. The pretreated effluent will be discharged to the City of Marinette WWTP.

Menominee Paper Company

Menominee Paper Company operates two paper machines and two converting operations. The Company completed construction of a new treatment facility in 1989 for its process wastewater. The expansion plan began in 1977 and was reactivated in 1984. Construction began during the summer 1988 in advance of the signing of the City of Menominee WWTP consent judgement (discussed above in the Menominee WWTP section) in 1989. In June, 1990 the Menominee Paper Company agreed to pay a $2.1 million civil fine for violations of the Clean Water Act stemming from inadequate wastewater treatment.

The wastewater treatment plant has been on-line since August, 1989. Monitoring is required in their NPDES permit (effective August, 1989) for the following parameters: BOD, suspended solids, pH, oil and grease, copper, dissolved oxygen, phosphorus, floating solids and temperature. The NPDES permit also requires effluent biomonitoring every two months. Results of the completed tests are summarized in Table V.4.

Table V.4 **Menominee Paper Company Effluent Biomonitoring Results**

Lab	Date	Test Organism	Test Type	Pass/Fail
Midstate Associates	March 90	Pimephales promelas	Acute	Pass
		Daphnia magna	Acute	Pass
Midstate Associates	May 90	Pimephales promelas	Acute	Pass
		Daphnia magna	Acute	Pass

Note: Pimephales promelas are fathead minnows. Daphnia magna are water fleas.

Scott Paper Company

Prior to 1972, the Scott Paper Company operated a calcium based sulphite pulp mill in Marinette and a groundwood pulp mill in Menominee. Wastewaters from these mills were virtually untreated. Some sulphite liquor was used as roadbinder with the rest discharged to the Menominee River. In 1972, the Menominee pulp mill was closed and a primary treatment system was constructed to treat wastes from the remaining mill (Oman, 1989).

Biomonitoring is required in the Scott Paper Co. WPDES permit (issued February 28, 1989 and modified April 12, 1990) as well as monitoring for the following parameters: BOD, suspended solids, pH, copper, mercury (total), dioxin (2,3,7,8-TCDD), acrolein, 2,4,6-trichlorophenol, 3,3'-dichlorobenzidine, fluoranthene, hexachlorobenzene, pentachlorobenzene, 1,2,4,5-tetrachlorobenzene, alpha-BHC, beta-BHC, gamma-BHC, technical grade-BHC, chlordane, dieldrin, 4-4'-DDT, endosulfan, endrin, heptachlor, total PCBs, and toxaphene. Scott Paper will be required to conduct three acute and three chronic bioassays in each of the first two years of the modified permit, and one acute and one chronic bioassay beginning anytime between eighteen and nine months prior to permit expiration (December 31, 1993) (Oman, 1990). During the recent permit reissuance process, Scott Paper Company, conducted four bioassays which are summarized in Table V.5. Scott Paper Company has requested a hearing to challenge limits in the modified permit. The hearing will be conducted in the near future.

Table V.5. Scott Paper Company Effluent (Outfall 004) Biomonitoring Results

Lab	Date	Test Organism	Test Type	Pass/Fail
Institute Of Paper Chemistry[1]	Jun 86	Pimephales promelas	Chronic	Pass
		Ceriodaphnia dubia	Chronic	Pass
	Jun 6, 88	Pimephales promelas	Acute	Pass
		Ceriodaphnia dubia	Acute	Pass
		Daphnia magna	Acute	Pass
	Jun 26, 88	Pimephales promelas	Acute	Pass
		Ceriodaphnia dubia	Acute	Pass
		Daphnia magna	Acute	Pass[2]
	Jul 17, 88	Pimephales promelas	Acute	Pass
		Ceriodaphnia dubia	Acute	Fail
		Daphnia magna	Acute	Pass

Note: Pimephales promelas are fathead minnows. Ceriodaphnia dubia, and Daphnia magna are water fleas.

[1] Performed all tests.
[2] Data indicated failure but test procedure abnormalities were noted.

Since these bioassays were done before the permit was issued the failed test will not trigger compliance requirements specified in the WPDES permit.

Secondary Sources

Secondary sources are those which transport, treat, or become temporary repositories for waste products and from which pollutants escape. Generally pollutants from secondary sources have been released from disposal systems that have failed (SAIC, 1987). For example, contaminated sediments, contaminated ground water, leaking landfills, and leaking septic systems are considered secondary sources. Secondary sources in the AOC are described below.

Menominee City Landfill

The Menominee City landfill is a 20 acre site located west of the City of Menominee approximately 950 feet northeast of the Menominee River (Figure V.2). It served as a solid waste disposal site for the City of Menominee and the surrounding area from before World War II until its closure in 1982. The MDNR coordinated several studies beginning in 1982, to determine if the landfill had contaminated the underlying groundwater, and, if so, the extent of any contamination (Austin, C.L., et al., 1987). Laboratory analyses have detected at least eight compounds in the groundwater (Table V.5).

Table V.6 Compounds Found in Groundwater from Menominee City Landfill

Maximum Compound	Maximum Concentration Found at Monitoring Wells (ug/L) (ppb)
trichloroethene	1500 DR
vinyl chloride	40
1,1,1-trichloroethane	14 UC
Isophorone	440 mg/L (ppm)
1,1-Dichloroethene	2.4
MIBK (methylisobutyl-ketone)	not quantified, verified
trans-1,2-Dichloroethene	490 DR
cis-1,2-Dichloroethene	<4 K
1,2-Dichloropropane	<17 INT, K
Bromodichloromethane	0.04
Heptachlor-epoxide	not quantified, verified
MEK (methylethylketone)	660
Toluene	130 DR

Note:
DR - High sample dilution required to bring value into analytical working range.
UC - No attempt has been made to confirm the reported identity by a second independent technique due to equipment or sample problems.
INT - Interference encountered during analysis resulted in no obtainable value.
K - Substance, if present, is below this level.

From: Austin, C.L., et al., 1987.

Among other elevated parameters detected were sulfate, chloride, chemical oxygen demand, total organic carbon, and nitrogen. State of Michigan ground water criteria and Federal drinking water standards are included in Appendix V.1. Contaminants were determined to be moving in the groundwater in two directions: westerly north-northwesterly and easterly-southeasterly.

However, since the contaminant plumes have not yet moved from the landfill property there is no current effect on the river. The plume, which is moving in an easterly-southeasterly direction, will eventually enter the river if measures are not taken to control the contamination on site. Remedial measures are still being negotiated between the State of Michigan and the City of Menominee and other parties concerning the contaminated groundwater.

Ansul Fire Protection Company's Former Arsenic Salt Storage Area

From the mid-1960's to 1978, Ansul Fire Protection Company stored an arsenic waste salt (approximately 2% arsenic by weight) and arsenic salt sludges on site (Figure V.2) as part of a herbicide manufacturing process. The salt piles remained uncovered until 1972, allowing seepage to the underlying soil layers and runoff to the river. Contributing to the arsenic contamination problem from the salt vault area was the direct discharge of arsenic waste salts to the river by Ansul Fire Protection Company from the early 1960's through 1966. During the 1970's, the wastes were removed to a hazardous waste landfill (Tusler, 1986). The arsenic salt which was washed into the soils by precipitation, has continued to be transported by groundwater passing through the area of contamination. The direction of groundwater flow is toward the river making this site a major source of arsenic pollution to the Menominee River and sediments.

Menominee/Marinette Spills and Leaking Underground Storage Tank Sites

The Michigan Environmental Response Act (Act 307 of 1982 as amended August 1989) provides for an annual evaluation and ranking of sites of environmental contamination, based on relative risk posed to the environment and human health (MDNR, 1989). Six sites are located in Menominee Township including two sites where contaminated groundwater and soils are affecting residential wells. The source of groundwater contamination (including toluene, benzene, ethylbenzene, xylene) was either unknown or due to leaking underground petroleum storage tanks. One leaking underground storage tank has been identified on the Michigan side of the AOC. Contamination at nine sites by leaking underground storage tanks has been noted on the Wisconsin side of the AOC (Nogalski, 1989). The site locations are presented in Appendix V.4. The Menominee County Road Commission and the Menominee Highway Garage are on the Act 307 list as sites contaminated by salt. The Menominee River turning basin is also on the Act 307 priority list. The last of the Menominee County sites is listed as Green Bay Paint Sludges and is described below. The effect of leaking underground storage tanks and spills to the river is unknown. However, due to the proximity of these sites to the river and bay it is possible that some of the contaminants from these sites may eventually be transported to the river if remedial measures are not taken to control the contamination.

Green Bay Paint Sludge Disposal Site

Evidence collected to date indicates that the current owner of the majority (approximately Areas I and II) of the paint sludge disposal site (Figure V.2) is Flanders Industries, Inc., a furniture company. Paint sludge wastes were apparently dumped behind the plant and into Green Bay for disposal. Waves continue to wash nodules of paint sludge on to a one-half mile stretch of shoreline extending from the plant toward the City of Menominee.

A preliminary investigation (GZA-Donohue, 1989) of the site mapped the rough extent of paint sludge within the bay and provided chemical analysis of paint sludge samples. Sludge samples were obtained from Areas I and II for analysis. None of the composited samples exhibited characteristics of a hazardous waste (in accordance with 40 CFR Subpart C 261.20-261.24). Sample analysis results are presented in Appendix V.2. The contaminated area off the shore in Green Bay was divided into three sections (Figure V.3). GZA-Donohue describes them as:

- Area I represents the approximate extent of a continuous layer of paint sludge impregnated with metal debris and drums. The deposit is 1-2 feet thick and approximately 22,500 square feet.

- Area II represents the approximate extent of metal debris and drums. Area II extends approximately 350 feet east from the shoreline.

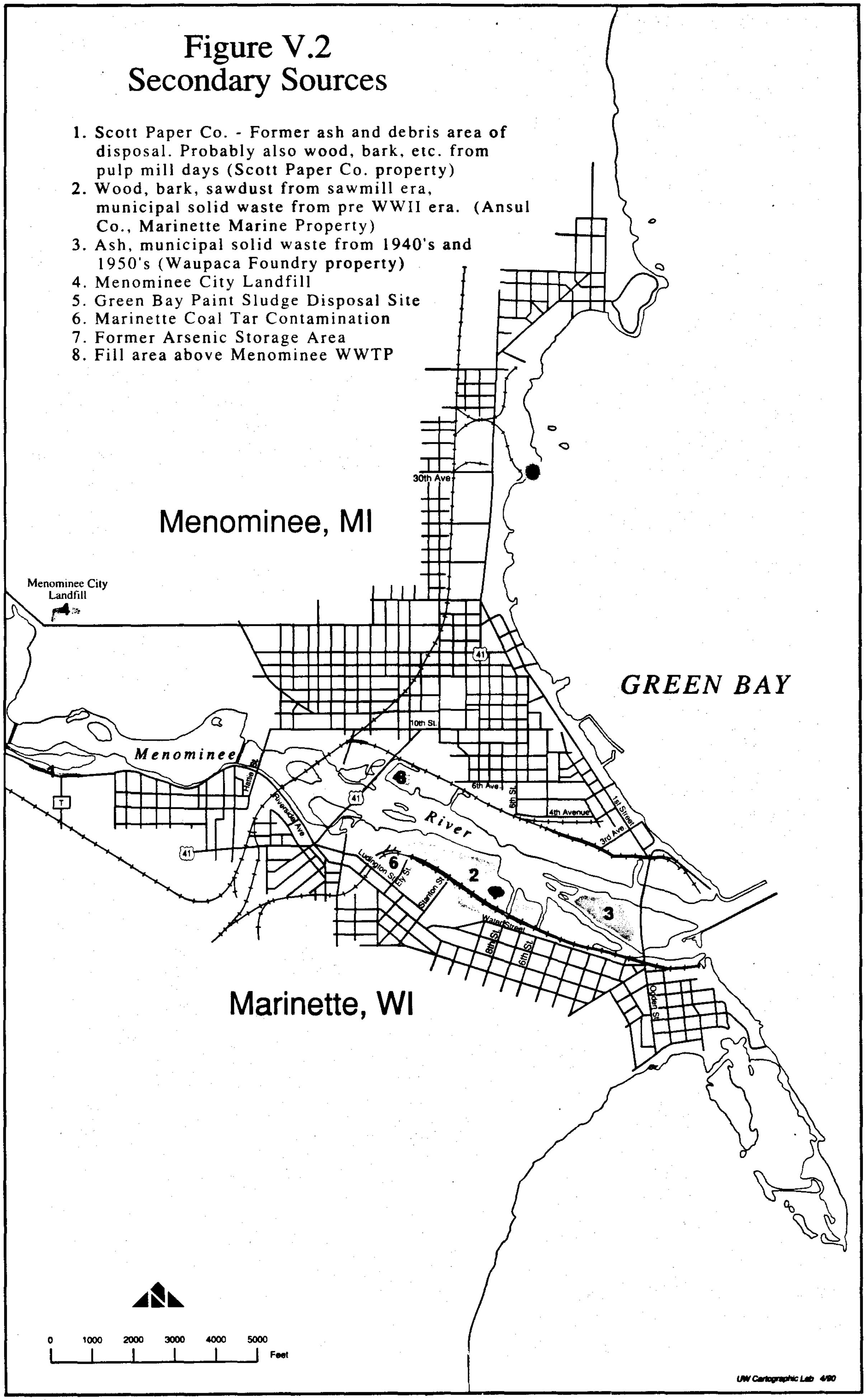
- Area III represents the approximate extent of wood debris which surrounds area II to the south and east.

- Paint sludge and cinder fill was also observed on land in a grassy field east of the furniture company.

Due to the small size of most of the pieces of paint sludge (3 inches to 3 feet in diameter) and the fact that they have been scattered by wind and wave action, most of the removal work will probably be done by hand (Harrington, 1989). An interim measure will be initiated in early fall of 1990, at which time a clean-up contractor will be selected and preliminary sediment sampling will be conducted. The cleanup which is targeted to remove paint sludge and metal from areas I and II and stray nodules along the shoreline south of the Lloyd Flanders plant site will begin in early spring of 1991. The clean up, will be targeted to remove paint sludge and metal debris from areas I and II.

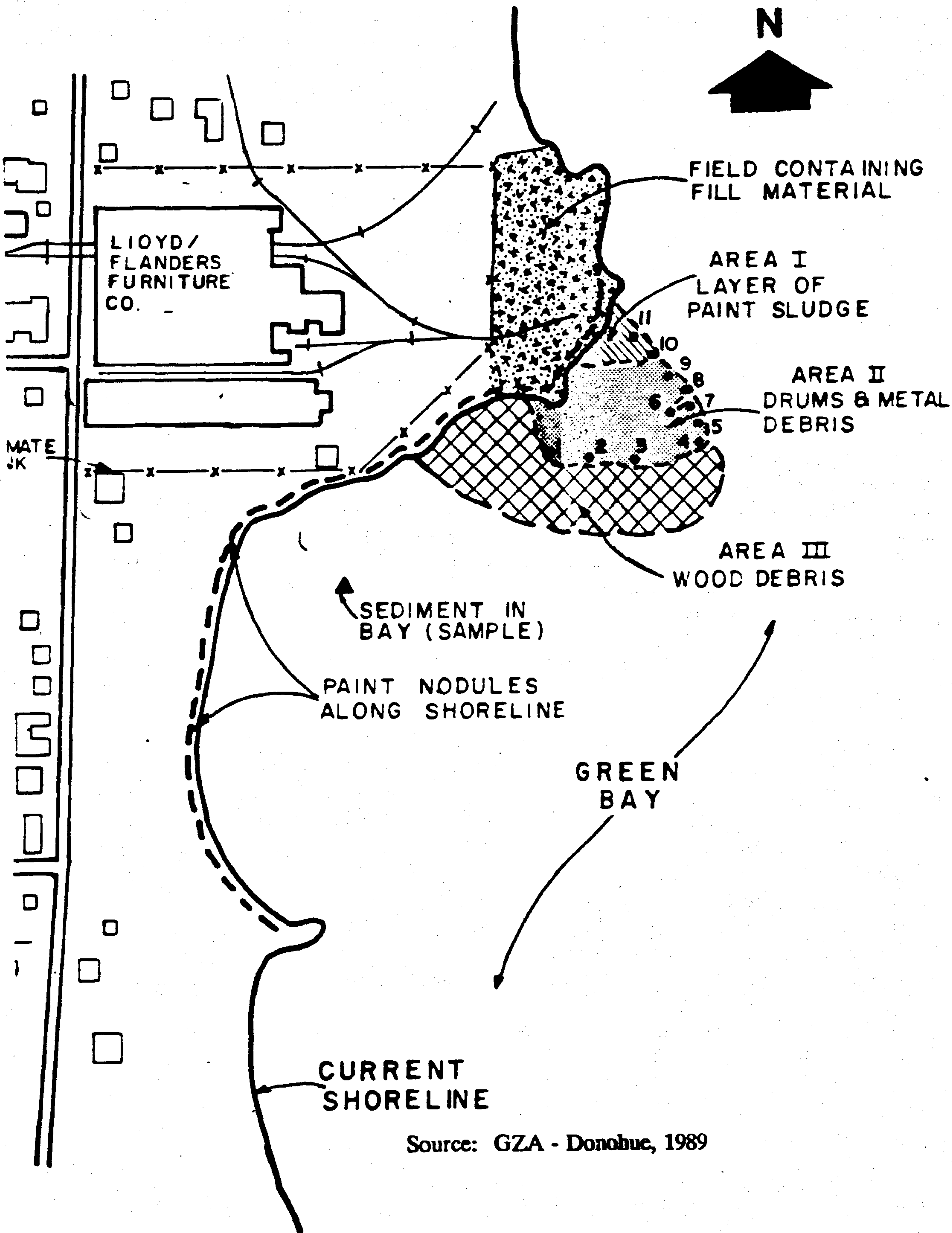
Figure V.2
Secondary Sources

1. Scott Paper Co. - Former ash and debris area of disposal. Probably also wood, bark, etc. from pulp mill days (Scott Paper Co. property)
2. Wood, bark, sawdust from sawmill era, municipal solid waste from pre WWII era. (Ansul Co., Marinette Marine Property)
3. Ash, municipal solid waste from 1940's and 1950's (Waupaca Foundry property)
4. Menominee City Landfill
5. Green Bay Paint Sludge Disposal Site
6. Marinette Coal Tar Contamination
7. Former Arsenic Storage Area
8. Fill area above Menominee WWTP



The surface water between the paint sludge site and the City of Marinette drinking water intake will be monitored during clean up for suspended particulate and other parameters to ensure that they do not exceed water quality standards. The clean up will be designed so that the disturbance of sediments does not cause effects of a greater magnitude than a typical storm (Harrington, 1989). The City of Marinette's drinking water intake is located approximately one mile south of the sludge site. The City of Menominee's drinking water intake is located approximately one mile north of the sludge site.

FIGURE V.3
Green Bay Paint Sludge Contaminated Areas



Source: GZA - Donohue, 1989

The extent of paint sludge on the shore and within the bay is such that habitat in this location has likely been affected. Benthic organisms have likely been decreased in this area due to the poor habitat conditions caused by the extensive layer of paint sludge found offshore in the bay. No data is available, however, to quantify a change in benthic organisms at this location.

Marinette Coal Tar Contamination

Coal tar residues were discovered in June 1989, at the expansion site of the Marinette WWTP (Oman, 1989). The site was previously a coal gasification plant. Wastes from the plant were apparently deposited on site (Figure V.2).

Soil samples were analyzed for cyanide, volatile and semi-volatile organic compound concentrations. Based on extraction procedure toxicity tests the soils were classified as contaminated but not considered a hazardous waste. Analyses detected various concentrations of volatile and semi-volatile organic compounds (refer to Appendix V.3).

The contaminated soils will be removed from the site and deposited in a Michigan landfill located outside the AOC. Some of the contaminated soil encountered during construction has already been removed and some has been temporarily placed in an onsite containment area (Mann, 1989). Wastewater from dewatering wells, already in place due to construction activities, has been routed through the WWTP. The flow from these wells will be monitored and sampled on a weekly basis until construction is complete. The site investigation and risk assessment is on-going and is scheduled to be completed by October, 1990.

The effect on the river from contaminants found at this location is unknown. However, the direction of groundwater flow indicates that some of the pollutants would eventually be transported to the river. Remedial measures are likely to be aimed at controlling the transport of pollutants from the site.

Riverfront Filled Areas

The land between Marinette Marine and Waupaca Foundry was originally wetlands. Beginning in the period of heavy lumbering (roughly 1880) this area was used as a dump site for saw mill wastes (Figure V.2). The City of Marinette disposed of solid wastes in this area until the late 1950's. Since solid waste disposal was not regulated in Wisconsin until the late 1960's there is not a record of the exact type and quantity of materials deposited. The impact to the river from these wastes is unknown.

The presence of the wastes was noted by WDNR personnel during construction of buildings on the Ansul Fire Protection Co. property (Nogalski, 1989). Excavated material was disposed of in a landfill. The Waupaca Foundry location may have also been filled with a combination of municipal and industrial solid wastes. The area upriver and adjacent to Menominee Wastewater Treatment plant is also a filled area.

Dredged material from the river channel near River Park was reportedly used as fill (Janowitz, 1990). Scott Paper Company disposed of boiler ash and demolition wastes on its property (near the river) prior to 1970 (Nogalski, 1989). There is no data to indicate if these wastes and fill have had an adverse affect on the river.

Rural Nonpoint Sources of Pollution

Although the AOC is located in an urban area, rural nonpoint sources of pollution from upper reaches of the river could have an impact on the AOC water quality. Forestry comprises approximately 80 percent of the land use in the Menominee River Basin upriver from the AOC. Agriculture makes up a much smaller percent of land use, consequently, nonpoint source pollution associated with agriculture is greatly reduced in the Menominee River compared to a river basin of similar size in an agricultural region. The most significant activity related to forestry, which frequently causes nonpoint source pollution, is the construction of roads across and adjacent to streams. This activity may also cause indirect erosion due to changes in drainage patterns and systems.

Historically, detailed water quality information has not been available to assess potential effects of forestry activities on water quality. However, the Menominee River Basin Cooperative Water Quality Study, coordinated by the Soil Conservation Service, will examine nonpoint sources of pollution in detail. This project will help identify critical areas contributing nonpoint source pollutant loadings to the Menominee River basin (Wisconsin and Michigan). Pollutant loadings, such as suspended solids (silt), from upstream locations may impact the water quality of the AOC.

Urban Nonpoint Sources of Pollution

The Cities of Menominee and Marinette are sources of urban nonpoint pollution. Some specific sources of pollution in the cities include automobiles (heavy metals and polycyclic aromatic hydrocarbons (PAH)); fertilizers and pesticides; metal corrosion; pet wastes; soil erosion from undeveloped and construction sites; air pollution; storage piles of coal, salt, soil, and snow; leachate from old dumps and landfills; leakage from underground petroleum storage tanks; and spills.

The City of Menominee has a county enforced construction site erosion control ordinance based on a plan developed by the Central Upper Peninsula Planning and Development Commission. The City of Marinette has various ordinances which affect construction activities in controlling nonpoint sources of pollution (e.g. floodplain ordinance and city construction contracts with conditions stipulating erosion control practices). Neither the City of Marinette nor the City of Menominee currently deposit snow directly into surface water.

Other sources of nonpoint pollution include runoff from parking lots, rooftops, streets and storage areas. Precipitation washes contaminants from these surfaces to the river via storm sewers. There are 15 storm sewer outfalls in the City of Marinette, 10 discharge to the river and 5 discharge to Green Bay (Figure V.4). Three storm sewers are nonpipe drainages (grass swales) which allow some infiltration of water to the ground thereby reducing the pollutant loading to the river (Sevener, 1989).

There are 29 storm sewer outfalls in Menominee, of which 11 discharge into the river and the remainder discharge to the bay (Figure V.4). Four of the discharges to the bay are nonpipe drainages. Six of the river storm water discharges are combined sewer overflows (CSO). The largest CSO (#2) is located just downstream from the Menominee WWTP.

Without monitoring, the extent of nonpoint source pollution in the AOC is largely unknown. However, sediment monitoring in pockets of the river may give some indication of contaminant deposition. The Sixth Street Slip area receives storm sewer discharge and contains sediments with high concentrations of lead, zinc, copper, cyanide, Kjeldahl nitrogen, and oil and grease.

Air Emission Sources

Industrial, commercial, and other (automobile) air emissions from both Wisconsin and Michigan sources occur in the AOC. The following four facilities contributed 90 percent of the air emissions from stationary sources (sulfur dioxide (SO_2), particulate, nitrous oxides (NO_x), and carbon monoxide (CO)) to the AOC from the City of Menominee: Lloyd/Flanders Furniture Company, Menominee Box and Lumber Company, Menominee Paper Company, Richardson Brothers Company (Lundgren, 1989). In the City of Marinette the following facilities contribute approximately 90 percent of the air emissions from stationary sources, (SO_2, particulate, NO_x and CO) to the AOC: SpecialtyChem Products Corporation, Scott Paper Company, Ansul Fire Protection Company, Rodman Industries, Waupaca Foundry, American Excelsior, and Biehl Construction (Patterson, 1989). SpecialtyChem Products Corporation will no longer be a major air emissions source due to the closure of its sulfur dioxide production unit.

Atmospheric Deposition

The Green Bay Mass Balance Study is conducting atmospheric deposition analyses to quantify target chemical loads to Green Bay. The "master" air deposition station is located at the University of Wisconsin - Green Bay. Closer to the AOC is a routine monitoring station located in Door County at Peninsula State Park. This station, and another located in the Upper Peninsula of Michigan at Fayette State Park, provide data on trace organic chemicals by sampling precipitation on a biweekly basis (Debrock, 1989). The information collected from this study may be helpful in understanding

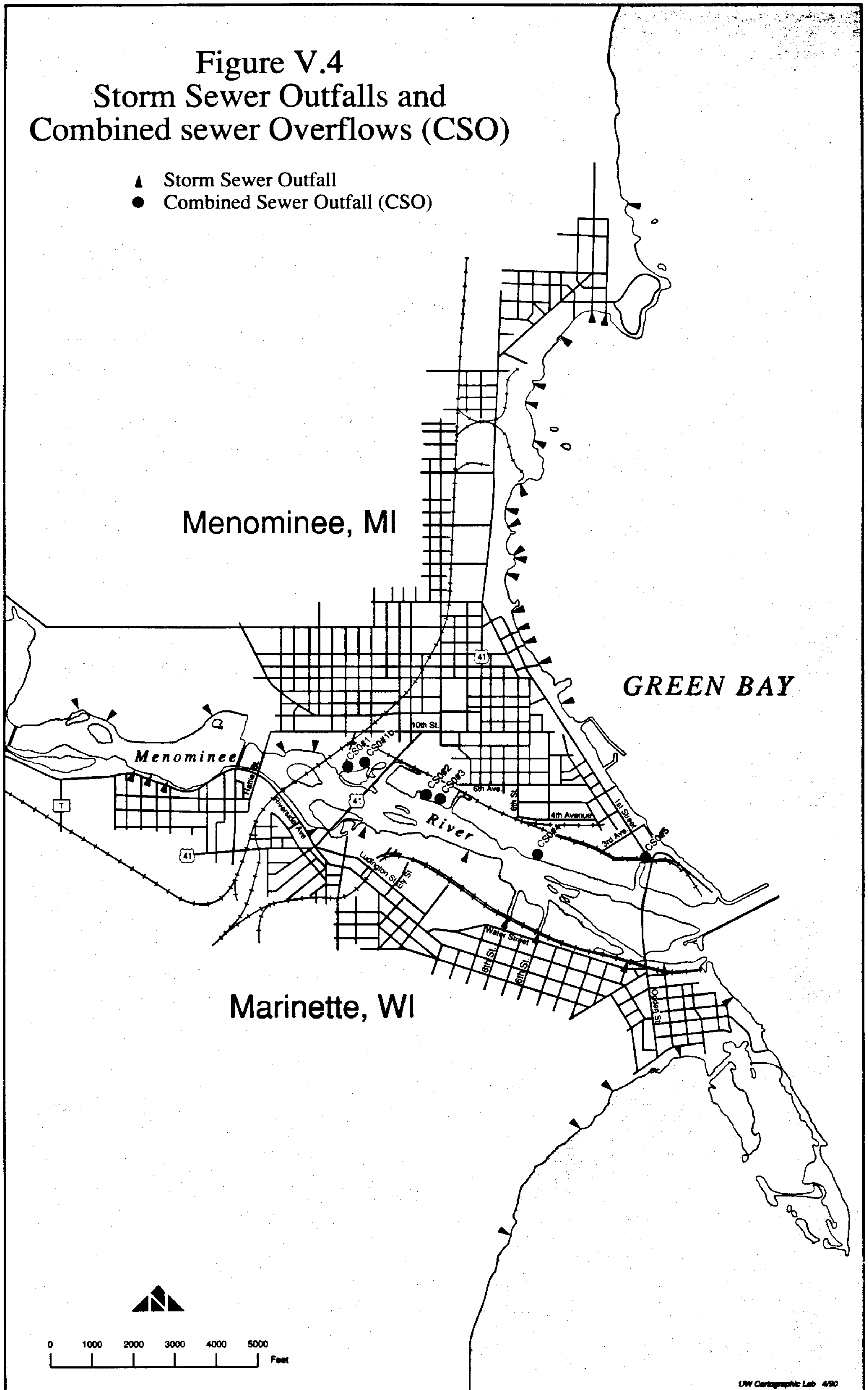


Figure V.4
Storm Sewer Outfalls and Combined sewer Overflows (CSO)

the impact of atmospheric deposition on water quality conditions in the AOC.

Air emissions data is available from Michigan and Wisconsin sources in the AOC. Michigan has established permit limits for sources of criteria pollutants (particulates, sulfur dioxide, carbon monoxide, ozone, hydrocarbons, lead, and nitrous oxides). Reports of hazardous air emissions are not yet required by MDNR as these rules are being developed by Michigan's Air Quality Division. Wisconsin DNR requires facilities to submit annual air emission reports of criteria pollutants as well as emission reports of hazardous air pollutants. Wisconsin's hazardous air emission regulations (Chapter NR 445, Wis. Adm. Code) restrict emissions of substances which are acutely toxic, carcinogenic or are suspected carcinogens. The rules were adopted in May, 1988 and annual emission reports were required beginning in 1989. The 1989 emissions information is not yet available. The 1988 emission reports for criteria pollutants from facilities in Marinette and Menominee are summarized in Appendix V.5.

Air emission information is also available through Section 313 of the Superfund Amendments and Reauthorization Act (SARA) Title III. Section 313 of SARA Title III requires certain facilities to report the environmental release of any of 328 listed chemicals. SARA Title III toxic chemical release summary reports are presented in Appendix V.5 for facilities in Marinette and Menominee. It should be noted that local atmospheric deposition of compounds, reported under NR 445 or SARA Title III, should not be assumed, as the fate of air emissions is dependant on many factors. The effects of these emissions on the AOC are unknown.

Coal and Salt Pile Runoff

Coal storage piles are located in Marinette along the Menominee River at the Ansul Fire Protection Company and the Marinette Fuel and Dock Company and at the Menominee Paper Company in Menominee. Salt, limestone and scrap metal are also stored at the Marinette Fuel and Dock facility. In Wisconsin salt piles must be covered and constructed on a sloped, impervious pad (Wis. Adm. Code, Transportation 277).

The WDNR Bureau of Wastewater Management considers runoff from coal and salt piles to be contaminated stormwater and therefore not exempt from the requirements of the wastewater discharge permit program (WPDES). NR 213, Wis. Adm. Code will require that liners be installed under coal piles unless it can be shown that surface water and ground water standards will not be violated. Runoff from coal piles located at power plants is collected, treated, and discharged under the WPDES permit for the facility.

Michigan DNR has evaluated coal pile runoff from 15 facilities. Based on this information six metals have been identified that may be present in coal pile runoff at levels which may require monitoring or permit limits for environmental and public health reasons. The six metals are: cadmium, mercury, nickel, selenium, silver, and zinc (Creal, 1988). Coal pile runoff usually has a low pH and generally is a source of suspended solids, sulfate, metals (aluminum, chromium, manganese, zinc), chlorides, phosphorus, and ammonia (Cross, F.L., 1981). The sulfur content of the coal is believed to directly affect the pH of the coal pile runoff (Stahl and Davis, 1984, Davis and Boegly, 1981). A 1987 WDNR study of combined coal and salt runoff at Isle La Plume (LaCrosse, WI) found levels of chloride, sulfate, copper as well as the field pH measurement that exceed groundwater and/or surface water quality standards found in Wisconsin Administrative Codes NR 140, NR 102, and NR 105 (Sullivan, 1987).

A Wisconsin DNR committee was formed in 1989, to study controls necessary for storage pile runoff (Kaemmerer, 1989). In 1990, the WDNR Lake Michigan District will conduct a study of water quality impacts due to runoff from salt piles. The Lake Michigan District study was motivated, in part, by Green Bay Remedial Action Plan recommendations (Behrens, 1989). This study will provide specific information on water quality impacts in the AOC as well as other locations due to coal and salt pile runoff. Results should be available by 1991.

Salt storage in both solid and liquid forms is regulated in Michigan by the Part 5 Rules of Public Act 245, Acts of 1929, specifically R323.1157. Diked or curbed liquid salt storage areas must be able to retain the volume of the largest storage tank. Other containment measures may be used as approved by the Michigan Water Resources Commission. Salt stored in piles is required to be covered or enclosed to prevent runoff and seepage or leakage onto or into surface or ground water. Salt piles may not be within 50 feet of any lake or stream unless otherwise required or approved by the Commission.

Bulk storage piles other than coal and salt are also found in the AOC. Scrap metal is piled on the northwest end of the Waupaca Foundry property near the Menekaunee Bridge. Scrap metal and soil are stored in piles on the Marinette Fuel and Dock Co. (Sevener, 1989). Scrap metal pile runoff is not regulated but is a likely source of metals (Kaemmerer, 1989). Scrap paper is piled at Menominee Paper Company. Loose paper from these piles has been noted as an aesthetic problem in the vicinity of Menominee Paper Co. (Johnson, 1990).

Table V.6 presents a summary of the impaired uses in the AOC based on the location of the pollution problems. Figures V.1-V.4 illustrate the locations of pollution sources in the AOC.

Table V.7 Location of Pollution Resulting in Impaired Uses

Location of Problem	Impaired Use
Turning Basin Sediments, Eighth Street Slip	Restriction on Dredging
Green Bay Paint Sludge Site	Degradation of Benthos
Sediment water from Turning Basin and Eighth Street Slip	Degradation of Fish Populations and Degradation of Benthos
Development along the near shore areas of the Lower Menominee River and Green Bay Shoreline north of the River's mouth	Loss of Fish and Wildlife Habitat, Degradation of Fish Populations
Menominee CSO, Menominee Marina	Total and Partial Body Contact
Lower Menominee River and Fox River/Green Bay	Fish Consumption Restriction

VI. POLLUTANT LOADINGS

Introduction

Pollutant loadings from point and nonpoint sources to the Lower Menominee River area of concern are discussed below. Point sources of pollution include direct discharges from a pipe or outfall. Nonpoint sources of pollution cannot be traced to a single point source, such as a municipal or industrial wastewater treatment plant discharge pipe. Nonpoint sources of pollution include runoff from agricultural land, construction sites, urban streets, and barnyards. Arsenic contaminated groundwater from the Ansul Fire Protection Company is another source of pollution in the area of concern.

A study being completed by the U.S. Soil Conservation Service will assess the impact of agricultural and other land use activities for the Menominee River Basin.

Point Sources

The locations of major municipal and industrial discharges (Michigan and Wisconsin) to the Lower Menominee River are shown in Table VI.1. There are four industrial and two municipal facilities with key discharges (past or ongoing) to the AOC.

Table VI.1 Location of the Key Municipal and Industrial Discharges in the AOC

Facility Name	Location
Menominee Paper Company	Michigan
Scott Paper Company	Wisconsin
Ansul Fire Protection Company	Wisconsin
SpecialtyChem Products Corporation	Wisconsin
City of Menominee WWTP and CSO's	Michigan
City of Marinette WWTP	Wisconsin

The majority of these facilities discharge conventional pollutants such as total suspended solids, phosphorus or exert a biochemical oxygen demand (BOD). The SpecialtyChem Products Corporation has a combined discharge with the Ansul Fire Protection Company through Outfall 001.

Table VI.2 summarizes, by pollutant, the monthly average loadings from 1988 and 1989 discharge monitoring report data, as well as the permit limits for each of the major facilities. A more complete summary report of monthly discharge monitoring data (both concentrations and loadings), is contained in Appendix VI.1.

Table VI.3 summarizes the number of permit violations from January, 1988 through September, 1989 by parameter for each significant discharger to the Lower Menominee River. The table also lists the date the permit was last issued, the expiration date of the current permit, and the reporting period for the discharge monitoring data.

The total pollutant loading to the Menominee River was calculated from all of the major Wisconsin and Michigan point sources (Tables VI.4 and VI.5). In addition, Figures VI.1 and VI.2 show the relative percent of the total loadings for BOD_5 and total suspended solids respectively to the Menominee River from each of the key discharges, as well as the combined sewer overflows. The 1990 bar graph is estimated based on loading data from August-December 1989. This data reflects loading to the river from key sources after the improvements and expansion of the WWTP's at the City of Menominee and Menominee Paper Company.

An assessment of the wasteload allocation (WLA) for the Lower Menominee River was conducted in 1988 by the WDNR, Bureau of Water Resources Management. The estimated assimilative capacity for the Lower Menominee River was adequate to support existing point sources (Fenske, 1988). The combined municipal and industrial discharges to the Menominee River use approximately 50 percent of the estimated assimilative capacity of the river for BOD_5, as shown in Figure VI.3.

Based on Michigan's Section 304(1) "Short List" (February, 1989), which was developed per requirements of the 1987 Clean Water Act Amendments, the Menominee River in the AOC is listed as a toxic-impaired water. Metal discharges, specifically mercury and copper from the Menominee wastewater treatment plant (WWTP), were identified as the problem. Source reduction measures, including separation of the Menominee Paper Company wastewater from the Menominee WWTP in August, 1989, and improved wastewater treatment systems, has resulted in increased treatment efficiency at that facility, and has curtailed the toxic discharge problem. Post-construction monitoring jas confirmed that condition.

Loading to the Menominee River from the Menominee Paper Company and the City of Menominee WWTP changed as of August, 1989. Wastewater treatment improvements recently completed at these two facilities were expected to significantly reduce waste loadings to the Menominee River by the end of 1989. Although comparison of the average BOD and suspended solids loadings for 1988 and 1989 indicates a substantial increase in 1989, loadings from September to December 1989 for both facilities are notably reduced.

FIGURE VI.1

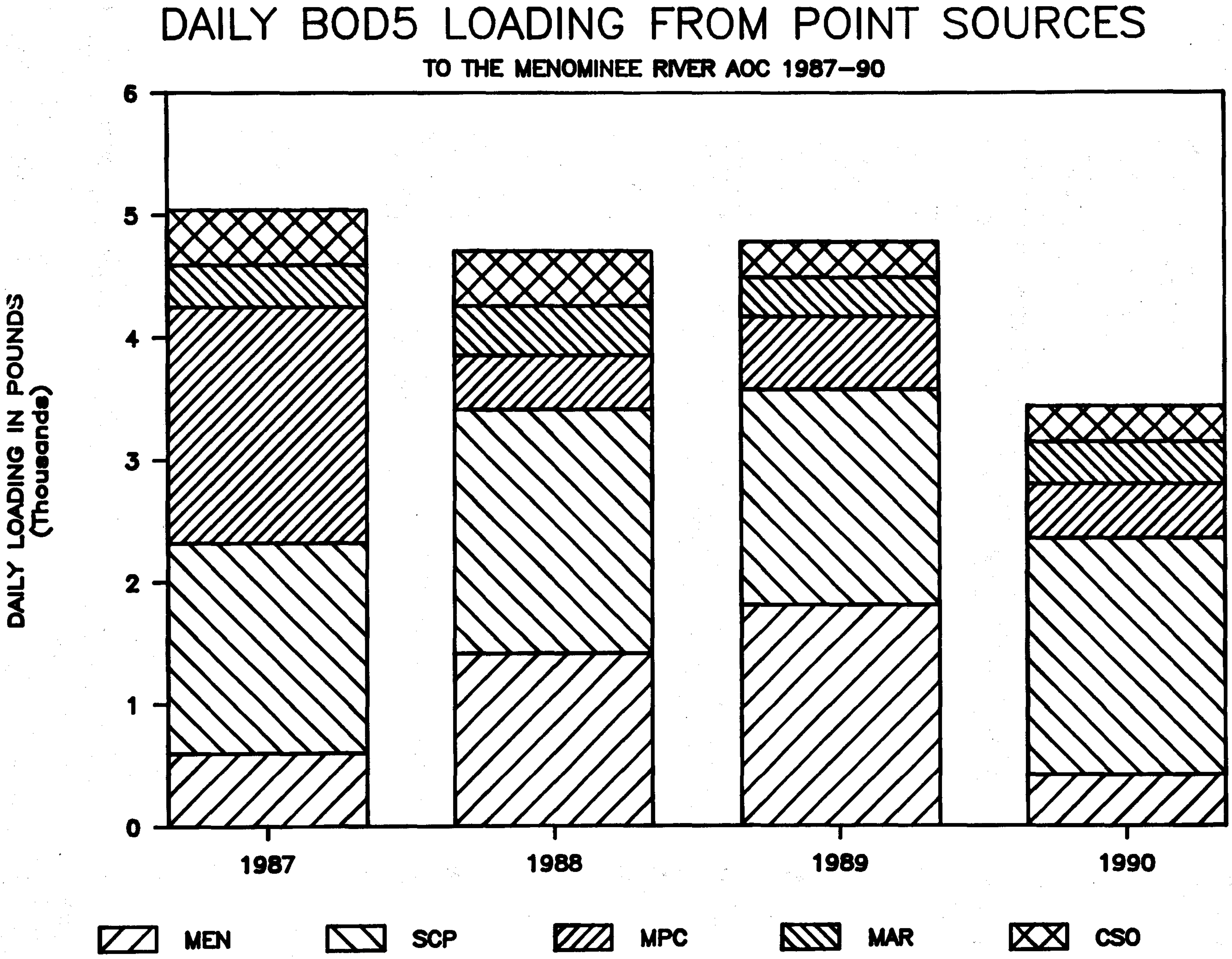

DAILY BOD5 LOADING FROM POINT SOURCES
TO THE MENOMINEE RIVER AOC 1987-90
DAILY LOADING IN POUNDS
(Thousands)
0
1
2
3
4
5
6
1987
1988
1989
1990
MEN
SCP
MPC
MAR
CSO

FIGURE V1.2

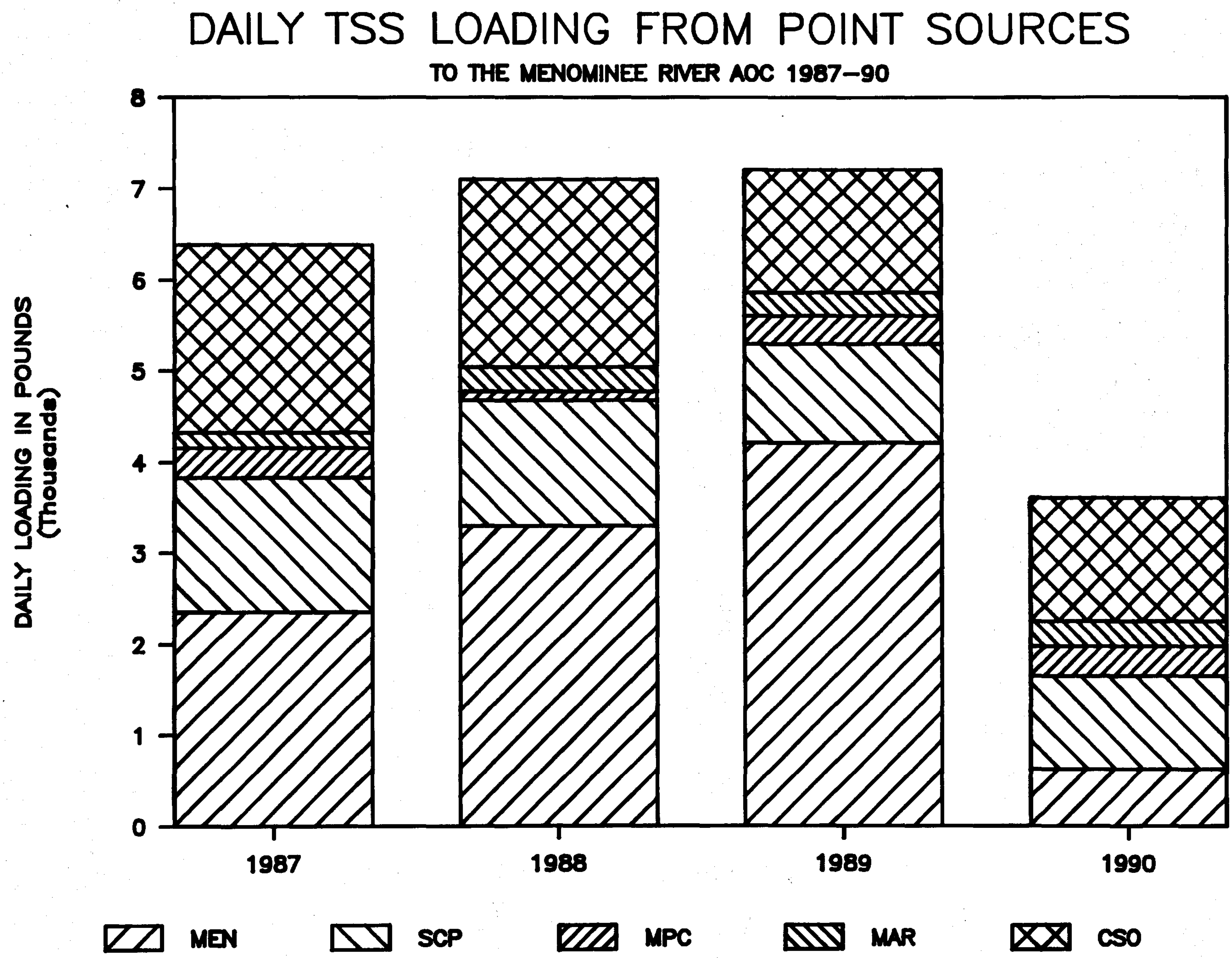
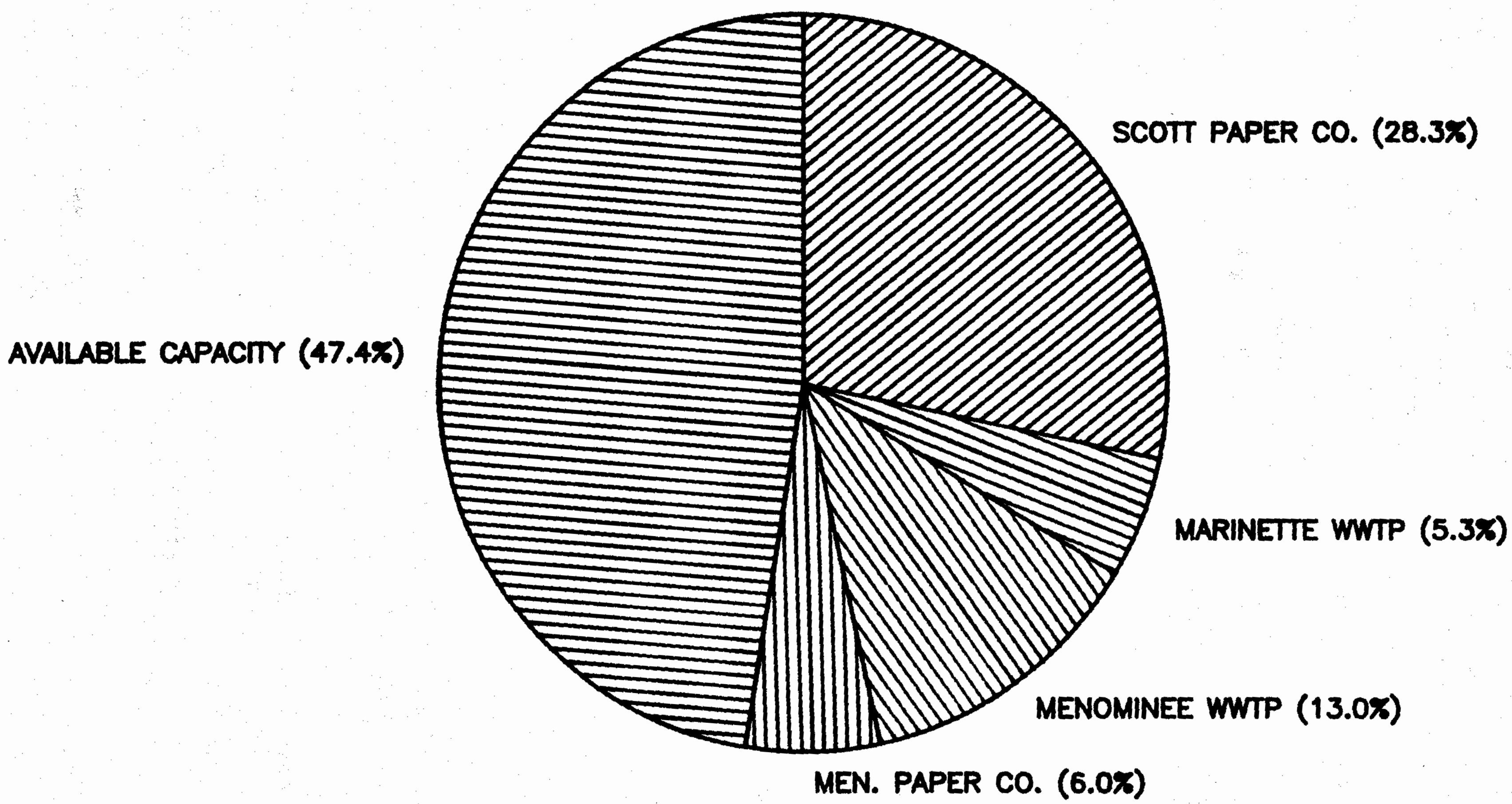

DAILY TSS LOADING FROM POINT SOURCES
TO THE MENOMINEE RIVER AOC 1987-90
DAILY LOADING IN POUNDS
(Thousands)
0
1
2
3
4
5
6
7
8
1987
1988
1989
1990
MEN
SCP
MPC
MAR
CSO

FIGURE VI.3

ESTIMATED BOD5 CAPACITY OF

MENOMINEE RIVER BASED ON PERMIT LIMITS



A Consent Decree issued to the City of Menominee by EPA requires a combined sewer overflow correction program be implemented by August 1, 1990. This correction program could result in the elimination of the largest CSO's. Table VI.6 provides a projection of loadings from Michigan CSO's in 1989 based on anticipated removal of CSO number two.

For the key permittees that have recently had their permits reissued (Ansul Fire Protection Company, the City of Marinette, Scott Paper Company and Menominee Paper Company), biomonitoring has been included as a requirement. The other primary dischargers in the AOC will also have biomonitoring included as a requirement, upon reissuance of their permits. This will help to ensure that key facilities discharging to the Lower Menominee River will not only have to meet the loading and concentration limits in their permits, but that they also cannot discharge pollutants that are acutely or chronically toxic to fish and aquatic life. Whole effluent biomonitoring results are summarized in Chapter V.

As a Federal requirement, industrial dischargers must conduct an analysis for all pollutants that could be present in their discharge. A form (2C) must be filled out which lists the analytical test results, prior to each permit reissuance. Based on the 2C forms submitted by key Wisconsin dischargers (Ansul Fire Protection Company and Scott Paper Company), pollutants, other than those regulated in the discharge permits, are not present at concentration levels requiring effluent limits.

Nonpoint Sources

The Menominee River AOC receives nonpoint source pollution from a number of different sources. Since the AOC is located in an urban/industrial setting, the nonpoint sources are primarily the result of urban runoff. As shown in Table VI.7, pollutants reaching the Menominee River from nonpoint sources in the AOC are typical of urban nonpoint runoff. These pollutants include: organics, inorganics, heavy metals, total suspended solids, BOD, COD, nutrients, bacteria, and volatile organic compounds.

There are three basic land uses associated with urban areas: commercial, residential and industrial. Much of the heavy industry in the AOC is located along the river in Marinette. Menominee's heavy industrial area is less defined, but one of the largest industries along the river is Menominee Paper Company.

It is not possible to estimate loadings for each of the contaminants reaching the Lower Menominee River from nonpoint sources because the necessary information does not exist. However, research data in general has shown that urban nonpoint sources can generate shock loadings to receiving waters much greater than those from point source discharges. Consequently, a monitoring strategy is needed to examine nonpoint source pollutant loadings to the Menominee River AOC. A discussion of the potential sources of nonpoint pollution in the area of concern is contained in Chapter V.

There are 15 storm sewer outfalls in the City of Marinette and 29 storm sewer outfalls in Menominee (refer to Figure V.4 for a location of these storm sewers). Very limited monitoring data is available from these storm sewer outfalls, especially as it relates to runoff events, that would indicate the extent of nonpoint source problems. Sediment monitoring at the Sixth Street slip indicates high concentration levels of lead, zinc, cyanide, copper and oil and grease deposited in the sediments, which may be the result of a storm sewer that drains the area.

Given the number of storm sewers in Menominee and Marinette (a total of 44 of which 22 discharge directly into the river), the AOC is vulnerable to nonpoint source impacts from storm water runoff. Monitoring recommendations for nonpoint source pollution will be developed in the stage two report.

Ansul Fire Protection Company's Former Arsenic Salt Storage Area

Arsenic contamination of groundwater and sediment is a primary source of pollution identified in the area of concern (Chapters IV and V). Arsenic contaminated groundwater entering the river from beneath the property at Ansul Fire Protection Company as well as leaching of arsenic from contaminated sediment in the turning basin and the adjacent south channel of the river are significant sources of pollution. Concentrations of arsenic detected in groundwater beneath the Ansul Fire Protection Company have exceeded 2,000 parts per million (ppm) in 1987 with an average concentration of 1000 ppm. Concentrations of arsenic in contaminated sediment in the turning basin in 1985 were detected as high as 5,493 ppm (mg/kg dry weight) (Baker, unpublished).

Analytical results from the sediment water samples (WDNR 1989, see Chapter 6) detected arsenic levels at 3,900 and 18,000 ug/l (ppb) in the turning basin and the adjacent 8th Street Slip, respectively. Those arsenic concentrations are significantly above the NR 105, Wis. Adm. Code, acute life standard of 364 ug/l (ppb). An estimated 0.14 to 1.4 pounds of arsenic per day are entering the river from groundwater flowing beneath the property of the Ansul Fire Protection Company (Tusler, 1989). This estimated loading is probably low due to the seiche flushing of the sediments. Tusler calculated the arsenic loading (in pounds/day) to the Menominee River using Darcy's Law as follows:

Groundwater Flow = Q = KIA (Darcy's Law)
Mass Loading = QC

where:

Q	=	flow rate
K	=	hydraulic permeability
I	=	groundwater gradient
A	=	aquifer area perpendicular to flow
C	=	contaminant concentration

The hydraulic permeability of the deposits below the salt vault is 10^{-3} to 10^{-4} centimeters per second (cm/s). Based on 1979 groundwater elevations (the last time comprehensive non-pumping water level measurements were taken), the groundwater gradient was determined to be about 0.001 (a one foot drop for every 1000 feet). For an aquifer area, Tusler assumed that the groundwater was moving through an area about 400 feet wide (approximately the width of the salt vault) and 20 feet deep (the depth from the water table to a relatively impermeable silt/clay layer). An average value of 1000 ppm was used as the contaminant concentration for arsenic in the groundwater beneath the Ansul Fire Protection Company site.

At the higher hydraulic permeability (10^{-3} cm/s), the estimated loading is 1.4 pounds of arsenic per day to the Menominee river. At the lower hydraulic permeability rate of 10^{-4} cm/s, the estimated loading is 0.14 pounds of arsenic per day to the river. It should be noted that based on the rough assumptions made on the permeability and the groundwater gradient, as well as the effects due to seiche flushing, the actual arsenic loadings are probably within two orders of magnitude of the calculated values (Tusler, 1989).

Table VI.2 Monthly Average Loadings for 1988 and 1989 from Facilities Discharging to the Menominee River in the AOC

Menominee Paper Company Effluent - 1989

	Flow (MGD)		BOD_5 (lbs/day)		TSS[1] (lbs/day)	
Month	Ave.	Max.	Ave.	Max.	Ave.	Max.
January	0.067	0.154	433	1176	171	1515
February	0.146	0.74	959	6284	281	1781
March	0.136	0.337	910	3079	435	2539
April	0.119	0.451	928	3385	-	-
May	0.054	0.297	439	2972	429	2392
June	0.100	0.53	409	1864	114	849
July	0.51	1.05	866	7426	349	1687
*						
August	0.922	1.14	488	1360	423	1868
September	0.760	1.15	485	1115	215	658
October	0.690	0.936	259	388	261	528
November	0.670	1.08	421	1063	300	682
December	0.638	0.944	598	1088	452	726
Average	0.40	0.74	600	2600	312	1384
Permit Limits	-	-	2100	3150	1100	1650
Permit Limits[2]	-	-	900	1350**	1700	2550**

[1] Total Suspended Solids
[2] Permit limits in effect 8/28/89
* Menominee Paper Company WWTP Startup - 7/19/89
** Seven (7) day average

Table VI.2, Continued

Menominee Paper Company Effluent - 1988

	Flow (MGD)		BOD_5 (lbs/day)		TSS[1] (lbs/day)	
Month	**Ave.**	**Max.**	**Ave.**	**Max.**	**Ave.**	**Max.**
January	0.120	0.550	781	2831	92	336
February	0.035	0.322	274	2416	47	516
March	0.15	0.20	1047	1317	170	196
April	0	0	0	0	0	0
May	0.098	0.301	836	2937	174	599
June	0.02	0.07	169	445	24	97
July	0.076	0.4	420	2451	80	350
August	0.042	0.195	256	1477	84	1065
September	0.035	0.217	245	1673	102	2050
October	0.034	0.260	264	1771	185	3373
November	0.036	0.184	263	1386	44	239
December	0.075	0.41	308	2430	68	445
Average	0.07	0.3	442	1921	97	842
Permit Limits	-	-	2100	3150	1100	1650

[1]Total Suspended Solids

Table VI.2, Continued

Menominee WWTP Effluent - 1989

Month	Flow (MGD) Ave. (30 day)	BOD[2] (lbs/day) Ave. (30 day)	BOD[2] (lbs/day) Ave. (7 day)	TSS[1] (lbs/day) Ave. (30 day)	TSS[1] (lbs/day) Ave. (7 day)	Total Phosphorus (lbs/day) Ave. (30 Day)	Total Phosphorus (lbs/day) Ave. (7 day)
January	2.08	1773	2274	4894	6980	20.85	33.01
February	2.34	2223	2839	7095	9671	25.41	33.23
March	3.22	3593	4307	7392	11275	29.61	56.53
April	3.48	3611	4163	6905	11393	31.99	58.17
May	2.25	2639	3584	11464	16790	18.83	26.36
June	2.79	4272	5204	8070	14945	28.00	60.67
July	2.32	1486	2338	1562	3700	13.55	27.11
August	1.95	1081	1579	1888	2867	27.76	47.35
September	1.58	401	750	569	993	18.48	21.12
*							
October	1.68	278	428	294	440	14.05	19.67
November	1.80	192	319	273	415	7.52	7.52
December	1.58	144	202	100	119	4.97	7.86
Average	2.26	1808	2332	4208	6633	20.15	32.66
Permit Limits[3]	-	1700	2500	2500	3700	1.0[5]	-
Permit Limits[4]	-	667	1200	800	1200	1.0[5]	-

[1] Total suspended solids
[2] Reported as BOD_5 January-August 1989, Reported as Carbonaceous BOD_5 September-December 1989.
[3] January-August 1989
[4] September-December 1989
[5] Total Phosphorus permit limit is 1 mg/L, conversion to lbs/day, based on the design flow of 3.2 MGD is: 26.69 lbs/day.
* WWTP renovations completed 10/1/89

Table VI.2, Continued

Menominee WWTP Effluent - 1988

Month	Flow (MGD) Ave. (30 day)	BOD (lbs/day) Ave. (30 day)	BOD (lbs/day) Ave. (7 day)	Carboneous TSS[1] (lbs/day) Ave. (30 day)	Carboneous TSS[1] (lbs/day) Ave. (7 day)	Total Phosphorus (lbs/day) Ave. (30 Day)	Total Phosphorus (lbs/day) Ave. (7 day)
January	2.83	748	1094	1417	1930	5.8	9.2
February	2.88	889	1036	1658	2110	5.8	11.6
March	2.82	1345	1794	3430	5673	5.0	8.3
April	3.79	2098	2587	4320	8767	5.0	6.7
May	3.41	1804	2067	2274	3671	4.2	5.0
June	2.83	1377	1777	3260	5485	5.1	7.9
July	2.89	902	1518	2786	5517	5.8	1.3
August	3.50	1636	2256	5456	10,024	5.8	10
September	2.86	1712	2114	3819	6543	6.7	8.3
October	2.73	1066	1415	3970	8480	9.2	1.4
November	2.89	1763	2130	3522	5073	5.0	5.8
December	2.36	1608	2382	3603	8871	5.0	7.5
Average	2.98	1412	1848	3293	6012	5.7	6.9
Permit Limits[2]	-	2000	2670	4000	5340	1.0[4]	-
Permit Limits[3]	-	1700	2500	2500	3700	1.0[4]	-

[1] Total suspended solids
[2] Permit limits for January-June 1988
[3] Permit limits for July-December 1988
[4] Total phosphorus permit limit is 1 mg/L, conversion to lbs/day, based on the design flow of 3.2 MGD is: 26.69 lbs/day

Table VI.2, Continued

Ansul Fire Protection Company Effluent - 1989
(Outfall 001)

Month	Flow (MGD)	As (lbs/day)	Be (ug/L)	T1 (ug/L)	Hg (ug/L)
January	2.24	0.22	<1	3	<0.4
February	2.16	0.20	<1	<1	<0.2
March	1.93	0.37	<1	<1	0.6
April	2.24	0.63	<1	<1	0.8
May	2.59	0.35	<1	<1	1
June	2.21	0.72	<1	<1	<0.2
July	2.34	0.55	1	<1	<0.2
August	2.41	0.52	<1	<1	<0.4
September	2.32	0.96	<1	<1	<0.4
October	1.93	0.68	<1	<1	<0.2
November	1.78	2.32	<1	<1	<0.2
December	2.30	1.33	<1	<1	<0.4
Average	2.20	0.74	1.0	1.2	0.4
Permit Limits[1]					
Daily Maximum			233	141	4.8
Monthly Average.			40.3		4.4

[1] These limits will become effective January 1, 1991

ANSUL COMPANY MASS DISCHARGE - 1989

	Average Mass Discharge (lbs/day)	Monthly Average Limit (lbs/day)	Daily Maximum Limit (lbs/day)
Arsenic	0.740		
Beryllium	0.020		
Cadmium	0.001	0.16	0.69
Chromium	0.011	1.08	2.77
Chromium(+6)	0.001		
Copper	0.015	1.31	3.38
Cyanide	0.013	0.04	0.07
Lead	0.005	0.26	0.69
Mercury	0.010		
Nickel	0.096	1.51	3.98
Oil & Grease	4.900	16.5	52
Silver	0.001	0.15	0.43
Thallium	0.020		
TSS	7.800	19.6	60
Zinc	0.232	0.94	2.61

NOTE: Ansul is required to monitor cadmium, hexavalent chromium, nickel, cyanide, zinc, copper, lead, silver, total toxic organics, total suspended solids, oil and grease, and pH at an internal sampling point (#101). See following table.

Table VI.2, Continued

Ansul Fire Protection Company
Internal Sample Data - 1989
(Sample Point 101)

	FLOW (MGD)	Cd (ug/L)	Cr (ug/L)	Cr(+6) (ug/L)	Ni (ug/L)	Zn (ug/L)	CN (ug/L)	Cu (ug/L)	Pb (ug/L)	Ag (ug/L)	TSS (lbs)	Oil & Grease (lbs)
January	0.07	9	29	2	261	1262	20	22	11	1	24.6	4.4
February	0.05	2	8	2	259	266	20	13	1	1	5.2	2.8
March	0.05	4	6	4	150	237	31	5	1	1	3.9	3.8
April	0.06	5	48	2	182	402	29	65	11	1	10.5	3.9
May	0.06	1	60	2	207	713	53	30	1	2	7.2	5.1
June	0.06	1	23	2	130	328	20	10	1	1	7.9	6.8
July	0.06	1	31	2	235	386	20	21	1	1	8.9	3.5
August	0.07	1	8	2	130	277	20	30	1	2	5.2	5.3
September	0.07	1	3	6	112	211	20	28	20	2	5.4	7.5
October	0.06	1	1	2	125	340	20	43	30	1	4.6	6.8
November	0.06	2	6	2	94	257	20	27	7	1	4.8	3.8
December	0.06	1	6	2	204	357	20	37	20	1	5.3	5.3
Average	0.06	2	19	3	174	420	24	28	9	1	8	5
Permit Limits												
Daily Maximum		640	2770	590	3980	2610	780	220		90	60	52
Monthly Average		260	1710		2380	1480	650				19.6	16.5

NOTE: Sample point 101 is an internal categorical limit sampling point of metal finishing process effluent discharged through Outfall 001.

Table VI.2, Continued

Ansul Fire Protection Company Effluent - 1988 (Outfall 001)

	Flow (MGD)	As (lbs)	Cd (ug/L)	Cr (ug/L)	Ni (ug/L)	Zn (ug/L)	Cn (ug/L)	Cu (ug/L)	Ag (ug/L)	TSS (lbs)	Be (ug/L)	Tl (ug/L)	Hg (ug/L)
January	1.88	1.5	3	2	41	72	1	7	1	7.8			
February	1.99	1.3	1	2	44	62	1	13	1	6.5			
March	2.15	0.6	2	2	11	18	1	11	1	7.9			
April	1.95	2.4	2	11	17	54	1	12	1	9.1			
May	2.28	0.7	2	2	20	82	1	17	1	15.2			
June	2.5	0.4	2	4	17	27	1	14	1	12			
July	2.36	0.6	1	2	95	107	1	17	1	14.8			
August	2.61	0.6	1	5	55	22	3	6	1	14.4			
September	2.8	0.5	2	2	52	71	2	1	1	14.2			
October	2.37	0.6								20	1	7	0.3
November	2.09	0.6								18.2	1	1	0.2
December	1.86	1								15.6	1	5	2.7
Average	2.2	0.9	2	4	39	57	1	10.9	1	13	1	4	1
Permit Limits(1)													

(See next page for notations)

Table VI.2, Continued

Ansul Fire Protection Company Outfall 001 Effluent - 1988

Average Daily Load

	Pounds/Day
Arsenic	0.90
Cadmium	0.03
Chromium	0.01
Chromium(+6)	0.07
Nickel	0.73
Cyanide	0.02
Copper	0.20
Silver	0.02
TSS	13.00
Beryllium	0.02
Thallium	0.08
Mercury	0.01
Lead	0.005
Oil and Grease	6.60

NOTE: (1) Ansul's discharge permit was reissued in 1988; therefore, some limits have changed. For simplicity both limits are not shown here. Current limits are shown in Ansul's 1989 summary table.

Beryllium, mercury, and thallium were included in the company's new permit, and the other metals were dropped from monitoring requirements for the main outfall.

The daily mass loadings for some pollutants identified (i.e., silver, cyanide, chromium(+6), beryllium, and mercury) are conservatively high since all non detected values were assumed to be present at the reported detection limit. For example, beryllium was not reported to be detected and silver was reported to be determined in only 2 samples in monitoring during 1988.

Table VI.2, Continued

Ansul Fire Protection Company
Ansul Internal Sample Data - 1988
(Sample Point 101)

	FLOW (MGD)	Cd (ug/L)	Cr (ug/L)	Cr(+6) (ug/L)	Ni (ug/L)	Zn (ug/L)	CN (ug/L)	Cu (ug/L)	Pb (ug/L)	Ag (ug/L)	TSS (lbs)	Oil & Grease (lbs)
January	0.06	7	6	2	66	715	37	33	5	1	7.8	7.8
February	0.07	4	4	2	107	374	8	10	4	3	6.5	10.1
March	0.07	5	12	2	57	162	8	13	3	3	7.9	3.2
April	0.06	9	15	2	131	600	1	19	10	2	9.1	7.1
May	0.07	4	19	2	84	702	2	43	5	1	15.2	10
June	0.07	1	14	3	75	370	1	17	1	1	12	5.6
July	0.06	4	40	2	335	795	4	19	3	1	14.8	3.5
August	0.08	1	38	2	153	328	3	22	1	1	14.4	5.2
September	0.07	14	37	2	222	704	1	9	1	1	14.2	7.3
October	0.08	8	4	5	223	368	6	10	1	1	20	5.1
November	0.08	3	24	2	222	424	8	27	3	1	18.2	6.4
December	0.08	10	44	2	271	660	4	22	53	1	15.6	8
Avg.	0.07	6	21	2	162	517	7	20	8	1	13	7

NOTE: Ansul's discharge permit was reissued in 1988 therefore some limits have changed. For simplicity both limits are not shown here. Current limits are shown in Ansul's 1989 summary.

Sample point 101 is an internal categorical limit sampling point of metal finishing process effluent discharged through outfall 001.

Table VI.2, Continued

City of Marinette Effluent - 1989

Month	Flow MGD	BOD_5 (lbs/day)	TSS (lbs/day)	Total Phosphorus (lbs/day)	Cyanide (ug/L)	Copper (ug/L)	Aldrin (ug/L)	Heptachlor (ug/L)
January	4.41	257	110	6				
February	4.06	372	203	9				
March	4.25	390	248	9				
April	5.01	167	209	10				
May	4.74	356	395	16				
June	5.62	281	328	12				
July	4.94	288	206	7				
August	4.92	328	369	9				
September	4.01	334	201	5				
October	3.97	331	199	6	30	23	<0.01	<0.01
November	4.53	378	302	9	38	<14	<0.01	<0.01
December	4.27	356	321	11	50	18	<0.06	<0.06
Average	4.56	320	258	9	39	18	0.03	0.03
Permit Limits(1)	-	30(1)	30(1)	1(2)	92.4	85.7	0.19	0.46

(1) Monthly average limits are in mg/L(ppm). For both BOD_5 and TSS the monthly average limit is equivalent to 1276 pounds/day based on the treatment plant design flow of 5.1 million gallons per day and the concentration limits of 30 ppm.

(2) The monthly average limit is in mg/L (ppm). For total phosphorus the monthly average limit is equivalent to 43 pounds/day based on the treatment plant design flow of 5.1 million gallons per day and the concentration limit of 1.0 ppm.

Table VI.2, Continued

City of Marinette Effluent - 1988

Month	Flow MGD	BOD_5 (lbs/day)	TSS (lbs/day)	Total Phosphorus (lbs/day)
January	4.98	581	249	11
February	4.6	460	192	9
March	5.17	561	216	14
April	5.94	545	297	14
May	5.02	377	167	13
June	4.29	787	1395	65
July	4.01	234	100	8
August	3.94	197	66	4
September	4.14	242	35	5
October	4.01	234	67	9
November	4.87	325	162	9
December	5.1	340	213	9
Average	4.7	407	263	14
Permit Limits	-	30(1)	30(1)	1(2)

(1) Monthly average limits are in mg/L (ppm). For both BOD_5 and TSS the monthly average limit is equivalent to 1276 pounds/day based on the treatment plant design flow of 5.1 million gallons per day and the concentration limit of 30 ppm.

(2) The monthly average limit is in mg/L (ppm). For total phosphorus the monthly average limit is equivalent to 43 pounds/day based on the treatment plant design flow of 5.1 million gallons per day and the concentration limit of 1.0 ppm.

(2) The 35 pounds/day permit limit is based on a concentration limit of 1 mg/L.

Table VI.2, Continued

Scott Paper Company Effluent - 1989

Month	Flow MGD	BOD_5 (lbs/day)	TSS (lbs/day)
January	4.90	1856	1200
February	4.91	1397	1094
March	4.61	1434	1244
April	4.72	1747	799
May	5.04	1731	1099
June	5.31	2030	1071
July	5.19	1271	1357
August	5.90	2412	1116
September	6.31	1731	1155
October	5.29	2001	1038
November	5.06	1747	985
December	4.84	1747	813
Average	5.17	1759	1081
Permit Limits	--	3508[1]	2806

[1] 30 day average.

Table VI.2, Continued

Scott Paper Company Effluent - 1988

Month	Flow MGD	BOD_5 (lbs/day)	TSS (lbs/day)
January	5.6	1600	1920
February	5.92	1690	1870
March	6.09	1960	1480
April	5.8	2160	1870
May	5.94	2090	1110
June	5.88	2240	1380
July	4.79	1810	1330
August	5.74	2530	1500
September	5.14	1760	820
October	5.14	1530	780
November	4.68	2110	1040
December	4.66	2460	1450
Average	5.45	1995	1379
Permit Limits	--	3508[1]	2806

[1] 30 day average

Table VI.3. Permit Information for Municipal and Industrial Discharges in the AOC

Facility	Permit Last Issued	Expiration Date of Current Permit	Reporting Period for discharge Monitoring Data	Parameter	Number of Permit Violations
Scott Paper Company	12/31/86	12/31/93	1/88-9/89	pH	4
Ansul Fire Protection Company	9/30/88	6/30/93	1/88-9/89	TSS[1]	9[4]
				pH	2
SpecialtyChem Products Corporation		9/30/87	1/88-9/89	Sulfite	2
				TSS[1]	3
City of Marinette Wastewater Treatment Plant	6/29/84	3/31/89	1/88-9/89	Total Phosphorus	2
				Residual Chlorine	14
				BOD_5	1
Menominee Paper Company	8/29/89	2/28/93	1/88-12/88	pH	3
				TSS[1]	2
City of Menominee Wastewater Treatment Plant[2]	9/85	6/30/90	1/88-12/88	TSS[1]	9
				CBOD[3]	1
				Dissolved Oxygen	3
				Fecal Coliform	4
				BOD_5	2
				Total Phosphorus	1
				% Removal BOD_5	2
				% Removal TSS	6

(1) Total Suspended Solids
(2) The City of Menominee WWTP permit has been modified in December, 1987 and May, 1988.
(3) Carboneous biochemical oxygen demand.
(4) These permit exceedances were at an internal sampling point, not at the outfall to the river.

Table VI.4 Total Loadings for Conventional Pollutants to the Menominee River for 1989

Facility	Average Loadings in lbs/day[1] BOD$_5$	Total Suspended Solids	Total Phosphorus	Discharge Flow to the Menominee River (MGD)[4]
Scott Paper Co.	1759	1081	-	5.17
City of Marinette	320	258	9	4.56
Ansul[2]	-	-	-	2.20
City of Menominee	1959[5]	4582	21.53	2.32
Menominee CSOs[3]	293	1353	3.36	0.40
Menominee Paper Co.	600	312	-	0.35
Total Loadings[6]	4931	7586	33.89	15

(1) For Wisconsin facilities the loading is based on a monthly average; for Michigan facilities the loading is based on a daily average. The difference between states (monthly versus daily averages) is due to the way the data are reported.

(2) Ansul Fire Protection Company

(3) Combined Sewer Overflows, loadings are estimated based on an annual average flow of 147.3 million gallons (McNamee, Porter and Seeley, 1986).

(4) MGD is million gallons per day.

(5) From September-December 1989 BOD was reported as carbonaceous BOD.

(6) From all facilities

Table VI.5. Total Loadings for Heavy Metals, Volatile Suspended Solids, and Chloroform to the Menominee River from Major Wisconsin and Michigan Point Sources

Facility	Ansul Fire Protection Company	Menominee Combined Sewer Overflows[2]	
Pollutant	Average Monthly loadings in lbs/day	Average Annual loadings in lbs/day	Total 1988[1] Annual Loadings in lbs
Arsenic	0.9	-	328
Beryllium	0.02	-	7.3
Cadmium	0.03	0.007	4.4
Chromium	0.07	0.29	111
Copper	0.20	0.21	81
Cyanide	0.02	-	1.5
Lead	0.005	0.12	49
Mercury	0.01	0.002	4
Nickel	0.73	-	58.4
Silver	0.02	0.004	1.6
Thallium	0.08	-	29.2
Zinc	1.07	0.74	391
Iron	-	6.76	2467
Manganese	-	0.25	91
Chloroform	-	0.009	3.3
Volatile Susp. Solids	-	646	235,790

(1) There may be low level loadings from other sources which are not documented (i.e., storm sewer discharges, WWTP effluent).

(2) Based on the McNamee, Porter, & Seeley study (1987).

Table VI.6 Comparison of Existing and Projected Effluent Quality from Menominee Combined Sewer Overflows (CSO)

	1989 Effluent Quality[1]	1990 Projected Effluent Quality[2]
Parameter	Ave. Daily Loadings (lbs/day)	Ave. Daily Loadings (lbs/day)
BOD_5	1,353	712
Total Susp. Solids	293	154
Total Phosphorus	3.36	1.8

(1) Based on an estimated annual runoff flow of 147.3 million gallons per year

(2) Based on an average flow of 0.21 million gallons per day and assuming that the largest contributing CSO (CSO #2) is eliminated in August 1990. CSO #2 contributes a significant portion of the total loading, consequently there is a large projected decrease in loadings from 1989 to 1990.

Table VI.7 Primary Nonpoint Sources of Pollution in the AOC

Nonpoint Sources	Typical Pollutants
Atmospheric deposition (from automobile and point sources)	Heavy metals (from autos) carbon dioxide, sulfur dioxide, nitrates, plus acids formed from these substances from point sources; nitric acid in the case of autos.
Construction site erosion	Suspended solids and oil & grease
Runoff from storage piles (coal, soil, salt)	Suspended solids & chlorides Some heavy metals from coal piles (i.e., arsenic, boron, zinc, lead, & copper)
Storm sewer outfalls (15 from the City of Marinette & 29 from the City of Menominee)	Heavy metals (i.e., lead, zinc, copper, mercury, etc.) Pesticides, inorganic and organic pollutants, biochemical oxygen demand, chemical oxygen demand, suspended solids, nutrients (nitrogen & phosphorus), and bacteria

VII. HISTORICAL RECORD OF MANAGEMENT ACTIONS

Table VII.1 lists the historical record of remedial actions directed at reducing and managing environmental pollution in the area of concern to restore or improve beneficial uses of the river. This chapter briefly describes each of these actions between the years of 1965 and 1989.

Table VII.1 Management Actions in the Menominee AOC: 1965-1989

Date	Management Action	Beneficial Use(s) Action is Aimed at Improving/Restoring
1965	Turning Basin last dredged by COE	Navigation
1973	WDNR issues Ansul an order which requires: a study; long term plan for managing salt wastes; a trench to reduce groundwater flow through the contaminated area	Fish and Wildlife, Recreation
1974	Menominee WWTP upgraded to secondary treatment	Localized Water Quality Improvements to Benefit Fish and Wildlife, Recreation
1979	Ansul installed a groundwater control trench under WDNR consent order	Fish and Wildlife, Dredging
1979	Michigan court order requiring Menominee Paper Co. to split its waste stream between the city WWTP and the Menominee River with other treatment provisions	Localized Water Quality Improvements to Benefit Fish and Wildlife, Recreation
1981	Ansul installed groundwater extraction and treatment system under WDNR consent order; the system was operated until 1986 under RCRA License	Fish and Wildlife, Recreation

Table VII.1, Continued

Date	Management Action	Beneficial Use(s) Action is Aimed at Improving/Restoring
1982	River and harbor (except turning basin) last dredged by COE	Navigation
1984	Statutory change in RCRA program	- - -
1985	Menominee River is included in Fish Consumption Advisory	Public Health
1986	WDNR imposes a sewer ban on City of Marinette for Category 1 bypassing in the collection system and treatment plant. This ban was in effect until 1989.	Fish and Wildlife; Recreation
1987	MDNR determines there are two plumes of contamination emanating from the City of Menominee landfill	Groundwater
1988	WDNR and MDNR begin a remedial action plan process for the Menominee River area of concern	All Water Quality Impaired Uses
1988	Ansul and U.S. EPA begin negotiations on RCRA Consent Order	Fish and Wildlife; Dredging
1989	Construction completed on Menominee Paper Co. Wastewater Treatment Plant for compliance with NPDES permit	Localized Water Quality
1989	U.S. EPA issued City of Menominee a Consent Order requiring a program for correction of combined sewer overflows by 8/1/90	Public Health
1989	MDNR investigation of paint sludge disposal site at Lloyd/Flanders Furniture Co.	Fish and Wildlife Habitat; Benthos
1989	Preliminary assessment of coal tar contamination at City of Marinette WWTP construction site.	Fish and Wildlife, Recreation

Wastewater Treatment Facilities

City of Menominee Wastewater Treatment Plant

The original treatment plant for the City of Menominee was built in 1940. It provided primary treatment to a capacity of 2.0 MGD. In 1974, the plant was upgraded to secondary treatment with a design flow of 3.2 MGD. No allowance for large industrial waste flows were included in the facility design (Johnson and Anderson, 1978). The Menominee WWTP has had an industrial pretreatment program since August 9, 1985.

The Menominee sewage collection system is comprised of both separate and combined storm and sanitary sewers with a total service area of about 1,400 acres. The combined sewer districts total about 450 acres and discharge to the Menominee River through five overflow structures when the sewer capacity is exceeded by the combination of storm water and/or snowmelt and sewage.

In 1978 the Menominee Paper Company became a major industrial discharger to the city wastewater treatment plant (WWTP). The paper company began discharging its process wastewater to the city WWTP based on engineering estimates of the WWTP's ability to handle the waste load. However, effluent quality decreased dramatically. Large increases in BOD and total suspended solids loadings to the river were measured. The City of Menominee had intended to expand the WWTP to effectively treat the added Menominee Paper Company wastewater. Federal funding was not awarded to the project, however, and the plant was not expanded. This situation resulted in the City of Menominee violating its NPDES permit.

Several actions were ordered as a result of U.S. EPA enforcement action which addressed the city's violation of its discharge permit. Ultimately, the city and paper company agreed to construction of separate treatment plants. Separation of city and paper company wastewater flows was completed on August 30, 1989.

Federal action was taken against the city for water quality violations. Because the City of Menominee could not meet the secondary treatment deadline of July 1, 1988, for the reasons described above, as required in the 1987 Amendments to the Clean Water Act (CWA), the U.S. EPA filed suit in Federal Court enjoining both the City and Menominee Paper Company for CWA violations. The resulting EPA consent order required the City of Menominee to disconnect Menominee Paper Co.'s wastewater discharge from the city WWTP by August 27, 1989. The consent order also required the city to complete construction on city WWTP facilities necessary to achieve compliance by November 1, 1989 with the final effluent limits in its NPDES permit (issued May, 1988). The City of Menominee was also assessed a $105,000 civil fine.

Water quality violations resulting from combined sewer overflows (CSOs) are also considered in the EPA consent order. A CSO correction program was required to be implemented by August 1, 1990. The CSO program addresses repairs, replacement, and regulation devices to minimize discharges, and infiltration and inflow to the sanitary sewer system. Because CSO number two has the greatest drainage area and contributes a greater discharge to the river than the four other CSO's, it was singled out in the consent order for correction ahead of the other Menominee CSO's.

The City of Menominee's NPDES permit, issued in September, 1985, required several plans and programs in addition to effluent limitation requirements. The permit required development of a long-term compliance plan for mercury discharges because of mercury concentrations found in the WWTP effluent. The City of Menominee WWTP was also included on the Clean Water Act Section 304(1) short list for toxic "hot spots" because of the mercury concentrations discharged by the WWTP. The City of Menominee's long-term compliance plan for mercury has been submitted to MDNR. Required monitoring of the City of Menominee's discharge in 1989 for mercury indicated that no detectable levels were present in the effluent. Other permit requirements include development of an industrial pretreatment program, a program for residuals management and a CSO notification program. These programs are already in place. New language addressing the interim and final combined sewer overflow control program requirements will be added to the City of Menominee's next permit to be issued during calendar year 1990 (the current permit expired June 30, 1990). The new permit requirements will coincide with and build on the conditions of the court order currently regulating the City of Menominee's CSO discharges to the river.

Menominee Paper Company Wastewater Treatment Plant

During the 1970's and 1980's Menominee Paper Company upgraded its treatment systems several times to reduce wastewater discharged to the river in response to changes in manufacturing processes, improvements in environmental technology and changes in environmental regulations. As noted above, the Menominee Paper Company began discharging its process wastewater (1.14 MGD) to the city WWTP in 1978. However, before connecting to the city, the company discharged primary clarified wastewater to the Menominee River. The Company also discharged approximately 4.5 MGD of contact and noncontact cooling water to the Menominee River. Because treatment of its process wastes by the city WWTP was not adequate, the company constructed its own treatment plant which began operation on August 28, 1989.

Menominee Paper Company recently entered into a Consent Decree with the U.S. EPA concerning water quality violations stemming from past inadequate wastewater treatment and was assessed a $2.1 million civil fine. The WWTP expansion consists of two separate and distinct treatment pathways; the first treatment process reclaims water for reuse on the paper machines, and the second treatment process provides secondary treatment to the excess water before discharge to the Menominee River. To handle the increase in sludge volume generated in the additional water treatment plant processes, the sludge dewatering system was also expanded. This plant is permitted to discharge a maximum of 2 MGD of treated process wastewater.

City of Marinette Wastewater Treatment Plant

The original treatment plant for the City of Marinette was constructed in 1938. The plant was upgraded to secondary treatment with an average design flow of 4.25 MGD in 1972. The wastewater collection system is comprised of both separate and combined storm and sanitary sewers. The current city program for sewer separation began in 1972.

Seven industries, with a combined discharge of 0.45 MGD resulted in disruptions of WWTP operations in 1987. The conditions, requiring evacuation of plant personnel, were traced to the process wastewater from the SpecialtyChem Products Corporation. Monitoring and analysis data disclosed high concentrations of organic chemicals (1,2-Dichlorobenzene, ethylbenzene, toluene, xylenes, hydroxyanisole, 1,4-dimethoxybenzene) leading to high chemical oxygen demand (COD) values. SpecialtyChem Products Corporation is working with the city to avoid future WWTP disruptions caused by their wastewater (Foth and Van Dyke, 1987). Techniques currently being used include pretreatment, and monitoring of the effluent prior to discharge to the City of Marinette (Oman, 1989).

The City of Marinette is in the process of expanding its WWTP and rehabilitating their collection system. The WWTP has a planned wet weather design flow of 7.8 MGD, and an average dry weather design flow of 5.1 MGD. Federal General Pretreatment regulations 40 CFR 403.8 and NR 211, Wis. Adm. Code, require a pretreatment program for WWTP's with design flows greater than 5 MGD and those receiving wastewater from industries. An industrial wastewater pretreatment program has been required as part of the city WWTP's proposed 1989 WPDES permit and is currently being designed by the City of Marinette's consultant according to a schedule contained in the permit. Prior to implementation, the program must receive the approval of the Wisconsin DNR and U.S. EPA. The program establishes the necessary procedures and legal authorities for the WWTP to inventory, monitor, control, and enforce pretreatment standards for all dischargers to the sanitary sewer system (Janisch, 1989).

Because of collection system and treatment plant bypassing in 1986, the City of Marinette was placed under a sewer service moratorium by the WDNR and the Wisconsin Department of Industry, Labor and Human Relations (WDILHR). The two Departments have a cooperative agreement to review private sewer submittals for conformance with Wis. Adm. Code NR 110.05. Under WDILHR's program, sewer connections for any building larger than a single residential unit or duplex will be denied if the community is under a sewer moratorium.

The capacity of the Marinette WWTP and collection system was unable to handle the flow during times of wet weather. To avoid flooding of treatment plant unit operations, portions of the influent raw wastewater were continuously bypassed around most of the treatment process providing only partial treatment. Sewer surcharging in the collection system also occurred. Surcharging results in the discharge of raw wastewater from manholes and backups in household basements throughout the city during storms.

The Marinette WWTP system was identified as having a Category 1 bypass situation. A Category 1 bypass or overflow is defined by the WDNR as one that occurs as a result of storm drainage or runoff resulting from a rain storm of an intensity which could occur more than once in five years (a relatively minor storm). The City of Marinette completed sufficient improvements to control bypasses and WDNR removed the sewer ban on September 1, 1989 (Oman, 1989).

The plant also received action level scores on its Compliance Maintenance Annual Report (CMAR) for 1986 and 1987. The CMAR is submitted to WDNR by the owner of a WWTP to describe the physical conditions and the performance of the sewer system during the previous calendar year. Action level scores indicate serious problems with the treatment plant resulting in non-compliance with effluent limits. Action level scores may require the treatment plant owner to submit to the WDNR a facility plan for plant improvements or expansion. In 1988, the results of the Compliance Monitoring Survey completed by WDNR for the treatment plant presented several conclusions and recommendations which addressed specific plant problems. These problems have been addressed in the current facility plan for the WWTP.

Harbor Dredging Activities

The Menominee River Harbor was first used commercially in the mid-1800's as a lumber shipping port. As the timber industry expanded in the densely forested lands surrounding the Menominee River, the harbor reached prominence as the largest lumber shipping port in the world (Korch, 1989). The last log drives on the Menominee River were in 1917, but the harbor remains commercially active, serving industries located on the edges of the river in the Cities of Marinette and Menominee. Recreational boats also frequently use the lower river channel.

The Lower Menominee River and Harbor is designated as a federal navigation project which requires the U.S. Army Corps of Engineers (COE) to maintain established depths for navigation channels. Between 1961 and 1982 the COE has completed five dredging projects on the harbor and river (Table VII.2).

Table VII.2 Menominee Harbor Dredging History: 1961-1982

Year	Location	Quantity (cubic yards)
1961	River and Harbor	50,796
1965	River and Harbor	26,818
1968	River	8,915
1968	River	10,625
1982	River and Harbor (except area adjacent to turning basin)	6,216

Source: COE Kewaunee Area Office, 1988.

The presence of contaminated sediments in the Menominee River and Harbor, especially within the turning basin, has become a major problem for dredging operations. The turning basin has not been dredged since 1965. Environmentally sound disposal of contaminated sediments is technically difficult and is rapidly becoming more and more expensive. Thus, the frequency of dredging projects may be slowed or halted due to the difficulty and expense of handling the sediments. Ultimately, navigation is affected in areas with contaminated sediments.

The COE has scheduled maintenance dredging for the harbor in 1990. The COE is also studying the feasibility of deepening portions of the shipping channel by several feet. Open water disposal of dredge spoil (within Michigan's Lake Michigan boundary) will continue if the material is determined to be uncontaminated.

Consumption Advisories

Fish consumption advisories were first issued in the State of Wisconsin in 1976. Advisories on fish consumption have been issued for the Menominee River below the Lower Scott (Paper Co.) Dam every year since 1985 due to PCB contamination. High concentrations of PCBs are present in sediments of the Lower Fox River and southern end of Green Bay. Fish bioconcentrate and bioaccumulate contaminants through ingestion and absorption from the water. Fish are mobile and most species can easily migrate throughout Green Bay and its tributaries. Therefore, a source of pollution in one area has the potential to result in the issuance of fish consumption advisories in other areas. It should also be noted that sediments in the Menominee River also contain PCBs, but at concentration levels much lower (<.03 - 2.0 ppm) than those of the Lower Fox River (average values 2.06 - 48.99 ppm). Refer to the Sediment Quality Assessment Section of Chapter IV for a discussion of PCB sediment concentrations.

Before 1985, the Menominee River was not specifically identified in the Wisconsin fish consumption advisory. However, the general wording of the advisory would have included the river segment below the Lower Scott Paper Dam as an affected tributary of Green Bay. In April, 1990 the Menominee River below the first dam was added to the Wisconsin mercury consumption advisory for rock bass. Fish consumption advisories are issued by the Wisconsin and Michigan Departments of Natural Resources based on contaminant levels established by the U.S. Food and Drug Administration. Fish consumption advisories are discussed in Chapter IV.

Arsenic Contamination In The Area Of Concern

From 1957 to 1977 the Ansul Fire Protection Company (Ansul) produced arsenic based herbicides. The process wastes, including arsenic salts, were discharged directly to the Menominee River adjacent to the turning basin from 1957 to 1966. In 1966 Ansul built a waste recycling plant to recover arsenic, but a year later they abandoned it.

Between 1971 and 1981 Ansul and WDNR entered into a series of mutually agreed upon consent orders. In 1973, the WDNR, in 1973, ordered Ansul to institute a study of the arsenic contamination problem, develop a long term plan for managing salt wastes, and install a trench to reduce the flow of groundwater through the contaminated area. Six years later, under a modified consent order from WDNR, Ansul installed a groundwater control trench. This trench was designed to limit the movement of arsenic across the site via groundwater transport. In 1981 Ansul installed a RCRA licensed groundwater extraction and treatment system under the order. Ansul treated over 16 million gallons of groundwater and removed 350 tons of arsenic between 1982 and 1986. Ansul was granted permission to halt extraction and treatment in 1986 after fulfilling certain conditions of the agreement; quarterly monitoring of groundwater on the site is ongoing. Under a Resource Conservation and Recovery Act authority, another consent order is currently being negotiated between WDNR, U.S. EPA and the Ansul Company. This order will consist of a RCRA Facility Investigation (RFI) and a Corrective Measures Study (CMS). If the CMS finds that remediation is necessary, the consent order will require Ansul Fire Protection Company to develop and implement a corrective action plan.

Contamination From Landfills And Disposal Sites In The Area Of Concern

Menominee City Landfill

The MDNR has conducted an extensive study of the Menominee City Landfill (Figure V.2). Remote sensing techniques, with ground truth verification were used to analyze the landfill for pollutant problems. In 1982, the study determined that isolated areas of the landfill had greatly elevated magnetic values indicating the possibility of buried drums. Two years later, soil gas samples from the landfill were found to contain methylene chloride, a toxic substance. In 1987, MDNR determined the presence of two plumes of contamination emanating from the landfill via the groundwater. In the westerly-north-northwesterly direction of groundwater flow the plume has reached Sunset Drive, a residential street northwest of the landfill. In the easterly-southeasterly direction of groundwater flow the plume is traveling toward County Road 577 (Austin, C.L.; et. al, 1987). These plumes are reportedly still within the landfill property boundaries (Janowitz, 1990). The State of Michigan is currently in litigation with the City of Menominee regarding groundwater contamination near the landfill. Reports on groundwater quality in the landfill area will become available at the conclusion of this litigation.

Green Bay Paint Sludge Disposal Site

The MDNR completed (through GZA-Donohue) a preliminary investigation of a paint sludge disposal site in October 1989. The site (a furniture manufacturing plant for 70 years) is located on the shore of Green Bay approximately two miles north of the Menominee River (Figure V.2). A furniture manufacturing plant has been located there since the early 1920's. Past operators used a wetland area behind the plant to dispose of paint sludges leftover from their furniture finishing process. Apparently these dumping practices continued for a number of years if not decades. Today, a large amount of artificial fill (containing paint sludge) is present behind the plant. The lake bottom around this area is covered with paint sludge. Nodules of the sludge continue to wash ashore and are common for up to a half mile south of the plant (Harrington, 1990). The preliminary investigation determined the approximate areal extent of paint sludges in the bay, near the site. Thirteen samples of the sludge were taken and composited for chemical analysis. Results from these analyses are presented in Appendix V.1. The wastes were not classified as hazardous according to 40 CFR Subpart C 261.20-261.24 (GZA-Donohue, 1989). A partial cleanup of wastes within the bay is expected to begin in 1990 (Harrington, 1989).

City of Marinette Coal Tar Contamination

In June 1989, during excavation at the City of Marinette WWTP, soils contaminated with coal tar residue were discovered. The site was once the location of a coal gasification plant is the likely source of the coal tar (Nogalski, 1989). Since the site is located along the river's edge, groundwater that is contaminated by passing through the soils will eventually reach the river. Construction site dewatering wells are being routed to discharge to the WWTP. The dewatering well discharge is monitored and sampled on a weekly basis (Mann, 1989). Contaminated soils are stored in a contained area at the plant site for removal to Michigan Environs landfill. The site assessment process is currently underway. Results from the analyses of contaminated soil samples are presented in Appendix V.2.

Remedial Action Plan

As far back as 1912, the Governments of Canada and the United States asked the International Joint Commission (IJC) 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 led to the elimination of waterborne disease epidemics in the Great Lakes Basin.

Over the years, 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 perspective to protect water quality and health of the Great Lakes System, has been used to include and address the complex interrelationships among water, land, air and all living things, including humans.

Since 1973, in its annual assessments of Great Lakes water quality, the IJC's Water Quality Board has identified Problem Areas. These 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 impaired beneficial uses.

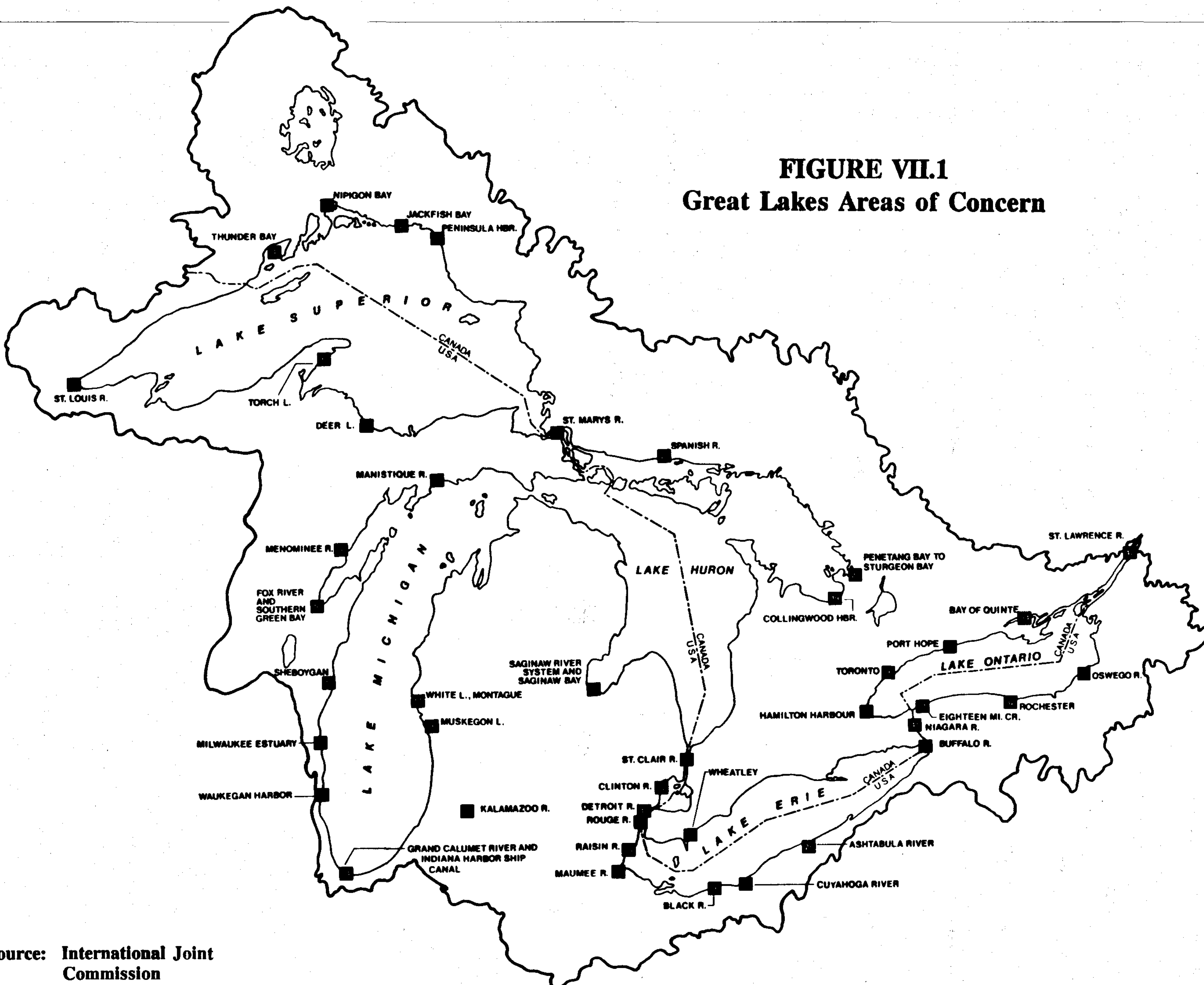
The number of AOC's has changed with time. The changes are a result of: improvements in water quality, the emergence of new problems, or the reinterpretation of the significance of previously reported problems based on more comprehensive data. The IJC's 1985 Water Quality Board Report contains a more complete discussion of the changes in numbers of reported AOCs. 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 with progress in implementing pollution controls. Despite considerable progress, particularly in abating bacterial pollution and eutrophication, there are still 42 identified AOCs in the Great Lakes Basin (Figure VII.1) with serious water quality problems. Others may be identified in the future based on new surveillance information. Although some AOCs still exhibit bacterial pollution and eutrophication problems (including dissolved oxygen depletion), 41 of the 42 AOCs have problems associated with contaminated sediments. It should also be noted that there is growing concern for loss of fish and wildlife habitat and biological diversity in the AOCs.

In 1985, the eight Great Lakes states and the Province of Ontario committed themselves to developing Remedial Action Plans to restore beneficial uses in each AOC within their political boundaries. Wisconsin committed to developing RAPs for the Lower Fox River and Green Bay, Sheboygan River and Harbor, St. Louis River, Milwaukee Estuary, and the Lower Menominee River. Michigan is also responsible for the Lower Menominee River as well as Torch Lake, Deer Lake, Manistique River, Kalamazoo River, Muskegon Lake, White Lake, Saginaw River and Bay, Clinton River, Rouge River, River Raisin, Detroit River, St. Marys River, and St. Clair River RAPs.

Remedial Action Plans identify specific measures necessary to control existing sources of pollution, abate environmental contamination already present, and restore impaired beneficial uses. The plans also identify responsible parties and a timetable for implementation.

The development of RAPs represents a challenging departure from most historical pollution control efforts. Previously, separate programs for regulation of municipal and industrial discharges, 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 of addressing problems through an ecosystem approach calls upon integration from a wide array of agency programs, the involvement of local citizens within the affected communities, and cooperation from a wide range of government entities. All programs, agencies, and communities affecting an AOC must work together on common goals and objectives in the RAP to assure its successful implementation (IJC, 1987).

FIGURE VII.1
Great Lakes Areas of Concern



Source: International Joint Commission

VIII. GOALS AND OBJECTIVES

Introduction

The goals and objectives for the Lower Menominee River Remedial Action Plan (RAP) were established with consideration for the goals and objectives of the Clean Water Act and Great Lakes Water Quality Agreement, state and federal water quality standards, and concerns of the RAP Citizen's Advisory Committee. Water quality objectives are included in chapter three; sediment quality guidelines are included in chapter four.

Listed below are: 1) the desired future state, developed by the Citizen's Advisory Committee, and 2) the long term goals and objectives for restoring beneficial uses in the Lower Menominee River area of concern (AOC), developed jointly by the Citizen's Advisory Committee and the Technical Advisory Committee.

The Citizen's Advisory Committee (CAC) developed a desired future state for the area of concern. The desired future state is a long range vision of what the area should be like in the future. It addresses the economic and environmental conditions and was used, in part, to develop the RAP goals and objectives.

The desired future state includes the co-existence of a healthy economy and environment; a diverse and environmentally safe transportation network and a sustainable recreational base. It also describes a balanced, productive fishery, water and sediment quality that is not detrimental to either human health or fish and wildlife, and a planned and integrated use of the waterfront.

The RAP goals and objectives were developed by the Technical Advisory Committee, factoring into consideration the desired future state developed by the CAC, and responsibilities for water quality and ecosystem protection included in international, federal and state agreements, guidelines and standards. Goals I, II, and IV are being addressed by the Technical Advisory Committee (TAC). Goal III is being addressed by the Citizen's Advisory Committee. Objectives 1 - 7 apply to the goals being addressed by the TAC; Objectives 8 - 13 apply to the goals being addressed by the CAC.

Lower Menominee River Desired Future State

The desired future state, as identified by the CAC, for the Menominee River and Bay area should include the following elements:

1. A healthy economy consistent with the desired future state and the long term maintenance of the area's natural resources,

2. A diverse transportation network, including a navigable river and harbor, and a land based system, which minimizes adverse environmental impacts,

3. A sustainable recreational base, for the enhancement of the area's tourism industry including: swimmable waters; adequate public access; enhancement of aesthetics and the preservation of scenic beauty of the area; enhancement of water-based recreation facilities; and preservation of diverse wildlife populations,

4. Water from the river and bay that is drinkable after standard treatment,

5. A balanced and productive fishery, fully edible by all persons,

6. Water and sediment quality that is not detrimental to human health and wildlife,

7. Planned use of the waterfront for industrial, commercial, residential, recreational and wildlife purposes consistent with the desired future state, and

8. No adverse impacts in the area of concern from other areas of the watershed, bay or region.

Ecosystem Goals And Objectives For Restoration Of Impaired Uses

Goals

1. Protect the aquatic ecosystem of the Menominee River and harbor from the impacts of toxic and convenient pollutants,

2. Maintain a balanced aquatic and terrestrial community to ensure long term health of the ecosystem,

3. Maintain and enhance recreational and commercial uses of the Menominee River and harbor consistent with long term maintenance of the natural resource base and a healthy economy,

4. Limit nutrient enrichment to protect the Menominee River and Lake Michigan from the effects of eutrophication, and

5. Include and encourage public participation in the development and implementation of the Lower Menominee River Remedial Action Plan.

Objectives

1. Evaluate exposure risks from in-place pollutants to fish, aquatic life, wildlife, and human health to determine the need for remedial action,

2. Eliminate all toxic effects to fish and aquatic life from point source discharges,

3. Identify and eliminate all toxic effects to fish and aquatic life from nonpoint source discharges,

4. Maintain the water quality in the river and the bay so that it is drinkable after standard treatment,

5. Maintain a balanced productive fishery that is edible by all persons,

6. Improve water and sediment data bases to better evaluate environmental quality in the area of concern,

7. Restore, protect and enhance environmental corridors (Figure III.4),

8. Limit nutrient inputs/additions to the Menominee River and harbor area,

9. Promote public attitudes and perceptions of the waterfront as a valuable aesthetic resource,

10. Develop, improve and maintain shoreline access and recreational facilities for public use and enjoyment of the river and bay,

11. Protect wildlife and fishery habitat in near shore and wetland areas,

12. Reduce conflicts among user groups,

13. Encourage commercial and industrial developments that build upon and enhance the value of the waterfront,

14. Improve the scenic beauty along the river and bay shoreline,

15. Clean up sediment contamination to protect human health, fish, aquatic life and wildlife,

16. Eliminate all raw sewage discharges and/or overflows and other known bacterial problems to the river and Green Bay to meet water quality standards for total and partial body contact (including recreational uses) throughout the AOC, and

17. Pursue all opportunities to reduce or eliminate the discharge of toxic substances to the AOC via the direct or indirect discharges to surface waters, runoff from land surfaces, and air emissions.

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GLOSSARY FOR TERMS AND ABBREVIATIONS FOUND IN THIS PLAN

Abbreviations

AOC: Area of Concern

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

BACT: Best Available Control Technology.

BCT: Best Conventional Technology.

BMP: Best Management Practice.

BOD: Biochemical Oxygen Demand.

BPT: Best Practicable Technology.

CAC: Citizens Advisory Committee.

CDF: Confined Disposal Facility.

COE: United States Army Corps of Engineers.

CFS: Cubic Feet Per Second, a measure of flow in streams.

CSO: Combined Sewer Overflow.

DO: Dissolved Oxygen.

EPA: U.S. Environmental Protection Agency.

GBMBS: Green Bay Mass Balance Study.

GLFC: Great Lakes Fishery Commission.

IJC: International Joint Commission.

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

MCL: Maximum Contaminant level.

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

MGD: Million of Gallons Per Day; a measurement of water flow.
1 MGD = 1.55 cfs

MDNR: Michigan Department of Natural Resources.

MDPH: Michigan Department of Public Health.

mg/L: Milligrams Per Liter; a unit of measure of concentration generally equivalent to parts per million (ppm).

ng/L: Nanograms Per Liter; a unit of measure for concentration generally equivalent to parts per trillion (ppt).

NOAA: National Oceanic and Atmospheric Administration.

NPDES: National Pollution Discharge Elimination System, which requires permits for wastewater discharges.

NPS: Nonpoint Source Pollution.

PAHs: Polycyclic Aromatic Hydrocarbons.

PCBs: Polychlorinated Biphenyls.

POTW: Publicly owned treatment works.

PPB: Parts Per Billion; a unit of measure for concentration.

PPM: Parts Per Million; a unit of measure for concentration.

PPT: Parts Per Trillion; a unit of measure for concentration.

RAP: Remedial Action Plan.

RI/FS: Remedial Investigation/Feasibility Study.

RPCs: Regional Planning Commission.

RCRA: Resource Conservation and Recovery Act of 1976.

SCS: Soil Conservation Service of the United States Department of Agriculture.

SS: Suspended Solids.

TAC: Technical Advisory Committee.

TSCA: Toxic Substances Control Act, a federal law.

μg/L: Micrograms Per Liter; a unit of measure for concentration generally equivalent to parts per billion (ppb).

μmho Micromho; the standard unit of measure for electrical conductance.

USDA: United States Department of Agriculture.

USEPA: United States Environmental Protection Agency.

USFWS: United States Fish and Wildlife Service, U.S. Department of Interior.

USGS: United States Geological Survey.

VOC: Volatile Organic Compound.

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.

WDOT: Wisconsin Department of Transportation.

WGNHS: Wisconsin Geologic and Natural History Survey.

WLA: Wasteload Allocation.

WPDES: Wisconsin Pollution Discharge Elimination System.

WSLH: Wisconsin State Laboratory of Hygiene.

WWTP: Wastewater Treatment Plant.

Terms

ACTION LEVEL:

Concentration of a contaminant in fish or wildlife (poultry) which would trigger issuance of a Fish Consumption Advisory. Essentially synonymous with trigger level and health standard.

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 demand and/or 50% of the total nitrogen. Advanced wastewater treatment is also known as " tertiary treatment."

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. Nutrient-enriched water increases algae growth.

AMMONIA:

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

ANAEROBIC:

Without oxygen.

ANTIDEGRADATION:

A policy which states that water quality will not be lowered below background levels unless justified by economic and social development considerations.

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.

ARSENIC:

A naturally occurring, elemental metalloid which may occur in several valence states and which may form both organic and inorganic compounds. The toxicity of arsenic varies widely with valence state, form, and receptor organisms. Traditional uses of arsenic include insecticides, herbicides, wood preservatives, alloys, and pharmaceuticals.

ASSIMILATIVE CAPACITY:

The ability of a water body to purify itself of pollutants without detriment to fish and aquatic life or other beneficial uses of the waterbody.

ATTAINMENT AREA:

An area which meets air quality standards.

BACTERIA:

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

BALANCED COMMUNITY:

A community that supports an abundant and usually diverse population of forage fish, game fish, and other aquatic biota (zooplankton, phytoplankton, macroinvertebrates).

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 run off from land surfaces.

BIOACCUMULATION:

The uptake and retention of substances by an organism from its surrounding medium and from its food. 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:

A test for pollutant toxicity. Tanks of fish or other organisms are exposed to varying doses of wastewater effluent; lethal doses of pollutants in the effluent are thus determined.

BIOAVAILABILITY:

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 can affect availability.

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. Carbonaceous BOD is the result of the same test conducted in a shorter time period. The greater the degree of pollution by organic matter the higher the BOD.

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 a river or bay. Other environmental laws may limit filling to some degree.

CARCINOGENIC:

The ability of a chemical to cause cancer.

CATEGORICAL LIMITS:
The basic level of treatment required for all point source discharges. For municipal wastewater treatment plants this is secondary treatment (30 mg/1 effluent limits for SS and BOD). For industry the level is dependent on the type of industry and the level of production. Effluent limits more stringent than categorical may be required if necessary to meet water quality standards.

CHLORINATION:
The application of chlorine to wastewater to kill bacteria and other organisms.

CHLORORGANIC COMPOUNDS (CHLORORGANICS):
A class of chemicals which contain chlorine, carbon and hydrogen. Generally refers to pesticides and herbicides that can be toxic. Examples include PCB's 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:
Injurious or debilitating effects of long-term exposure of nonlethal toxic chemicals to organisms. An example of the effect of chronic toxicity could be reduced reproductive success.

CLEAN WATER ACT:
"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 sanitary sewage to the treatment plant; during heavy rainfall, the sewer becomes swollen with stormwater and sewage. If the treatment plant cannot process the added flow, untreated sewage is discharged to surface waters via a treatment plant bypass or a combined sewer overflow.

COMPLIANCE MAINTENANCE:
Part of the areawide Water Quality Management Plans that identifies actions municipal treatment facilities should take to ensure they continue to meet existing and future effluent limits.

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

CONGENERS:
Chemical compounds that have the same molecular composition, but have different molecular structures and formula. For example, the congeners of PCB have chlorine located at different spots on the molecule. These differences can cause differences in the properties and toxicity of the congeners.

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

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

COOLING WATER:

Means water which has been used primarily for cooling but which may be contaminated with process waste of airborne material. Examples are the discharge from barometric condensers or the blowdown from cooling towers (NR 205, Wis. Adm. Code).

CRITERIA:

See water quality criteria.

CRITERIA AIR POLLUTANTS:

These consist of particulates, carbon monoxide, sulfur dioxide, nitrogen dioxide, volatile organic compounds, ozone, and lead. Ambient air quality standards are the concentrations of criteria air pollutants allowed in outdoor air based on levels established by the U.S. EPA.

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.

DISINFECTION:

A chemical or physical process that kills organisms which cause disease. Chlorine is often used to disinfect wastewater.

DISSOLVED OXYGEN (DO):

Oxygen dissolved in water. Low levels of dissolved oxygen cause bad smelling water and threaten fish survival. Low levels of dissolved oxygen are often due to inadequate wastewater treatment. The Wisconsin and Michigan Departments of Natural Resources considers 5 ppm DO necessary to support a balanced community of fish and aquatic life.

DREDGING:

Removal of sediment from the bottom of water bodies.

ECOSYSTEM:

The interacting system of a biological community and its nonliving surroundings.

EFFLUENT:

Solid, liquid or gas wastes (by products) which are disposed of on land, in water or in air.

EFFLUENT LIMITS:

These establish the maximum amount of a pollutant that can be discharged to a receiving stream. Limits depend on the pollutants involved, the water quality standards that apply for the receiving waters, and the characteristics of the receiving water.

ENVIRONMENTAL CORRIDORS:

Environmentally sensitive areas within sewer service areas which are not eligible for sewered development. Environmental corridors may include wetlands, shorelands, floodway and floodplains, groundwater recharge areas, and other sensitive areas.

ENVIRONMENTAL PROTECTION AGENCY (USEPA):

The 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.

EUTROPHIC:

Refers to a nutrient-rich lake or stream. Large amounts of algae and weeds characterize a eutrophic water body. (see also "Oligotrophic" and "Mesotrophic").

EUTROPHICATION:

The process of nutrient enrichment of a waterbody. 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 coliforms is particularly important when water is used for drinking and swimming.

FURAN (2,3,7,8-tetra-chloro-dibenzofurans):

A chlorinated organic compound which is highly toxic.

GROUNDWATER STANDARDS:

Numerical standards for substances of health or welfare concern which consist of an enforcement standard and a preventive action limit (PAL) - the PAL being a percentage of the enforcement standard which indicates a problem may be developing.

HABITAT:

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

HEALTH STANDARD:

See Action Level.

HEAVY METALS:

A group of metals which may be present in municipal and industrial wastes that pose long-term environmental hazards if not properly disposed. Heavy metals can contaminate ground and surface waters, fish and food. The metals of most concern are: arsenic, cadmium, chromium, copper, lead, mercury, selenium and zinc.

HERBICIDE:

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

HYPEREUTROPHIC:

Refers to a lake with excessive fertility. Extreme algae blooms and low dissolved oxygen are characteristics.

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, particularly water quality issues.

LC_{50}:

Concentration of a toxic substance in water which is lethal to 50% of the test population exposed to the toxic substance.

LD_{50}:

The dose (amount actually ingested by an organism) of a toxic substance which is lethal to 50% of the test population.

LEACHATE:

The contaminated liquid which seeps through a landfill or other material and contains water, dissolved and decomposing solids. Leachate may enter the groundwater and contaminate drinking water supplies.

LOAD:

The total amount of materials or pollutants reaching a given water body.

MACROPHYTE:

A rooted aquatic plant.

MARGINAL USE:

A use that cannot support a fishery or a balanced community of aquatic organisms because of natural conditions (physical, chemical, biological or human activities.

MASS BALANCE:

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

MAXIMUM CONTAMINANT LEVEL:

MCL means the maximum permissible level of a contaminant in water which is deliverable to the consumer service outlet of the ultimate user of a public water system, except in the case of turbidity where the maximum permissible level is measured at the point of entry to the distribution system (NR 109.04, Wis. Adm. Code).

MESOTROPHIC:

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

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. For streams, the mixing zone is one-third of the lowest flow that occurs once every 10 years for a seven day period.

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES):

A federal permit system to monitor and control the point source dischargers of wastewater. Dischargers are required to have a discharge permit and meet the conditions it specifies.

NONCONTACT COOLING WATER:

Means water used for cooling which does not come into contact with any raw material, intermediate or finished product, or waste and has been used in heat exchangers, air or refrigeration compressors, or other cooling means where contamination with process waste is not normally expected (NR 205, Wis. Adm. Code).

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.

OLIGOTROPHIC:
Refers to an unproductive and nutrient-poor lake. Such lakes typically have very clear water. (See also "Eutrophic" and "Mesotrophic.")

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

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 being most alkaline (basic).

PHENOLS:
Organic compounds that are byproducts of petroleum refining, textile, dye, and resin manufacture. High 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 in lakes and streams can lead to overfertile (eutrophic) conditions and algae blooms.

PLANKTON:
Tiny plants (phytoplankton) and animals (zooplankton) that live in water.

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

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 persistence in the environment, they have been detected in air, soil and water, and recent surveys have found PCBs in every section for the country, even those remote from PCB manufacturers.

POLYCYCLIC AROMATIC HYDROCARBONS:
PAHs consist of hydrogen and carbon arranged in the form of two or more fused rings. PAHs originate from both natural and anthropogenic sources. PAHs enter the environment through incomplete combustion of carbonaceous materials or direct release of petroleum or its products. Examples of compounds in the PAH group include benzo(a) anthracene, benzo(b) fluoranthene, benzo(a) pyrene, chrysene, phenanthrene, and pyrene.

PRETREATMENT:
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:
Toxic chemicals identified by the federal government because of their potential impact on the environment and/or human health. Major discharges are required to monitor for all or some of these chemicals when their WPDES permits are reissued (referred to as a 2C screening).

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 to the Clean Water Act were made in 1977, 1981 and 1989.

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

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

REMEDIAL INVESTIGATION/FEASIBILITY STUDY (RI/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.

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 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. Particles are deposited in areas where the water flow is slowed (i.e. harbors).

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.

SEWER SERVICE AREA:
An area presently served and anticipated to be served by a sewage collection system.

SILVICULTURE:
The care and cultivation of forest trees.

SLUDGE:
A byproduct of wastewater treatment; waste solids suspended in water.

SOLID WASTE:
Unwanted or discharged material with insufficient liquid to be free flowing.

STORM SEWERS:
A system of sewers that collect and transport rain and snow runoff. In areas that have separated sewers, such that stormwater is not mixed with sanitary sewage.

SUPERFUND:
A federal program which provides for cleanup of major hazardous waste landfills and land disposal areas.

SUSPENDED SOLIDS (SS):
Small particles of solid pollutants suspended in water.

SYNERGISM:
The characteristic property of a mixture of toxic substances that exhibits a greater-that-additive cumulative toxic effect.

TAC:
Technical advisory committee which assisted in the development of the Remedial Action Plan.

TERTIARY TREATMENT:
See advanced wastewater treatment.

TOTAL AND PARTIAL BODY CONTACT:
Means an activity where the human body may come into direct contact with water to the point of either total or partial submergence including swimming, water skiing, skin diving, wading, fishing, etc.

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

TOXICITY:
The degree of danger posed by a toxic substance to animal or plant life. Also see acute toxicity, chronic toxicity and additivity.

TREATMENT PLANT:
See wastewater treatment plant.

TRIGGER LEVEL:
See Action Level.

TROPHIC STATUS:
The level of growth or productivity of a lake as measured by phosphorus content, algae abundance, and depth of light penetration. The major categories of trophic status are oligotrophic, mesotrophic, eutrophic, and hypereutrophic.

TURBIDITY:
Turbidity is the lack of water clarity usually closely related to the amount of suspended solids in water.

UPSET:

Means an exceptional incident in which there is unintentional and temporary noncompliance with permit effluent limitations because of factors beyond the reasonable control of the permittee. An upset does not include noncompliance to the extent caused by operational error, improperly designed treatment facilities, inadequate treatment facilities, lack of preventive maintenance or careless or improper operation (NR 205, Wis. Adm. Code).

VARIANCE:

Government permission for a delay or exception in the application of a given law, ordinance or regulation. Also, see water quality standard variance.

WASTELOAD ALLOCATION:

Division of the amount of waste a stream can assimilate among the various dischargers to the stream. This results in a limit on the amount (in pounds) of a chemical or biological constituent discharged from a wastewater treatment plant to a water body. A water quality model may be used to calculate allowable loadings, which may very seasonally. (See assimilative capacity)

WASTEWATER:

Water that has become contaminated as a byproduct of some human activity. Wastewater includes sewage, washwater and the waterborne wastes of industrial processes.

WASTEWATER TREATMENT PLANT (WWTP):

A facility for purifying wastewater. Modern wastewater treatment plants may be capable of removing 95% of organic pollutants.

WATER RESIDENCE TIME:

The amount of time required to completely replace a waterbody's current volume of water with an equal volume of "new" water.

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 limits are met.

WATER QUALITY CRITERIA:

Measures 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 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.

WATER QUALITY STANDARDS:

The legal basis and determination of the use or potential uses of a water body and the water quality criteria, physical, chemical, or biological characteristics of a water body, that must be maintained to keep it suitable for the specified use.

WATER TABLE:

Surface below which all soil and rock openings are filled with water.

WATERSHED:

The land area that drains into a lake or river.

WETLANDS:

Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support specific types 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 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. This program is delegated to the state from the federal NPDES program.

ZOOPLANKTON:

Minute, free-floating or weakly swimming aquatic animals. They form an important food supply for larger aquatic animals.

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EARTH YEAR

WISCONSIN

1970 April 22 1990