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SAGINAW RIVER/BAY

REMEDIAL ACTION PLAN

DRAFT 1995 BIENNIAL REPORT

VOLUME 1

DECEMBER 1994

PREFACE

This draft 1995 biennial report of the Saginaw River/Bay Remedial Action Plan (RAP) was jointly prepared by numerous governmental agencies (local, state and federal), local governments, public organizations, and business representatives, through the committee structure of the Saginaw Bay National Watershed Initiative. The purpose of the document is to track progress under the RAP program and to identify actions needed to take the next steps in the restoration, protection and enhancement of environmental conditions in Saginaw Bay and its watershed.

Since completion of the original Saginaw River/Bay RAP document in September 1988, over 2/3 of the 101 actions identified have been at least partially implemented, and all 37 priority actions have been at least partially implemented. This second iteration of the Saginaw River/Bay RAP document describes many of these actions; the current environmental status of, and goals for, Saginaw Bay and the watershed; the growth of the Saginaw RAP process; and the additional actions needed to move forward with the RAP effort. The draft biennial report focuses on land use, nutrients, conventional water quality parameters, soil erosion/sedimentation, and upland habitat. It is envisioned that the 1997 biennial report will focus on toxic substances, contaminated sediments, and aquatic habitat.

The Saginaw River/Bay RAP is a multimedia, ecosystem-based, locally-driven process and participation from any interested party is welcome at any time. Comments on the document and the Saginaw River/Bay RAP process, or questions on how to become involved, may be directed to:

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VISION FOR SAGINAW BAY AND ITS WATERSHED

Saginaw Bay and its watershed will provide a safe, enjoyable, balanced environment with clean water for all forms of life. The bay will support the wide range of multiple uses and benefits typical of a Great Lakes embayment. Basin rivers, streams, lakes, drains and other waters within the watershed will also support multiple uses, while at the same time protecting the water quality of Saginaw Bay. Both the bay and the watershed will provide for biodiversity, naturally self-sustaining indigenous populations, good public health, recreational opportunities, and economic viability.

Participatory management efforts will foster optimization of uses and benefits without exceeding the carrying capacity of the ecosystem, while maintaining the flexibility to address the often conflicting natures of those uses. Management will include emphasis on the ecosystem approach to watershed management and creating an informed, knowledgeable public through environmental education.

The watershed will contain a citizenry committed to regional cooperation and a personal philosophy of stewardship. It will be a place where citizens accept the personal responsibility and challenge of pollution prevention in their own lives and lifestyles, and are committed to moving from a consumer society to a conserver society. Furthermore, there will be greater cooperation, leadership and responsibility among citizens of the basin for defining long-term policies and procedures that will protect the quality and supply of water in Saginaw Bay and its watershed for future generations.

To achieve this vision, Saginaw Bay and its watershed shall be protected against further degradation of water quality or functional loss of habitat. Furthermore, existing environmental conditions will be improved to (1) restore all currently impaired beneficial uses (as defined by the Great Lakes Water Quality Agreement) in the Saginaw River and Saginaw Bay; and (2) enhance other water-related uses in the bay and the watershed as appropriate. These protection, restoration and enhancement activities will be conducted through the sound management of human, economic and ecological resources.

EXECUTIVE SUMMARY

RAP PROCESS

The Saginaw River and Saginaw Bay have been listed as one of 43 Great Lakes Areas of Concern (AOCs) because degraded water quality conditions impair certain beneficial uses as defined by the Great Lakes Water Quality Agreement (GLWQA) of 1978 (as amended). The State of Michigan has implemented a Saginaw River/Bay Remedial Action Plan (RAP) process to address these water quality concerns. Though the Michigan Department of Natural Resources has been designated as the lead agency responsible for the RAP process, this draft 1995 biennial report of the Saginaw River/Bay RAP was jointly prepared by numerous governmental agencies (local, state and federal), local governments, public organizations, and business representatives, through the committee structure of the Saginaw Bay National Watershed Initiative.

The primary purpose of the Saginaw River/Bay Remedial Action Plan process is to: (1) define and describe the environmental problems in the Saginaw Bay watershed (focusing on surface water quality and habitat related issues), including a definition of the beneficial uses that are impaired, the degree of impairment, and the geographical extent of impairment; (2) define the causes of impairment, including a description of all known sources of pollutants involved and an evaluation of other possible sources; (3) define water use goals for Saginaw Bay and its watershed; and (4) identify and implement actions needed to restore, protect and enhance environmental quality to support these goals.

This approach is substantially broader than that defined in the GLWQA, in that it goes beyond the designated boundaries of the AOC itself (the Saginaw River and Saginaw Bay) to include the entire watershed, and includes a broader array of issues. Furthermore, environmental problems anywhere in the watershed can be addressed for their own sake, independent of whether or not the local problem contributes to the degradation of the Saginaw River or Saginaw Bay. One of the primary reasons that the Saginaw River/Bay RAP has been able to expand to include the whole watershed is the additional financial and staff resources provided to the effort through the Saginaw Bay National Watershed Initiative.

The Program Advisory Committee was the principal committee used to provide broad-based input and direction to the Saginaw Bay National Watershed Initiative and to facilitate the development of cooperative long-term strategies for the restoration and protection of the Saginaw Bay watershed. To assist with these tasks, the Program Advisory Committee established four Technical Advisory Committees (TACs). Each TAC addressed one of four specific topic areas: Water Quality, Soil Erosion and Sedimentation, Contaminated Sediments, and Habitat. The work products of the TACs comprise the bulk of this RAP document.

The Saginaw River/Bay Remedial Action Plan process began in July 1986 and the initial RAP document was completed in September 1988. The RAP identified 101 actions that were needed to further address the environmental problems in the Saginaw River/Bay AOC. By December 1991, only three years later, over two-thirds of the 101 actions had been at least partially implemented. Of the 37 priority actions identified, all had been at least partially implemented. This is remarkable implementation success given this era of decreased financial resources at the federal, state and local levels. The widespread support can be partially attributed to the relatively high priority given to this AOC at the state and federal level, as well as the involvement of local citizens, businesses and communities.

This second iteration of the Saginaw River/Bay RAP document describes many of these actions; the current environmental status of, and goals for, Saginaw Bay and the watershed; the growth of the Saginaw RAP process; and the additional actions needed to move forward with the RAP effort. The draft biennial report focuses on land use, nutrients, conventional water quality parameters, soil erosion/sedimentation, and upland habitat. It is envisioned that the 1997 biennial report will focus on toxic substances, contaminated sediments, and aquatic habitat.

This document serves as the technical, planning and project implementation focus for addressing environmental quality and habitat issues in the Saginaw Bay watershed. It is intended that this Remedial Action Plan be used by all agencies (federal, state, local), organizations and individuals concerned with, affected by, or impacting, water quality in Saginaw Bay or its watershed. Extensive efforts have been made to include all interested and/or affected parties in the development, review and implementation of this plan so that it fully addresses the issues from a variety of perspectives and is broadly supported. This RAP is much more comprehensive than previous planning documents in that it examines environmental quality from an ecosystem perspective on a watershed basis rather than focusing on only a single pollutant source or issue, or a single large drainage basin.

The key to successfully implementing an ecosystem approach lies in the active participation, coordination and cooperation of the public and all program areas at the state, federal and local levels that have responsibilities relevant to the RAP. Participants need to be involved in all aspects and phases of the process including providing relevant data and information, contributing to decision making and policy related discussions, and facilitating the implementation of actions.

Participation in the Saginaw River/Bay RAP process is encouraged and welcome from **anyone** affected by, or concerned with, any topic addressed under the program. In addition to the obvious inclusion of individuals, communities, businesses, and organizations at the local or basin-wide level, this also includes state, regional (Great Lakes), national or international agencies and organizations concerned with the broader implications of RAP activities or outcomes. Consequently, participation within the scope of the RAP encompasses a broad spectrum of individuals and activities.

PROBLEM DESCRIPTION

Saginaw Bay is a southwestern extension of Lake Huron located in the east central portion of Michigan's lower peninsula. The bay has a large surface area of 1,143 square miles, is 52 miles long, and varies in width between 13 and 26 miles. The Saginaw Bay drainage basin is home to about 1.4 million people in 22 counties and contains 8,709 square miles, which is approximately 15% of Michigan's total land area.

Land use is very diverse in the Saginaw Bay basin spanning a spectrum from relatively undisturbed natural areas, to intensive agriculture lands and heavily industrialized urban settings. The majority of industrial activity takes place in one of the four major urban centers in the Saginaw River basin: Bay City, Saginaw, Flint or Midland. Agricultural production, which comprises approximately 50% of the land use, is particularly intense in the eastern and southern portions of the watershed.

Saginaw Bay is also a major recreational area. It has a world-class walleye sport fishery and, since it is on a major migratory bird flyway, it is a popular bird watching destination. The most outstanding habitat feature of the watershed is the expansive coastal wetlands of the bay, which is the largest remaining freshwater coastal wetland system in the nation. Consequently, the bay is particularly valuable to Lake Huron fish and wildlife communities as a major breeding and nursery area. In addition to supporting numerous plant and animal species that are endangered or threatened, the Saginaw Bay watershed includes several natural communities that are globally scarce or unique.

The major water quality problems are cultural eutrophication, toxic material contamination, and sedimentation. Pathogens are also occasionally a problem. The degraded environmental conditions have impacted biota, resulted in public health fish consumption and body contact advisories, affected taste in drinking water supplies and fish, created nuisance aesthetic conditions, and restricted navigational channel dredging activity. Additionally, loss of fish and wildlife habitat is a concern.

There are a variety of sources that continue to contribute contaminants to the Saginaw River and Saginaw Bay including industrial and municipal discharges, combined sewer overflows, contaminated sediments in the river and bay bottom, urban and agricultural nonpoint runoff, waste disposal sites, and the atmosphere.

Many of the ecosystem problems in the Saginaw Bay watershed are the result of land use practices. Recent comparisons of presettlement and current cover types for eight Michigan counties located entirely within the Saginaw Bay watershed revealed the extent of impacts land uses have had on the natural landscape. In most counties of the watershed, upland forests located on rich soils were cleared to the extent that, in some counties, as little as 2% of the acreage once supporting upland forests remain forested. In addition, major forest type conversions occurred, greatly modifying the habitat for many plants and animals. Of the eight counties where direct comparisons were made, between 44% (Genesee) and 77% (Gladwin) of the wetland acreage present in the 1830s remain today. A clear pattern of past exploitation of conifer-dominated swamps and the drainage of wet prairies has nearly eliminated these types from several counties. It is estimated that only half the historical acreage of Saginaw Bay coastal marshes remains today.

Despite the widespread land use changes that have occurred, and continue to occur, in the Saginaw Bay watershed, there are numerous gaps and barriers within the institutional framework for land use control and environmental protection that inhibit ecosystem restoration, enhancement and protection. In order for the local land use decision forum to become an effective tool for environmental quality management, the linkages between national, state and local institutions need to be better understood and mechanisms for merging their similar policy goals developed.

Effective water quality management is a complex interplay of law, policy, management, and investment of financial resources. Historically, water quality management has not recognized the importance of the cumulative impacts of individual land use decisions within the management framework. The most effective water quality management program will incorporate environmentally sensitive land use planning and regulatory tools into its management scheme. Failure to add the local decision component to the broader water quality management framework will diminish its effectiveness and leave many water quality goals unmet.

SMALL WATERSHED PRIORITIZATION PROCESS

One objective of the Saginaw Bay National Watershed Initiative and Saginaw River/Bay RAP processes is to ensure that the programs and projects undertaken by participants are directed toward actions that will have the greatest benefit within the watershed. In an effort to better define problem areas and sources of impacts, a subwatershed prioritization process for the Saginaw Bay watershed was begun in February 1993.

Simply put, the purpose of the Saginaw Bay watershed prioritization process is to evaluate the subwatersheds in the basin based on the level of impact on the resource and the value of the resource. The information is used to improve coordination of monitoring, planning and implementation activities among local, state, and federal agencies, as well as local businesses and public organizations, in their efforts to describe, protect, restore, and enhance the natural resources of the Saginaw Bay watershed.

The Saginaw Bay watershed prioritization process currently addresses all 69 of the hydrologic management units established in the watershed for this process, and includes four phases.

Phase 1 is the collection/summarization of data on the following topics: ecological indicators (effects), source delineation (causes), habitat evaluation, and public interest.

Phase 2 involves the integration of the source delineation and ecological indicators sections to derive an impact assessment of the subwatershed; and the integration of public interest and habitat evaluation sections to derive a resource value.

Phase 3 evaluates the resource value and the impact assessment with watershed goals to derive a technical rating for the subwatershed.

Phase 4 provides information on the probability that the outlined technical needs of the subwatershed, derived in Phase 3, can or can not be effectively addressed at a given time. This subwatershed ranking is derived through the filtering of Phase 3 technical rating through a likelihood of success section.

Draft initial prioritizations for certain portions of Phase 1 have been completed.

WATER QUALITY

Sedimentation is a major cause of degraded environmental conditions in the Saginaw Bay watershed, and wind and water erosion of agricultural land is the major source. High water erosion areas (>1.5 tons/acre) are located in portions of Huron, Tuscola, Lapeer, Gratiot, Isabella, Shiawassee and Montcalm counties. Thirty-one of the 69 management units were identified as being highly susceptible to wind erosion and 22 management units were listed as medium. Management units falling in these two categories were predominantly located in the coastal basins, the headwaters of the Tittabawassee River, and sporadically throughout Gladwin, Midland and southern Tuscola counties.

Eutrophication is also presently a water quality problem in Saginaw Bay, and in watershed streams as well. Eutrophic waters are high in organic or nutrient matter that promote biological growth and reduce dissolved oxygen concentrations. Accelerated eutrophication can lead to turbidity, taste and odor problems, growth of nuisance blue-green algae, filter clogging in water intakes, aesthetic impairments, and fish kills. Nutrients often accumulate in the inner bay water column due to current patterns that inhibit the mixing of inner and outer bay water.

Water quality conditions are most degraded, with respect to total suspended solids and nutrients, in the east coastal basin tributaries, especially the drains in the southern portion of the basin among which Northwest Drain had the worst conditions. The Flint River had the most degraded water quality among Saginaw River tributaries. When compared among all rivers, the Flint ranked as a high priority river for total phosphorus, BOD and chlorophyll a. It also had the highest concentrations among Saginaw River tributaries for all parameters except total suspended solids and nitrite-nitrate, which were both higher in the Cass River. The best water quality was found in the Tittabawassee River basin and the northern rivers of the west coastal basin.

Fifty-nine percent of the watersheds biologically assessed as part of the small watershed prioritization process were represented by moderately to severely impaired biological communities. Moderately to severely impaired physical habitat conditions may be responsible for up to 90% of the biological impairment demonstrated. Much of the physical habitat impairment was attributed to improper land use practices. Generally, the Cass and Tittabawassee river systems maintained higher quality biological communities than other major Saginaw River tributaries and the west and east coastal basin streams.

Total phosphorus loads to Saginaw Bay averaged 1700 metric tons/year from 1973 through 1975. Despite the fact that phosphorus loads to surface water in the Saginaw Bay watershed from major municipal wastewater treatment plants decreased significantly, falling from 800 mt/yr in 1974 to 108 mt/yr in 1992, the MDNR estimated total phosphorus loads at 2158 metric tons in 1991, and 946 metric tons in 1992. This indicates that not only are phosphorus loads to Saginaw Bay still high, but that there are substantial year-to-year fluctuations. Preliminary data from recent calculations indicate that on a per acre basis, total phosphorus loads in 1992 were greatest in Mud Creek, followed by Quanicassee River and Northwest Drain. The lowest per acre phosphorus loads were from watersheds in the west coastal basin. Relative to point sources, the nonpoint source contribution to Saginaw Bay annual total phosphorus loads was quite large, ranging from 80% in 1992 to 91% in 1991.

ACTIONS NEEDED

This document identifies over 100 actions needed to further address the environmental degradation problems in Saginaw Bay and its watershed, focusing on land use, water resources, habitat and related topics. The ultimate goal is to achieve the "vision" established for the bay and the watershed. The actions describe a wide range of activities that RAP participants will work to implement, in applying expanded efforts beyond existing programs and activities.

The estimated cost of the actions identified is more than $107 million over the next ten years (a period of time used for cost projection purposes only). This represents only a **small** portion of the overall cost since (1) estimates cannot be made on many actions, and (2) actions to address toxic substances are not included because toxic material issues were not addressed by the technical advisory committees for this biennial report (it is expected that the TACs will address toxic substances in the next biennial report).

The activities outlined in this Remedial Action Plan are presented as current perceptions of the needed actions. They will be used to plan and guide remedial efforts at this stage of the Remedial Action Plan process. Since the RAP process is iterative, these actions are subject to further evaluation and modification consistent with changing environmental conditions in the watershed or the acquisition of data supporting adjustments in scope or approach. Additional discussion of the remedial actions is encouraged and comments are welcome at any time from any interested party.

CHAPTER I: INTRODUCTION

A. SCOPE OF SAGINAW RIVER/BAY RAP

1. Purpose

In 1987, the U.S. and Canadian governments signed a Protocol amending the Great Lakes Water Quality Agreement (GLWQA). The Protocol added specific programs, activities and timetables that more fully address issues identified in the 1978 GLWQA. Annex 2 of the 1987 Protocol requires the development and implementation of Remedial Action Plans for the Great Lakes Areas of Concern. These RAPs are to serve as an important step toward virtual elimination of persistent toxic substances and toward restoring the maintaining the chemical, physical and biological integrity of the Great Lakes basin ecosystem. The GLWQA requires the parties to cooperate with state and provincial governments to ensure that RAPs are developed and implemented for Areas of Concern.

The Saginaw River and Saginaw Bay have been listed as one of 43 Great Lakes Areas of Concern (AOCs) by the International Joint Commission (IJC) because degraded water quality conditions impair certain beneficial uses as defined by the Great Lakes Water Quality Agreement of 1978 (as amended). The State of Michigan has agreed to develop a Remedial Action Plan (RAP) for each of the 14 AOCs within the state's jurisdiction to address these water quality concerns. The Michigan Department of Natural Resources has been designated as the lead agency responsible for development of the RAPs.

The primary purpose of the Saginaw River/Bay Remedial Action Plan process is to achieve the following.

- To define and describe the environmental problems in the Saginaw Bay watershed (focusing on surface water quality and habitat related issues), including a definition of the beneficial uses that are impaired, the degree of impairment, and the geographical extent of impairment.

- To define the causes of impairment, including a description of all known sources of pollutants involved and an evaluation of other possible sources.

- To define water use goals for Saginaw Bay and its watershed, and to identify and implement actions needed to restore, protect and enhance environmental quality to support these goals.

This approach is substantially broader than that defined in the GLWQA, in that it goes beyond the designated boundaries of the AOC itself (the Saginaw River and Saginaw Bay) to include the entire watershed, and includes a broader array of issues. Furthermore, environmental problems anywhere in the watershed can be addressed for their own sake, independent of whether or not the local problem contributes to the degradation of the Saginaw River or Saginaw Bay. One of the primary reasons that the Saginaw River/Bay RAP has been able to expand to include the whole watershed is the additional financial and staff resources provided to the effort through the Saginaw Bay National Watershed Initiative.

2. Saginaw Bay National Watershed Initiative

In September 1990, the MDNR and local communities started work on a process to nominate Saginaw Bay for inclusion in the EPA National Estuary Program (NEP). In the following months, a nomination document was prepared. Later, it was determined that Saginaw Bay was not eligible for inclusion in the NEP. Instead, the Saginaw Bay watershed was designated as the first project under the National Watershed Initiative Program on September 30, 1991.

The Saginaw Bay National Watershed Initiative (Initiative) pursued an organizational and conceptual approach modeled after the NEP. The primary goal of the Initiative process is to develop a comprehensive water quality and habitat management effort to identify issues impacting the use or quality of water resources and habitat throughout the Saginaw Bay watershed, and to implement actions necessary to effectively restore, enhance and protect the watershed. While building on the cooperative networks already being utilized in the Saginaw Bay area, the Initiative strengthened ongoing efforts and expanded existing interagency coordination. As one example, this Saginaw River/Bay RAP document was developed through the committee structure of the Initiative.

B. ENVIRONMENTAL SETTING

Saginaw Bay is a southwestern extension of Lake Huron located in the east central portion of Michigan's lower peninsula (Figure I-1). The bay has a large surface area of 2,960 square kilometers (1,143 square miles), is 83 kilometers (52 miles) long, and varies in width between 21 and 42 kilometers (13 and 26 miles). The Saginaw Bay drainage basin is home to about 1.4 million people in 22 counties and contains 22,557 square kilometers (8,709 square miles), which is approximately 15% of Michigan's total land area.

Twenty-eight major rivers, creeks or agricultural drains flow directly into Saginaw Bay, but about 75% of the tributary hydraulic input comes from the Saginaw River. The Saginaw River watershed covers 16,260 square kilometers (6,278 square miles) and is the largest river watershed in Michigan. The Saginaw River itself is only 35 kilometers (22 miles) long and most of its flow originates from the four major tributaries that empty into it - the Cass, Flint, Shiawassee and Tittabawassee rivers.

The physical boundaries of the Saginaw River/Bay Area Of Concern are defined as extending from the head of the Saginaw River, at the confluence of the Shiawassee and Tittabawassee rivers upstream of Saginaw, to its mouth, and all of Saginaw Bay out to its interface with open Lake Huron at an imaginary line drawn between Au Sable Point and Point Aux Barques. However, as described earlier, the Saginaw River/Bay RAP has expanded its scope to address the entire Saginaw Bay watershed.

Land use is very diverse in the Saginaw Bay basin spanning a spectrum from relatively undisturbed natural areas, to intensive agriculture lands and heavily industrialized urban settings. The majority of industrial activity takes place in one of the four major urban centers in the Saginaw River basin: Bay City, Saginaw, Flint or Midland. Agricultural production, which comprises approximately 50% of the land use, is particularly intense in the eastern and southern portions of the watershed.

Saginaw Bay is also a major recreational area. It has a world-class walleye sport fishery and, since it is on a major migratory bird flyway, it is a popular bird watching destination. The most outstanding habitat feature of the watershed is the expansive coastal wetlands of the bay, which is the largest remaining freshwater coastal wetland system in the nation. Consequently, the bay is particularly valuable to Lake Huron fish and wildlife communities as a major breeding and nursery area. In addition to supporting numerous plant and animal species that are endangered or threatened, the Saginaw Bay watershed includes several natural communities that are globally scarce or unique.

The major water quality problems are cultural eutrophication and toxic material contamination. Pathogens are also occasionally a problem. The degraded environmental conditions have impacted biota, resulted in public health fish consumption and body contact advisories, affected taste in drinking water supplies and fish, created nuisance aesthetic

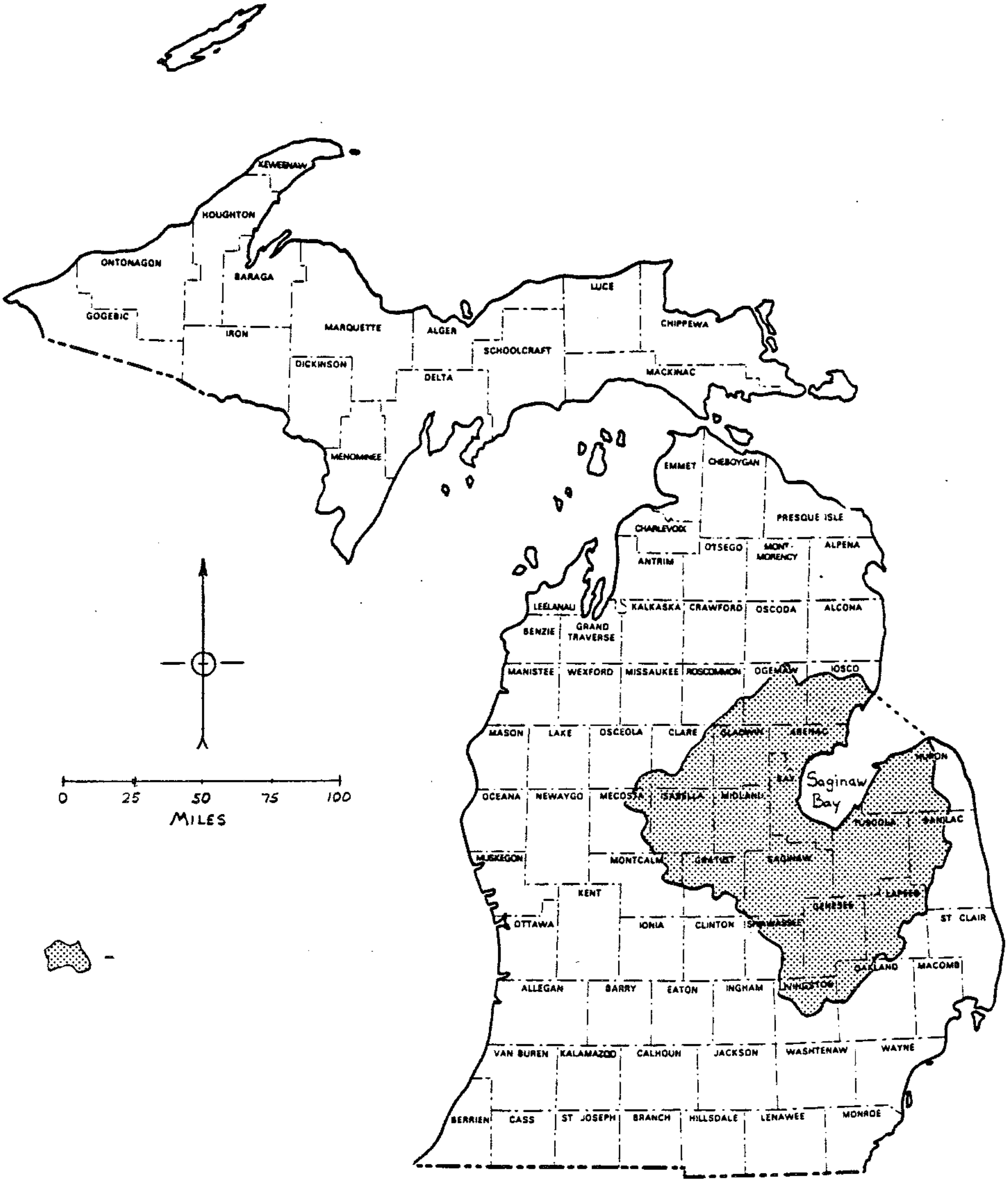


Figure I-1. Location of the Saginaw River/Bay Area of Concern.

conditions, and restricted navigational channel dredging activity. Additionally, loss of fish and wildlife habitat is a concern.

There are a variety of sources that continue to contribute contaminants to the Saginaw River and Saginaw Bay including industrial and municipal discharges, combined sewer overflows, contaminated sediments in the river and bay bottom, urban and agricultural nonpoint runoff, waste disposal sites, and the atmosphere.

Saginaw Bay is an important resource on which to focus additional water quality and habitat improvement efforts. Not only is it a valuable resource to Michigan, but water from Saginaw Bay eventually finds its way into open Lake Huron and can, therefore, potentially impact areas in other states or Canada. Saginaw Bay is important to people as a source of drinking water, recreational activities -- including pleasure boating, swimming, fishing, hunting and wildlife viewing -- commercial navigation, commercial fishing, general aesthetics, and the economic value of tourism activities it supports.

An in-depth discussion of the characteristics of Saginaw Bay and the watershed is provided in Appendix Three: Area Description.

C. SUMMARY OF BENEFICIAL USE IMPAIRMENTS

1. Definition of Beneficial Uses

A Great Lakes Area of Concern is defined in Annex 2 of the 1987 amendments to the Great Lakes Water Quality Agreement 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". Impairment of beneficial use is defined as a change in the chemical, physical or biological integrity of the Great Lakes system sufficient to cause any of the following:

- Restrictions on fish and wildlife consumption;
- Tainting of fish and wildlife flavor;
- Degradation of fish and wildlife populations;
- Fish tumors or other deformities;
- Bird or animal deformities or reproductive problems;
- Degradation of benthos;
- Restrictions on dredging activities;
- Eutrophication or undesirable algae;
- Restrictions on drinking water consumption, or taste and odor problems;
- Beach closings;
- Degradation of aesthetics;
- Added costs to agriculture or industry;
- Degradation of phytoplankton and zooplankton populations; and,
- Loss of fish and wildlife habitat.

In 1988, the IJC Water Quality Board developed additional guidance for the parties to the GLWQA (the federal governments of the U.S. and Canada) and the jurisdictions (the Great Lakes states and provinces) to identify AOCs and impaired beneficial uses. The guidance identifies specific types of geographic areas that are eligible to be AOCs, and establishes listing and delisting criteria (presented in Appendix Two: History of the Saginaw River/Bay RAP Process) for each of the 14 beneficial uses. Since some of the criteria are subjective, good judgement must be used when listing AOCs and identifying impaired uses.

It is important to note that although the Saginaw River/Bay RAP addresses the entire Saginaw Bay watershed, the GLWQA beneficial uses apply only to waters within the defined boundaries of Areas of Concern, which in this case includes the Saginaw River and Saginaw Bay.

2. Status of Individual Beneficial Uses in Saginaw River/Bay

Of the 14 potential beneficial use impairments listed in the GLWQA, 12 are considered to be impaired in the Saginaw River and/or Saginaw Bay (Table 1). Nutrient enrichment contributes to the greatest number of use impairments (8), followed by sedimentation (4). Toxic contaminants contribute to, or are thought to contribute to, three of the use impairments. A brief summary on the individual status of each beneficial use follows. Many of these issues are discussed in greater detail, and with respect to the whole Saginaw Bay watershed, in later chapters.

Restrictions on Fish and Wildlife Consumption

This use is impaired (Table 1). There are public health fish consumption advisories currently in effect for several species in the Saginaw River and Saginaw Bay. However, for the most part, these advisories are restricted to bottom feeding fish and fish with relatively high levels of body fat. There are no advisories for walleye or yellow perch, the principal sport fish, in Saginaw Bay, though an advisory does apply to these species in the Saginaw River.

People are advised to not eat any carp or channel catfish from either the Saginaw River or Saginaw Bay because PCB and dioxin concentrations in some fish tissue samples exceed the Michigan Department of Public Health (MDPH) criteria for levels of public health concern. Additionally, for Saginaw Bay, it is suggested that people not eat lake trout over 26 inches because of contamination by PCB, dioxin and chlordane.

People are advised to restrict their consumption of lake trout under 26 inches (PCB and dioxin), rainbow trout (PCB) and brown trout (PCB), in Saginaw Bay to no more than one meal per week. However, nursing mothers, pregnant women, women who intend to have children, and children under age 15 should not eat these fish.

An additional special advisory applies to the Saginaw River (and the Tittabawassee River) which states that no one should eat large quantities of any species from the river because some fish, especially carp and catfish, have been found to contain PCBs and dioxin. Women who intend to have children should eat no more than one meal per month of fish from the river.

There are no wildlife consumption advisories.

Tainting of Fish and Wildlife Flavor

This use is impaired. There have been occasional angler reports of off-flavor in Saginaw River fish, though the number of these reports has declined in recent years. The cause is unknown. No off-flavor was detected in taste tests conducted on fish taken from the Tittabawassee River. There are no reports of off-flavor in fish from Saginaw Bay or in wildlife.

Current Status of GLWQA Beneficial Uses in the Saginaw River/Bay AOC

Use Impairment	Listing Guideline	Status	Reference	Cause/Source
Restrictions on Fish and Wildlife Consumption	When contaminant levels in fish or wildlife populations exceed currents standards, objectives, or guidelines, or public health advisories are in effect for human consumption of fish or wildlife. Contaminant levels must be due to input from the watershed.	Impaired. Public health no consumption advisory in effect for carp and channel catfish in the Saginaw River and Saginaw Bay, and in Saginaw Bay for lake trout over 26". A restrict consumption advisory is in effect for lake trout up to 26", rainbow trout, and brown trout in Saginaw Bay, and for all species in the Saginaw River.	1994 Michigan Fishing Guide	Cause: PCBs, dioxin, and chlordane. Sources: point sources, contaminated sediments, atmosphere.
Tainting of Fish and Wildlife Flavor	When ambient water quality standards, objectives, or guidelines, for the anthropogenic substance(s) known to cause tainting, are being exceeded, or survey results have identified tainting of fish or wildlife flavor.	Impaired. Occasional angler reports of off-flavor in Saginaw River fish. The number of reports has declined in recent years. No off-flavor was detected in taste tests conducted on Tittabawassee River fish.	MDNR district fisheries biologists.	Unknown cause.
Degraded Fish and Wildlife Populations	When management programs have identified degraded fish or wildlife populations due to a cause within the watershed, or when bioassays confirm significant toxicity from water column or sediment contaminants.	Impaired. Saginaw Bay fish community impaired with depressed yellow perch population numbers, and apparent low natural recruitment of walleye. Some top-predator wildlife species also have low population numbers.	Joint Fisheries/RAP workshop on habitat in AOCs, technical reports, and draft fisheries management plan.	Cause: loss of spawning and nursery habitat, loss of benthic prey, non-native species competition.
Fish Tumors or other Deformities	When the incidence rates of fish tumors or other deformities exceed the rates at unimpacted control sites or when surveys confirm the presence of neoplastic or preneoplastic tumors in bullheads or suckers.	Not impaired. Bullheads collected from the Saginaw River mouth (1989) showed no increased incidence (above background) of external or internal tumors.	EPA tumor study, MDNR fish surveys.	Reports of tumors on walleye and some other species are due to Lymphosistys, a common viral disease of fish, and not due to contamination.
Bird or Animal Deformities or Reproductive Problems	When surveys confirm the presence of deformities or reproductive problems in sentinel wildlife.	Impaired. Caspian tern colony on the Saginaw CDF has had numerous reproductive failures and developmental deformities.	Several technical reports.	Cause: thought to be due to toxics, principally PCBs and dioxins.

Current Status of GLWQA Beneficial Uses in the Saginaw River/Bay AOC

Use Impairment	Listing Guideline	Status	Reference	Cause/Source
Degradation of Benthos	When the benthic macroinvertebrate community structure significantly diverges from unimpacted control sites of comparable characteristics, or when sediment toxicity is significantly higher than controls.	Impaired. The mayfly Hexagenia limbata, historically abundant in Saginaw Bay, is currently only rarely found in the bay. The benthic community is dominated by pollution-tolerant oligochaetes and chironomids.	MDNR and NOAA survey data from 1986-1988.	Cause: sedimentation and cultural eutrophication. Source: point and nonpoint sources.
Restrictions on Dredging Activities	When there are restrictions on dredging or disposal activities because contaminant levels in the sediments exceed standards, criteria or guidelines.	Impaired. Sediments from certain areas of the navigation channel require confined disposal.	EPA guidelines for the disposal of Great Lakes harbor sediments are exceeded. Restrictions in ACOE dredging certification.	Cause: PCBs and heavy metals. Source: point and nonpoint sources.
Eutrophication or Undesirable Algae	When there are persistent water quality problems attributed to cultural eutrophication.	Impaired. Excessive levels of nuisance algae species periodically occur in Saginaw Bay.	Technical reports on the Saginaw Bay plankton community and analysis of organic debris washing up along the bay shoreline.	Cause: nutrient enrichment. Source: point and nonpoint sources.
Restrictions on Drinking Water Consumption or Taste and Odor Problems	When treated drinking water: 1) exceeds standards, objectives, or guidelines for disease organisms, hazardous/toxic chemicals, or radioactive substances, 2) has taste and odor problems, or 3) treatment required for raw water is beyond the standard treatment for the Great Lakes area.	Impaired. Drinking water drawn from inner Saginaw Bay must undergo treatment to remove objectionable taste and odor.	Bay City drinking water plant operators.	Cause: nutrient enrichment. Source: point and nonpoint sources.
Beach Closings	When waters commonly used for full or partial body contact recreation exceed the standards, objectives, or guidelines for such use.	Impaired. Contact advisories periodically issued for the Saginaw River, and Saginaw Bay near the Saginaw River mouth.	County health departments.	Cause: high fecal coliform counts and algal debris. Source: CSOs (high fecal coliform counts) point and nonpoint nutrient sources (algae)
Degradation of Aesthetics	When any substance in water produces a persistent objectionable deposit, or unnatural color, turbidity, or odor.	Impaired. Organic debris consisting of decomposing algae, macrophytes, and zooplankton periodically washes up along the Saginaw Bay shoreline.	Citizen complaints, recent field investigations.	Cause: Excessive biological productivity Source: Nutrients from point and nonpoint sources.

Current Status of GLWQA Beneficial Uses in the Saginaw River/Bay AOC

Use Impairment	Listing Guideline	Status	Reference	Cause/Source
Added Costs to Agriculture or Industry	When additional treatment is required prior to agricultural or industrial use.	Not Impaired.	No reported cases of additional costs incurred.	
Degradation of Phytoplankton and Zooplankton Populations	When phytoplankton or zooplankton community structure differs significantly from unimpacted control sites of comparable characteristics, or when plankton bioassays confirm toxicity in ambient waters.	Impaired. Excessive levels of nuisance phytoplankton and zooplankton species periodically occur in Saginaw Bay.	Technical reports on the Saginaw Bay plankton community and analysis of organic debris washing up along the bay shoreline.	Cause: nutrient enrichment. Source: point and nonpoint sources.
Loss of Fish and Wildlife Habitat	When fish and wildlife management goals have not been met as a result of loss of habitat due to perturbation of the physical, chemical, or biological integrity.	Impaired. Significant habitat loss and degradation has impaired reproductive success and growth of certain fish species.	Joint Fisheries/RAP workshop on habitat in AOCs, technical reports, and draft fisheries management plan.	Cause: sedimentation, loss of wetlands, exotic species, channelization, loss of riparian corridors. Source: Land use development, nonpoint sources.

Degradation of Fish and Wildlife Populations

This use is impaired. The Saginaw Bay fish community is considered to be degraded because (1) yellow perch population numbers are depressed and (2) the natural recruitment of walleye is low and the population is supported by stocking efforts. The causes are related to loss of spawning and nursery habitat, loss of large-sized benthic prey, and non-native species competition.

Some top-predator wildlife species, such as bald eagle and mink have low population numbers in the Saginaw Bay watershed. Suspected causes are reproductive impairment/failure due to toxic material contamination, and loss of appropriate habitat.

Fish Tumors or Other Deformities

This use is not impaired. There are no unusual occurrences of fish tumors or deformities reported from either the Saginaw River or Saginaw Bay. Bullheads collected from the mouth of the Saginaw River in 1989 to specifically look at this issue showed no increased incidence (above background) of external or internal tumors. Reports of tumors on walleye and some other species are due to Lymphosistys, a common viral disease of fish, and not due to contamination.

Bird or Animal Deformities or Reproductive Problems

This use is impaired. The caspian tern colony of the Saginaw Bay Confined Disposal Facility has had numerous reproductive failures and developmental deformities. Toxic contaminants, principally PCBs and dioxin, are suspected causes. There are no reports of unusual occurrences of animal deformities in the watershed.

Degradation of Benthos

This use is impaired. The mayfly Hexagenia limbata, historically abundant in Saginaw Bay and an important component of the fish forage base, is currently only rarely found in the bay. The benthic communities in both the Saginaw River and Saginaw Bay are dominated by pollution tolerant forms such as the aquatic worms Limnodrilus and midges Chironomus.

The original causes are thought to be pollution and habitat loss, primarily cultural eutrophication and sedimentation, though currently heavy fish predation is thought to be a major factor inhibiting re-establishment of the Hexagenia population. Hexagenia have shown good survivability in recent caged studies conducted in Saginaw Bay.

The benthic community is also currently undergoing rapid change as a result of recent colonization by zebra mussels and it is unknown what the final impact of this exotic species will be. The benthic community in Saginaw Bay is currently being surveyed by NOAA as part of their zebra mussel project.

Restrictions on Dredging Activities

This use is impaired. Sediments dredged from parts of the navigation channel in the Saginaw River and Saginaw Bay require confined disposal because of elevated levels of pollutants. The primary contaminant of concern is PCBs, though several metals, nutrients, and oil and grease are also present at levels that exceed the 1977 U.S. EPA Interim Guidelines for the Disposal of Great Lakes Harbor Sediments. This has resulted in operational and disposal restrictions being placed on dredging conducted in the Saginaw River, whether it be navigation channel dredging performed by the U.S. Army Corps of Engineers or their contractors, or private dredging conducted by marina owners or other riparian landowners.

Eutrophication or Undesirable Algae

This use is impaired. The most recent phytoplankton community composition results are from 1980, when excessive population levels of nuisance algae species where found in certain areas of Saginaw Bay. These communities were re-surveyed in 1991 and 1992, but the results are not yet available. However, the nuisance organic debris that continues to wash ashore along Saginaw Bay is often largely due to algal biomass. These conditions are caused by the cultural eutrophication of Saginaw Bay, which is brought about by excessive levels of nutrients.

In addition, the phytoplankton community may be impacted by the recent colonization of Saginaw Bay by zebra mussels. Zebra mussels are filter feeders and they remove much of the plankton biomass from the water they ingest. It is suspected that some plankton species may be more susceptible to removal from the water column than others, resulting in community population shifts. The Saginaw Bay plankton community was surveyed in 1991 and 1992 as part of the NOAA zebra mussel project, but the results are not yet available. It is unknown what the final impact of this exotic species will be.

Restrictions on Drinking Water Consumption, or Taste and Odor Problems

This use is impaired. Drinking water drawn from inner Saginaw Bay must undergo treatment to remove objectionable taste and odor. The cause has historically been excessive amounts of blue-green algae brought about by nutrient enrichment of Saginaw Bay.

Beach Closings

This use is impaired. Public advisories are periodically issued following storm events by local health departments warning against body contact with the Saginaw River, and Saginaw Bay near the Saginaw River mouth, because of elevated levels of fecal coliform bacteria resulting from combined sewer overflows. Advisories have also been issued at the Bay City State Park beach because of large amounts or organic debris both on shore and in the near-shore zone. This organic debris is due to nutrient enrichment of Saginaw Bay.

Degradation of Aesthetics

This use is impaired. Organic debris consisting of decomposing algae, macrophytes, and zooplankton periodically washes up along the Saginaw Bay shoreline. The cause is excessive biological productivity due to nutrient enrichment of Saginaw Bay.

Added Costs to Agriculture or Industry

This use is not impaired. There have been no reports of additional treatment required to address water quality concerns prior to agricultural or industrial use of water drawn from the Saginaw River or Saginaw Bay.

Degradation of Phytoplankton and Zooplankton Populations

This use is impaired. The most recent plankton community composition results are from 1980, when excessive population levels of nuisance species where found in certain areas of Saginaw Bay. These communities were re-surveyed in 1991 and 1992, but the results are not yet available. However, the nuisance organic debris that continues to wash ashore along Saginaw Bay is often largely due to plankton biomass. These conditions are caused by the cultural eutrophication of Saginaw Bay, which is brought about by excessive levels of nutrients.

In addition, the plankton community may be impacted by the recent colonization of Saginaw Bay by zebra mussels. Zebra mussels are filter feeders and they remove much of the plankton biomass from the water they ingest. It is suspected that some plankton species may be more susceptible to removal from the water column than others, resulting in community population shifts. The Saginaw Bay plankton community was surveyed in 1991 and 1992 as part of the NOAA zebra mussel project, but the results are not yet available. It is unknown what the final impact of this exotic species will be.

Loss of Fish and Wildlife Habitat

This use is impaired. Significant habitat loss and degradation have occurred in the Saginaw River and Saginaw Bay. For example, despite the fact that expansive coastal wetlands of Saginaw Bay are the largest remaining freshwater coastal wetland system in the nation, only about 18,000 acres remain of the 37,000 acres estimated to have existed prior to European settlement. Other habitat degradation includes the sedimentation of fish spawning reefs in Saginaw Bay, human development of riparian lands along Saginaw Bay and the Saginaw River, removal of bottom substrates by dredging, numerous impacts from exotic species (e.g. macrophyte rooting by carp, substrate colonization by zebra mussels), and anoxic bottom conditions. This habitat loss and degradation has impaired the reproductive success and growth of numerous aquatic and wildlife species.

3. Pollutant Sources

There are a variety of sources that continue to contribute contaminants to the Saginaw River and Saginaw Bay including industrial and municipal discharges, combined sewer overflows, contaminated sediments in the river and bay bottom, urban and agricultural nonpoint runoff, other nonpoint sources (e.g. golf courses, construction sites, residential lawns), waste disposal sites, and the atmosphere. The majority of industrial discharges originate in one of the four major urban centers in the Saginaw River basin of Bay City, Saginaw, Flint or Midland. Approximately 50% of the Saginaw Bay watershed is in agricultural production and there are significant nutrient and sediment inputs from many of these areas, particularly in the eastern and southern portions of the watershed. The channelization of many area watercourses has substantially increased pollutant transport to the Saginaw River and Saginaw Bay, and contributed to erosion and habitat loss, by increasing water velocities and flow rates following storm events.

D. SAGINAW RIVER/BAY RAP PROCESS

1. RAP Document Development

The Saginaw River/Bay Remedial Action Plan process began in July 1986 and the initial RAP document was completed in September 1988. The RAP identified 101 actions that were needed to further address the environmental problems in the Saginaw River/Bay AOC. By December 1991, only three years later, two-thirds (68) of the 101 actions had been at least partially implemented. Of the 37 priority actions identified, all had been at least partially implemented.

This is remarkable implementation success given this era of decreased financial resources at the federal, state and local levels. The widespread support can be partially attributed to the relatively high priority given to this AOC at the state and federal level, as well as the involvement of local citizens, businesses and communities in the RAP process due to their desire to improve the environmental conditions that affect their quality of life.

Because of this success in implementing actions, it was determined that it would be appropriate to update the RAP in order to (1) incorporate the new data, (2) consider the new data results in evaluating past, ongoing or proposed actions, and (3) further develop and prioritize actions appropriate for the current situation.

One might consider the effort to revise the Saginaw River/Bay RAP to have actually begun back in September 1990, when the local community and the MDNR started to work on the process to nominate Saginaw Bay for inclusion in the EPA National Estuary Program, which ultimately resulted in the Saginaw Bay National Watershed Initiative. The nomination document that was developed drew heavily upon the RAP document and resulted in information on many RAP issues being updated.

In June 1992, work began on this second iteration of the Saginaw River/Bay Remedial Action Plan document. It was prepared jointly under the Saginaw River/Bay RAP Program and the Saginaw Bay National Watershed Initiative by numerous agencies, local governments, public and business organizations, and basin residents. It uses the terminology specified by the 1987 amendments to the GLWQA and defines the water quality problems in the Saginaw River and Saginaw Bay in terms of the 14 beneficial uses. It also includes relevant elements of all three RAP stages defined by the GLWQA. Additionally, it is a much broader, though more refined, document than the 1988 version, as described below.

This report is the first Saginaw River/Bay RAP to be developed under the new biennial approach to Michigan RAPs. It encompasses numerous differences from, and improvements on, the initial 1988 RAP document, the most significant of which are the following.

- A vision and numerous long-term and short-term goals have been developed to provide more specific guidance and quantitative measures for the overall RAP process.

- The "water quality problems" in the Saginaw River and Saginaw Bay addressed by the initial RAP are now described in terms of the GLWQA beneficial uses.

- This report takes a broader, ecosystem approach to the water quality problems, which has resulted in greater emphasis on habitat issues, fish populations, and wildlife communities.

- This document identifies, to a much greater degree, which small watersheds are contributing the most to the impairment of beneficial uses in the Saginaw River and Saginaw Bay.

- The report deals with environmental problems throughout the watershed, instead of addressing upstream areas only if they were contributing to the degradation of the Saginaw River or Saginaw Bay (the "Area of Concern").

- A major component, that will greatly assist efforts to address the environmental problems in such a large drainage basin, is the comprehensive small watershed prioritization process to rank watersheds with respect to each other on local conditions as well as impacts on the bay.

- This first biennial report focuses on nutrient, conventional parameter, and habitat issues. Toxic substances and contaminated sediments will be addressed in the next biennial report.

This document serves as the technical, planning and project implementation focus for addressing surface water quality and habitat issues in the Saginaw Bay watershed. It is intended that this Remedial Action Plan be used by all agencies (federal, state, local), organizations and individuals concerned with, affected by, or impacting, water quality in Saginaw Bay or its watershed. Extensive efforts have been made to include all interested and/or affected parties in the development, review and implementation of this plan so that it fully addresses the issues from a variety of perspectives and is broadly supported. This RAP is much more comprehensive than previous planning documents in that it examines environmental quality from an ecosystem perspective on a watershed basis rather than focusing on only a single pollutant source or issue, or a single large drainage basin.

The RAP is not the start of this process -- water pollution reduction programs have been ongoing in the Saginaw Bay basin since the 1920s -- nor is it the end. The RAP is viewed as a long-term project. It is anticipated that the RAP document will be periodically updated and revised as more data is acquired, remedial measures are implemented, and environmental conditions improve. The RAP process itself for this AOC will eventually end when it has been documented that all the beneficial uses identified as being impaired are fully restored or it is shown that they cannot be restored to any further extent. However, pollution control efforts will continue, and it is probable that the RAP will also continue, though perhaps in a less formal form.

The history of the Saginaw River/Bay RAP process, and the rationale for the new approach using biennial RAP documents, is described in greater detail in Appendix Two: History of the Saginaw River/Bay RAP Program.

2. General RAP Concepts

It is important to view the development and implementation of the Saginaw River/Bay RAP as a process, rather than as a finite activity that concludes with the publication of a document. The document(s) that is produced as a result of the process is merely a snapshot of the environmental situation at a given point in time, one that reveals that the resolution of specific problems often proceeds on different schedules.

In order to ensure that the process moves forward, the RAP must be developed in full recognition that there will be more information available on some use impairments than on others, that there may be data gaps, and that more information may be needed to completely describe a use impairment or to identify the remedial actions that will restore the use. In cases where data or information needs are identified, this is stated in the RAP. The information, when obtained, will be included in subsequent updates or revisions of the RAP. In other words, the development and implementation of the RAP should be viewed as an iterative process.

The primary focus of the RAP process is the identification of the next actions required to progress toward problem resolution. In doing so, however, it must be stressed that the RAP process is not intended to replace, duplicate or supersede other programs. The RAP utilizes both the mandates and the resources available from other programs to address as many aspects of the identified problems as possible. The RAP process will coordinate efforts with other existing programs to the fullest extent possible to ensure the most effective, efficient use of resources and to ensure a comprehensive ecosystem approach. Special attention is given to ensuring that priority activities are conducted under the appropriate program, and to developing strategies to address those issues that are not covered under existing programs.

The primary goal of the Saginaw River/Bay RAP is to restore, enhance, and protect beneficial water uses. This will be a long, complex effort requiring reduction of all sources of pollutants or disturbance contributing to the identified problems, and may also necessitate changing existing or planned human activities. In some cases, complete restoration of uses may be dependent of actions taken on a basin-wide or regional basis. Achievement of these RAP goals will be a very important step toward obtaining the GLWQA goals of (1) the virtual elimination of persistent toxic substances, and (2) restoring and maintaining the chemical, physical and biological integrity of the Great Lakes basin ecosystem.

A key aspect of the Saginaw River/Bay RAP process is the commitment of participants to an ecosystem approach to addressing the environmental problems. To this end, participants endeavor to ensure that all causes -- chemical, physical, biological and societal -- of the identified use impairments are noted, and that a multi-media approach to restoring and protecting beneficial uses is employed.

3. Participatory Approach

The key to successfully implementing an ecosystem approach lies in the active participation, coordination and cooperation of the public and all program areas at the state, federal and local levels that have responsibilities relevant to the RAP. Participants need to be involved in all aspects and phases of the process including providing relevant data and information, contributing to decision making and policy related discussions, and facilitating the implementation of actions.

Participation in the Saginaw River/Bay RAP process is encouraged and welcome from **anyone** affected by, or concerned with, any topic addressed under the program. In addition to the obvious inclusion of individuals, communities, businesses, and organizations at the local or basin-wide level, this also includes state, regional (Great Lakes), national or international agencies and organizations concerned with the broader implications of RAP activities or outcomes. Consequently, participation within the scope of the RAP encompasses a broad spectrum of individuals and activities.

Participation includes a wide variety of activities beyond the traditional public meetings and committees directly related to the development and implementation of the RAP. It essentially includes any action that impacts, or has the potential to impact (either positively or negatively), beneficial uses in the Saginaw Bay watershed. Citizen awareness and knowledge of local water quality problems has generated local public support that helped to implement many of the remedial actions proposed in the 1988 RAP. The purpose of such diverse participation is to:

(1) enhance the <u>quality of decision making</u> by providing the opportunity for participants to contribute pertinent information and input;

(2) discover the <u>issues of concern</u> to those who are interested in, or may be affected by, decisions on a given topic, the full range of values that apply to these issues, the extent of possible solutions to problems, and the benefits/consequences of each solution;

(3) enhance participants <u>awareness and education</u> as it relates to environmental quality and RAPs;

(4) facilitate the coordination of existing programs to the fullest extent possible to ensure the most effective, efficient use of resources and to ensure a comprehensive, multi-media ecosystem approach to the restoration and protection of beneficial uses; and,

(5) foster broad-based support in the development, funding and implementation of RAP actions.

Several formal committees were established under the Saginaw Bay National Watershed Initiative program and utilized for the development of this RAP. Each committee consisted of a diverse range of participants (listed in Appendix One: Participants) from local, state and federal agencies, local government, industry, agriculture, and public organizations.

The Program Advisory Committee was the principal committee used to provide broad-based input and direction to the Initiative, and to facilitate the development of cooperative long-term strategies for the restoration and protection of the Saginaw Bay watershed. To assist with these tasks, the Program Advisory Committee established four Technical Advisory Committees (TACs). Each TAC addressed one of four specific topic areas: Water Quality, Soil Erosion and Sedimentation, Contaminated Sediments, and Habitat. The work products of the TACs comprise the bulk of this RAP document. Specifically, the TACs were charged with the following on-going responsibilities:

(1) review existing information regarding the nature and extent of the problem/issue;

(2) identify concerns and alternative solutions for each problem/issue;

(3) develop short-term (1 - 5 year) goals for addressing the problem/issue;

(4) develop long-term (3 - 10 year) goals for addressing the problem/issue;

(5) prioritize watersheds and subwatersheds for future implementation activities;

(6) update appropriate portions of the Saginaw River/Bay Remedial Action Plan; and,

(7) identify data needs.

The compilation and interpretation of data regarding the Saginaw Bay watershed is a major undertaking. Ensuring that this information is easily accessible and effectively utilized by participants that generate new data, identify actions needed, and develop policy for the watershed, is essential. Originally it was anticipated that the TACs would develop appropriate data integration/management processes to achieve the recommended goals. It became clear, however, that due to the specific technical nature of this task, another TAC on data management and integration was needed and one was approved by the Program Advisory Committee.

Besides carrying out similar tasks as described previously for the other TACs, but relative to data integration/management, specific additional responsibilities of the Data Management and Integration TAC include the following.

(1) Evaluate the potential uses/implementation of GIS in the Saginaw Bay watershed.

(2) Outline current data management capabilities and practices of agencies involved in assessing environmental issues in the Saginaw Bay watershed.

(3) Evaluate communication needs/capabilities of agencies involved in assessing environmental issues in the Saginaw Bay watershed.

(4) Determine commonly acceptable formats for data sharing/integration.

(5) Evaluate various mechanisms for data management that will support the goals developed by the other TACs.

Initial topics to be discussed by the Data Management and Integration TAC include the following.

Metadata - In essence, data about data. Metadata provides information on the characteristics of a data set, and organizations to contact to obtain a data set. Included in this would be QA/QC information about the data sets.

Electronic Card Catalogue - A computerized reference source from which to identify information of interest and locate the source.

Data Standards - Development of standards for data collection and format is essential, particularly for the sharing of geographic information.

Networks - Access to the data in computerized form is easiest through networks. Several networks should be reviewed for their accessibility: Gemnet, Internet, and GLIN. Others may be looked at as well.

At this time GIS-oriented data developed as part of the Initiative program are being stored on either the MDNR Michigan Resource Information System (MIRIS) or the Saginaw Bay National Watershed Initiative's Intergraph system at Saginaw Valley State University. Both the MIRIS and Initiative's GIS systems can provide all interested users with hard copy information. The Initiative is currently working with local governments in the Saginaw Bay watershed to determine beneficial uses for GIS at the local level.

Another related data integration task is being conducted by the Consortium for International Earth Science Information Network (CIESIN) as part of an EPA grant. CIESIN is designing a prototype environmental information and decision support system using the

Saginaw Bay watershed as a demonstration site. It is hoped that this system will provide the mechanism to facilitate data management and integration, and provide easy access to information regarding the Saginaw Bay watershed. It is anticipated that the Data Management and Integration TAC will provide technical input/review for the development of this decision support system.

E. LONG-TERM GOALS

USES

1. Restoration of the Impaired GLWQA Beneficial Uses

The Great Lakes Water Quality Agreement (GLWQA) identifies 14 potential beneficial use impairments in Great Lakes Areas of Concern (AOCs) that should be restored if they are impaired. The Saginaw River and Saginaw Bay area is one of the 43 AOCs that are currently identified by the International Joint Commission (IJC). Twelve of the 14 uses are presently considered to be impaired in the Saginaw River/Bay AOC (Table 1).

The vision includes the restoration of these uses in the Saginaw River and Saginaw Bay. In general, successful restoration will be achieved when a beneficial use meets the delisting guidelines in the "Listing/Delisting Guidelines for Great Lakes Areas of Concern" as approved by the IJC in January 1991. However, if it is determined that conditions in Lake Huron as a whole, or natural conditions in Saginaw Bay, prevent full restoration within the context of the delisting guidelines, the restoration goals for the Saginaw River/Bay AOC will be modified accordingly.

2. Protection and Enhancement of Other Water-Related Uses

The vision references other water-based uses that should be protected and/or enhanced in the bay and the watershed beyond those of the GLWQA. Among these are water associated recreation, public access, and navigation.

3. Small Watershed Management and Prioritization

Develop multi-use management plans for individual watersheds based on ecological conditions and local uses.

WATER QUALITY

1. Meet Michigan Water Quality Standards for Ambient Water and Drinking Water.

The vision requires that Michigan's ambient water quality standards, which were developed and are periodically updated pursuant to the federal Clean Water Act, be met throughout Saginaw Bay and its watershed. Furthermore, federal and state drinking water standards must be met for water supplies drawing water from Saginaw Bay or within the watershed. In addition, toxic contamination levels in water, sediment and biota will be reduced to the lowest level practicable.

2. Obtain a mean phosphorus concentration of 15 ug/l in inner Saginaw Bay.

This goal was originally developed for the "State of Michigan Phosphorus Reduction Strategy for the Michigan Portion of Lake Erie and Saginaw Bay". Achievement of the goal is expected to eliminate taste and odor problems (those caused by the impacts of nutrient enrichment, e.g.. blue-green algae blooms) in drinking water supplies drawn from the bay. It is also expected that achievement of the goal would restore Saginaw Bay to a mesotrophic ecosystem.

3. Reduce the annual phosphorus load to Saginaw Bay to 440 metric tons or less.

This goal was also originally developed for the "State of Michigan Phosphorus Reduction Strategy for the Michigan Portion of Lake Erie and Saginaw Bay". Achievement of the goal is expected to result in mean phosphorus concentrations in inner Saginaw Bay of 15 ug/l.

4. Achieve annual mean total phosphorus concentrations in flowing waters (i.e. rivers, streams, creeks, drains) of 0.1 mg/l.

This goal was derived to both reduce phosphorus loads to Saginaw Bay and to restore degraded conditions in watercourses with elevated phosphorus levels. The 0.1 mg/l value was obtained from review of the scientific literature (0.1 mg/l or less is required to prevent nuisance conditions in streams) and evaluation of the present concentrations observed in watershed streams.

5. Achieve annual mean total suspended solids concentrations in flowing waters of 50 mg/l.

This goal was derived to both reduce sediment loads to Saginaw Bay and to restore degraded conditions in watercourses with elevated levels of total suspended solids. The 50 mg/l value was obtained from review of the scientific literature and evaluation of the present concentrations observed in watershed streams.

BIOLOGICAL COMMUNITIES

1. Reduce eutrophication in Saginaw Bay to reduce populations of nuisance species and restore a balanced mesotrophic biological community.

2. Re-establish a self-sustaining Hexagenia limbata mayfly population in Saginaw Bay at an appropriate level of abundance.

3. Re-establish diverse, abundant benthic macroinvertebrate populations in Saginaw Bay, and throughout the watershed, to support critical growth needs of basin fish populations.

4. Reduce toxic material levels in fish tissue to the point where public health fish consumption advisories are no longer needed for any species in the bay or watershed.

5. Reduce toxic material levels in fish tissue so that there are no adverse impacts on piscivorous wildlife (including top predators such as mink, otter and bald eagles) from consuming fish from anywhere in the bay or the watershed.

6. Manage fish and wildlife populations pursuant to management plans developed for the bay and the watershed.

Fisheries, wildlife and habitat management plans need to be developed and implemented for the watershed as a whole. These plans will also address restoration and enhancement where applicable. Consideration of the impacts, control and management of nonindigenous species would be inherent to these plans.

7. Restore a balanced fishery in Saginaw Bay by enhancing the numbers of predaceous game fish, such that by year 2000 prey fish abundance is measurably reduced.

    -- Enhance predator abundance by stocking, regulatory protection, and habitat improvement, while maintaining harvest levels of at least 454,550 kg (1 million pounds) through year 2000 and allowing harvest of predators to reach at least 681,800 kg (1.5 million pounds) by year 2020.

    -- Restore valued fisheries at lower trophic levels such that extractions of "nonpredatory" species reach at least 1,000,000 kg (2.2 million pounds) by year 2000 and 1,365,640 kg (3 million pounds) by year 2020.

8. Ultimately, eliminate the need for fish stocking programs.

9. Enhance specific fish populations as follows:

Enhance the walleye population of Saginaw Bay to its estimated potential, producing an annual sport fishing yield of at least 300,000 fish or 227,270 kg (0.5 million pounds) by year 2000, and 600,000 fish or 454,550 kg (1 million pounds) by year 2020.

Reestablish a self-sustaining walleye population in Saginaw Bay at an appropriate level of abundance.

By year 2000, inventory the largemouth and smallmouth bass fisheries of Saginaw Bay and identify their management needs.

Increase abundance of northern pike through habitat improvement and stocking, such that annual extractions increase from the present level of 54,550 kg (120 thousand pounds) to 90,910 (200 thousand pounds) by year 2020.

Experimentally introduce Great Lakes muskellunge to Saginaw Bay by year 2000.

By year 2020, restore yellow perch growth and maintain yield at a level characteristic of the 1950s. Length at age five should be near 21.6 cm (8.5 inches). Yield should be maintained at existing levels, near 363,640 kg (800 thousand pounds).

Monitor the status and ecological impacts of the invasion of white perch, while attempting to manipulate the population (by enhancement of predator numbers and promoting harvest of a desirable sport or commercial product), such that impacts upon native species are minimized.

Rehabilitate the lake herring by reducing competition from other species and, if necessary, by stocking, such that sport and/or commercial extractions recover to at least 181,820 kg (400 thousand pounds) by year 2020.

Maintain incentives for the commercial and sport harvest of carp, carpsucker, white sucker and freshwater drum, such that combined extractions of at least 454,550 kg (1 million pounds) annually are continued.

Maintain a favorable mix and appropriate abundance levels of non-game species to support and coexist with the desired game fish population.

10. Reduce sediment loads to enhance benthic macroinvertebrates and fish spawning habitat.

HABITAT

1. Protect, enhance and restore wetlands and other aquatic or riparian habitats in order to provide sufficient, diverse habitat to support biodiversity of waterfowl, aquatic species, and wildlife throughout the Saginaw Bay basin.

2. Restore wetlands to reflect native plant communities.

3. Restore drained wetlands along riparian corridors and Saginaw Bay to provide buffering capacity for storm water runoff to enhance water quality and reduce water quantity fluctuations.

4. Encourage habitat restoration, removal of dams and construction of fishways to increase the availability of tributary spawning sites, and improvements in tributary habitat, to enhance walleye populations.

5. Encourage protection of wetlands and sheltered areas in Saginaw Bay for largemouth and smallmouth bass.

6. Improve northern pike habitat, and access to natural wetlands, in Saginaw Bay by reducing turbidity.

7. Improve spawning habitat for fish in Saginaw Bay by reducing sediment loads.

8. In the state forest system, provide for the protection and wise use of healthy, productive, and undiminished forests and associated ecosystems for all forest outputs, including watershed protection, amenity and aesthetic benefit.

9. On private forest land, promote private forest development through assistance and incentives in support of the landowner's stewardship goals and objectives.

RECREATION

1. Prevent the need for any pathogen induced body contact advisories by preventing pathogen contamination throughout the watershed from exceeding the MDNR total body contact criteria of 200 fecal coliform per 100 milliliters of water.

2. Eliminate the degradation of swimming beaches (public and private) along the Saginaw Bay shoreline from the nearshore or beach accumulation of decomposing organic debris.

3. Provide at least 600,000 days of angler recreation per year on Saginaw Bay through year 2000, and one million days by year 2020.

4. Maintain current harvest levels for commercial fisheries operating under Michigan licenses or permits, while relocating most Saginaw Bay effort to the main basin.

5. Enhance recreational access opportunities through targeted land acquisition and access facility development. Regarding boating access, the emphasis is on taking advantage of existing deep water channels and larger capacity upland developments so that the pressures to develop elsewhere on Saginaw Bay can be relieved.

6. Upgrade interpretive facilities at the four state parks located along Saginaw Bay.

7. Decrease sediment loads to reduce channel dredging, thereby diminishing boating accidents and facilitating boating access.

SOURCES

1. Develop integrated land use planning throughout the Saginaw Bay watershed.

To a significant extent, land use will determine the future environmental quality of the Saginaw Bay watershed. Land use has a fundamental role in determining and sustaining the activities that take place within the watershed. The current lack of integrated land use planning is a basic issue with far reaching effects. Appropriate land use planning that considers sustainment of resources and long-term ecosystem health needs to be implemented to achieve the vision.

2. Improve local planning and zoning capabilities.

3. Implement best management practices throughout the Saginaw Bay watershed for land use and drainage improvement/maintenance to reduce watercourse erosion, sedimentation, pollutant transport, and habitat loss/degradation.

4. Virtually eliminate all inputs of persistent toxic substances to the Saginaw Bay watershed.

5. Eliminate, or obtain adequate treatment of, all combined sewer overflows in the Saginaw Bay watershed.

6. No acute or chronic sediment toxicity in the Saginaw Bay watershed as determined by bioassays consistent with state and federal assessment programs.

7. Eliminate the need for confined disposal of sediments dredged from federal navigation channels in the Saginaw Bay watershed, and dispose of dredged sediments in an environmentally acceptable manner.

8. Reduce phosphorus loads from point sources to the maximum extent possible.

9. Quantify the significance of wind erosion and atmospheric deposition for all pollutants of concern.

HYDROLOGY

1. Reduce the pollutant transport, erosion, and flooding associated with runoff events in the Saginaw Bay watershed.

2. Maintain adequate base flows in Saginaw Bay basin watercourses to support well-balanced, unimpaired aquatic communities.

3. Preserve, and restore where feasible, the natural hydrologic characteristics of the Saginaw Bay watershed.

4. Control erosion to eliminate/reduce the need for maintenance dredging throughout the Saginaw Bay watershed.

MULTI-USE CONFLICTS

1. Reduce multi-use conflicts

PUBLIC EDUCATION

1. Create an ecologically educated public that can make knowledgeable decisions on environmental and resource issues in the Saginaw Bay watershed.

F. SHORT-TERM GOALS

1. Phosphorus

Define where phosphorus reductions should be made:
- Priority watersheds
- Sources

Establish nutrient ratios important for phytoplankton communities.

Determine importance of:
- Water column versus sediments
- Dissolved versus attached
- Inputs versus recycling
- Upstream versus downstream

2. Suspended Solids

Determine priority watersheds where suspended solids reductions should be made.

3. Habitat

Identify habitats for restoration, protection and enhancement.

Based on the short-term, statewide wetland restoration goal of 50,000 acres by 2010, the proportionate share based on land area for the Saginaw Bay watershed is 7,500 acres (the watershed comprises nearly 15% of Michigan's land area), that is, creation of 500 wetland acres annually for the next 15 years.

4. Fisheries

Remove the existing bag limit on yellow perch for sport anglers.

Relax regulations on the commercial fishery so that age-3 and age-4 yellow perch could be harvested, perhaps with a slot limit of 6-8 inches.

There should be no restrictions on the sport or commercial harvest of white perch.

Determine spawning locations of white perch to enhance sport fishing opportunities.

Continue monitoring yellow perch growth.

Continue monitoring walleye age and growth.

Determine dynamics of walleye recruitment.

CHAPTER II: ACTIONS IMPLEMENTED SINCE 1988

The Saginaw River/Bay Remedial Action Plan (RAP) process began in July 1986. After several drafts, the initial RAP document was completed in September 1988. The RAP identified 101 actions that should be taken to further address the environmental problems. The 1988 estimated cost of implementing these actions over a 10-year period was $170 million. This estimate did not include any costs associated with sediment clean-ups if needed, which could add substantial additional costs.

Since completion of the RAP, over two-thirds of the 101 actions have been at least partially implemented. Of the 37 priority actions identified, all have been at least partially implemented. Additionally, because of the broad nature of many of the action descriptions, the actual number of individual projects undertaken to implement the actions (e.g. implementation of agricultural best management practices, public education activities, business/governmental facility and process improvements) are so numerous that they likely number in the thousands and consequently are not all listed here.

However, the following sections describe some of the major activities, grouped by general activity type, that have been implemented since completion of the Saginaw River/Bay RAP in 1988.

COORDINATING ACTIVITIES

Saginaw River/Bay Remedial Action Plan. 1986-ongoing. Much of the multiagency coordination on the development, funding and implementation of the actions described here is conducted within the scope of the Saginaw River/Bay RAP process. And, since 1991, much of the Saginaw River/Bay RAP process has been conducted through the committee structure of the Saginaw Bay National Watershed Initiative.

Saginaw Bay National Watershed Initiative (NWI). 1991-ongoing. The primary goal of the Saginaw Bay NWI process is to develop a comprehensive water quality and habitat management effort to identify issues impacting the use or quality of water resources and habitat throughout the watershed, and to implement actions necessary to effectively restore and protect the watershed. The NWI process is broader in scope than the RAP, dealing also with degraded conditions upstream of the Saginaw River and Saginaw Bay. The NWI and RAP processes are complementary and are being coordinated with each other. Additionally, the NWI has provided funds to many of the projects described in this section.

Saginaw Basin Watershed Council. 1991-ongoing. The council is a voluntary association of local governments organized to promote cooperation on river management issues. It is comprised of local government officials from throughout the entire Saginaw Bay drainage basin. The council enables local governments to cooperatively plan for and promote economic development, tourism, recreation and restoration/protection of soil and water resources. The council also serves as a means by which local governments can provide coordinated input on the Saginaw River/Bay RAP process.

Saginaw Basin Alliance. 1989-ongoing. This basin-wide 501(c)3 non-profit organization grew out of the Saginaw Basin Natural Resources Steering Committee (which provided formal public input during development of the 1988 RAP) and was incorporated to seek funding for, and implement, actions to address natural resource and related issues throughout the Saginaw Bay watershed. The organization publishes a quarterly newsletter called "Basinotes" and serves as a forum for formal public input on the Saginaw River/Bay RAP process.

Resource Conservation and Development Area. 1989-ongoing. A 15-county, locally organized, sponsored and directed non-profit organization in the Saginaw Bay watershed with multiple goals; but basically to work on enhancing the quality of life, natural resources, employment and recreation opportunities through economic development.

SBNWI Watershed Management Conference. 1993. A conference designed to bring together MDNR staff from throughout the Saginaw Bay basin, as well as staff from other parts of the state that work on projects in the watershed, to promote and facilitate ecosystem based watershed management. MDNR staff made up the bulk of the over 170 people in attendance, but there was also substantial representation from over a dozen agencies outside the MDNR and several local citizen groups. Two follow-up sessions were held in 1994.

NONPOINT SOURCE POLLUTION REDUCTION PROJECTS

Saginaw Bay Watershed Council Storm Drain Stenciling Program. 1994-ongoing. A local community project to label storm drains to help prevent the improper disposal of materials down these conduits through which contaminants can reach surface waters.

Huron Count Innovative Farmers. 1994-ongoing. A group of 47 Huron County farmers is cooperating with Huron County MSU Extension and the Soil Conservation District. One project is to evaluate production techniques that could be used to reduce phosphorus levels in soils that test high in phosphorus. The group's goal is to eliminate or reduce nutrient, sediment and pesticide loads to surface waters.

Saginaw Bay Storm Water Runoff Program. 1992-1994. This is a MDNR/local program for the development of storm water runoff controls in the Saginaw Bay watershed. Various committees are guiding the development and implementation of a strategy for storm water management and the development of a water quality monitoring program for the watershed. The focus is on non-regulated urban or suburban municipalities in the watershed.

EPA Urban Source Reduction Project. 1994. This U.S. Environmental Protection Agency project will demonstrate the use of GIS to develop and implement urban runoff, storm water management, and pollution prevention strategies within the Saginaw Bay watershed.

Thumb Livestock Manure Management Demonstration Project. 1994. This multi-agency (MSU-Extension, SCS, ASCS, MDNR) locally supported demonstration project addresses locally-identified, site-specific, manure management issues. The project involves a systematic, team approach to problem solving and decision making to provide producers with environmentally sound and economically feasible manure management practices. A comprehensive Manure Management Handbook for producers and agency personnel will also be developed for use as a resource manual.

Saginaw Bay National Watershed Initiative Soil Erosion and Sedimentation Control Program. 1991-1994. The purpose of this multi-agency, federally funded (approximately $550,000 annually), nonpoint source program is to protect and improve the water quality of Saginaw Bay and the Saginaw Bay watershed by controlling erosion and sedimentation; limiting the input of associated nutrients and toxic contaminants; minimizing off-site damages to streams, fish and wildlife habitat, and recreational facilities; and monitoring the progress achieved.

The following projects are a partial list of erosion control or related activities funded by this program. Some additional projects funded under this program are listed elsewhere in this summary under relevant topic headings.

FY 1993

Huron SCD	-	Bird Creek project
Gladwin SCD	-	Northern Tittabawassee River project
Shiawassee SCD	-	Agricultural BMPs
Gladwin/Clare SCDs	-	Tobacco River, livestock exclusions
Tuscola SCD	-	Allen Drain, filter strip follow-up
Bay/Midland SCDs	-	Windbreaks, vegetative row barriers and buffer strip establishment
Sanilac SCD	-	Cass River watershed agricultural BMPs
Iosco SCD	-	Au Gres and Rifle rivers agricultural BMPs
Huron Extension	-	Controlled drainage
Fenton/Lvgstn SCDs	-	Shiawassee River watershed
MSU Exten Hrn Co	-	Bean and beet no-till demonstrations
MSU Extension	-	Farm-A-Syst homeowner implementation (6 counties)
MDNR LWMD	-	Soils encoding into MIRIS system (1 county)
Saginaw Bay RC&D	-	to supply SCDs that receive Soil Erosion Control grants through the Initiative with engineering expertise

FY 1992

Lapeer SCD	-	Watershed protection project
Saginaw SCD	-	Soil erosion control program
Sanilac SCD	-	Cass River watershed project
Genesee SCD	-	Soil erosion control program
Shiawassee SCD	-	Soil erosion control program
Bay SCD	-	Soil erosion control program
Tuscola SCD	-	Allen Drain watershed project
Livingston SCD	-	Shiawassee River watershed project
Gladwin SCD	-	Little Sugar River erosion control project
Bay County Drn Com-		Crump Drain water quality project
ECMPDR	-	Soil erosion training materials
ECMPDR	-	Digital GIS soils encoding

FY 1991

- Six Soil Conservation Districts (Arenac, Genesee, Livingston, Midland, Saginaw and Shiawassee) received funds to provide technical assistance for the implementation of best management practices.
- One soil erosion specialist for the basin was supported to provide enhanced soil erosion and sedimentation control.
- The Bay County SCD was provided start-up assistance to become a county enforcing agency for soil erosion and sedimentation control.
- Two counties (Bay and Saginaw) were provided funds to coordinate efforts between local public health departments and county drain commissioners to identify and eliminate improper sources of nutrients, sediment and toxic contaminants to storm drains.
- Arenac County received assistance for the development of an engineering study to determine the cost-effective alternative for correction of the soil erosion problem in Whitney Drain.
- Development of computer capability to combine environmental quality and land use management information in the Saginaw Bay watershed for accessibility and use by local governments and organizations.

Resource Conservation and Development Area Nonpoint Source Projects. 1992-ongoing. The RC&D has been involved with the following nonpoint source projects and several other stabilization and shoreline control projects in the Saginaw Bay watershed.

1994. $31,000 for 12 Innovative Erosion Control Practices (Huron, Sanilac, Bay Gladwin, Arenac, Genesee, Clare, Tuscola, Gratiot, and Midland counties, Pheasants Forever, Shiawassee Parks).
1994. $15,000 for three hydroseeder demonstrations (Clare, Gratiot, and Sanilac counties).
1994. $42,000 for abandoned well closures.

1993. A $10,000 Saginaw County Streambank Stabilization project for Immerman Park using tree revetments.
1993. A $50,000 Saginaw County Planning Grant for Swan Creek.
1993. A $80,000 project for stabilizing the North Cedar River Road stream crossing in Gladwin County.
1993. A $52,000 Conservation/Drain Credit Study (proposed for Section 604(b) funding) to develop a system of reward (i.e. property tax/drain assessment reduction) for farmer's controlling erosion and maintaining drains. The Michigan Association of Drain Commissioners will also be taking part in the program to determine if related changes are needed in the state drain code.
1992. A $104,000 engineering study of the Whitney Drain in Arenac County to develop plans to stabilize the bottom and side slopes of the drain.

1992. A $49,000 Northern Tittabawassee River Watershed Planning Grant to do a streambank inventory and survey of homeowners for land use practices in Gladwin County.

RC&D Direct Grant Demonstration Project. 1994. The Saginaw Bay RC&D received an SBNWI grant to distribute financial assistance directly to landowners to improve water quality locally. The first phase of this project will give farmers, road and drain commissioners, and district organizations, small implementation grants to provide soil conservation measures. In the second phase, a minimum of 70 landowners will receive cost share incentives and an intensive educational campaign to promote proper sealing and capping of abandoned wells.

Michigan United Conservation Clubs Land Use and Zoning Study. 1992-1993. A $55,000 study to investigate links between land use decisions and environmental problems with the Saginaw Bay watershed and to assess the cumulative impact land use decisions may have on water quality. The 200-page report provides a historic and geographic overview of the watershed; reviews social influences on key economic, demographic and environmental quality data, providing an indication of the possible future these trends predict; examines the institutional structure for land use control and environmental protection, identifying barriers that may exist to achieve environmental quality objectives; and explores strategies that could assist in reversing the trend of environmental degradation, including potential future efforts needed to provide information to local decision-makers that will result in greater protection of water resources.

ECMPDR Urban Turfgrass Project. 1993-1994. A $50,000 East Central Michigan Planning and Development Region 604(b) funded study of managing turfgrass in the urban environment to maintain and protect water quality.

Genessee County SCD - Kearsley Creek Watershed Project. 1993-1994. This urban area project demonstrates practical nonpoint source conservation practices to lawn care businesses, homeowners, agricultural producers, and golf course operators. Implemented actions include filter strips, wetland restoration, turf-grass management, demonstration farms, and integrated crop management.

Sebewaing River Intercounty Drainage Board - Sebewaing River Watershed Management Project. 1993-1994. This project identifies the sources and methods of erosion for sediment and nutrients to address water quantity and quality issues in the Sebewaing River watershed. The project focuses on non-erosion BMPs, storage of storm water runoff, urban storm water management, agricultural operations, and drainage.

MSU-Shiawassee County, Site-Specific Farming Demonstrations. 1993-1994. Through the use of site-specific farming techniques, this demonstration project will address the over-application of fertilizers and pesticides on a field that sometimes occurs because of variation in soil characteristics within a field. This is done by separating and treating different soil types within each field with individualized application rates.

MSU Cooperative Extension Service Farmstead Assessment Project. 1992. A $75,000 project to assist farmers in learning the importance of pesticide storage as it relates to water quality in the watershed. Model pesticide storage structures were to be built on selected farm sites and a video produced to educate others about storage structures.

USDA Saginaw Bay Water Quality Demonstration Project. 1991-1995. The U.S. Department of Agriculture (USDA) will spend about $1.7 million to encourage farmers and agribusinesses in Saginaw, Tuscola, Bay and Huron counties to utilize BMPs to decrease phosphorus and sedimentation in Saginaw Bay, and agricultural pesticide and nitrate contamination in surface and groundwater.

SCS South Branch Kawkawlin River Watershed Project. 1991-2000. This $2.1 million, 10-year U.S. Soil Conservation Service (SCS) effort is an agricultural best management practice implementation project designed to improve river water quality by reducing sediment and phosphorus loads to the watercourse by approximately 70%.

Bay SCD South Branch Kawkawlin River Implementation Project. 1990-1993. The Bay County Soil Conservation District (SCD) received $163,340 to be used over a three-year period to implement BMPs within the South Branch of the Kawkawlin River watershed. The grant is designed to help accelerate a USDA PL-566 project (described above) in the watershed. The Bay SCD is working one-on-one with the farmers to develop and implement conservation plans which will lead to improved water quality on the South Branch of the Kawkawlin River. The BMPs installed with 319 monies include: filter strips, grade stabilization structures, and streambank protection practices.

Sanilac SCD Duff Creek Implementation Project. 1990-1996. The Sanilac SCD received a 319 grant for $25,180 in FY90 to conduct a planning project within the Duff Creek watershed in Sanilac County. In 1992, the SCD was awarded $188,235 to support the implementation of the plan including constructing livestock waste management facilities in the most critical areas of the Duff Creek watershed, as well as nutrient testing, conservation tillage, and side inlet structures. The ASCS Water Quality Incentive Project also awarded $188,000 to the Duff Creek Project to help landowners implement BMPs. These activities address the elevated levels of turbidity, nutrient runoff, bacteria and sedimentation. Agriculture comprises 75% of the land use in the watershed and includes a large number of dairy farms.

Isabella SCD North Branch Chippewa River Implementation Project. 1990-1994. The Isabella SCD received $36,000 in FY90 to perform a stream assessment, determine water quality problems and causes, and develop a practical implementation plan for the North Branch of the Chippewa River. In FY91, the Isabella SCD received $200,000 in 319 monies designated specifically for Areas of Concern to implement the first two years of the plan. In addition, the East Central Michigan Planning Development Region (ECMPDR) received a 604(b) grant for $33,818 to perform water quality monitoring on the North Branch of the Chippewa River. ECMPDR contracted with Central Michigan University to evaluate water quality in the watershed emphasizing biological indicators including: algae, macrophytes, benthic macroinvertebrates, and fish. The monitoring was also to include biweekly and event sampling of the watercourse for physical and chemical parameters to aid in habitat evaluation. In FY93, the Isabella SCD received an additional $100,000 in 319 funds for further implementation of the plan.

Tuscola SCD Allen Drain Implementation Project. 1990-1993. The Tuscola SCD received a 319 grant for $20,450 in FY90 to address pollution from extensive agricultural production in the Allen Drain watershed in Tuscola County. Row crops comprise 94% of the land use in the Allen Drain watershed and primarily are corn, sugar beets, dry beans, and soybeans. The SCD developed a comprehensive work plan to reduce sediment and nutrient loading to Allen Drain and the Saginaw Bay. The Tuscola SCD received $84,970 to implement this work plan from the Saginaw Bay Soil Erosion Control Program in FY92.

Arenac SCD Big Creek Planning Project. 1990. The Arenac County SCD received $30,504 in 319 funds to develop a plan to address nonpoint source pollution in Big Creek.

MSU/Huron County, Saginaw Bay Subirrigation/Drainage Project. 1986-ongoing. This multi-agency effort is designed to determine the feasibility of subirrigation (through underground tile networks) in the Saginaw Bay area with respect to soil suitability, water availability, water quality impacts, socio-economic impacts, and engineering needs. Michigan State University (MSU) has been conducting research on the effects of subirrigation on drainage outflow water quality at a clay soil research site near Unionville since 1986. In 1989, data on overland flow volume and water quality was also collected at this site. In 1991, MSU began a subirrigation rainshelter project with the capability to control rainfall and the water table for up to 40 research plots to enhance the development of subirrigation management guidelines to optimize water quality benefits.

HABITAT

Wetlands Research, Inc., Quanicassee River Watershed Study. 1994-1995. A collaborative project funded by the Great Lakes Protection Fund to provide state and local watershed planners information to help link wetlands restoration and water quality management plans.

SCMPC Urban Stream Restoration Project. 1994-1995. This Saginaw County Metropolitan Planning Commission project seeks to identify and restore urban streambanks for the dual purpose of protecting and maintaining riparian wildlife habitat, and controlling erosion.

MDNR Inventory of Historical Wetlands of the Saginaw Bay Watershed. 1992-1993. This Michigan Natural Features Inventory project used General Land Office surveys conducted between 1816 and 1856 to identify the location, extent, and type of wetlands, and the general nature of surrounding uplands, as they existed prior to wide-spread European settlement. This information was digitized into the MDNR MIRIS system. The data provides a historical benchmark for wetland-related projects within the Saginaw Bay watershed.

SVSU/PSC Saginaw Bay Wetland Restoration Project. 1993-1994. This $55,000 Saginaw Valley State University/Public Sector Consultants project will consolidate and evaluate Saginaw Bay watershed information that can be incorporated into the statewide

wetland strategy. It will also provide tools for local, state, and federal interests to utilize in their development of local wetland protection and restoration projects.

Lapeer SWCD Wetland Training/Restoration Program. 1993-1994. This $56,000 22-county training and implementation project has resulted in 17 wetland restorations encompassing 23 acres, with 13 additional restorations scheduled for 1994, in the Saginaw Bay watershed.

MDNR Saginaw Bay Area Habitat/Recreational Investment. 1987-ongoing. The MDNR had purchased $7 million worth of land in the Saginaw Bay vicinity from 1987 through 1990 to preserve important habitat and provide recreational opportunities. The department has also awarded $7 million in grants to local communities to improve recreational access and use.

U.S. Fish and Wildlife Service Wetland Restorations. Ongoing. Pursuant to the Food Security Act, Partners for Wildlife, and the North American Waterfowl Management Plan, the FWS has implemented a private lands wetland restoration program.

POINT SOURCE FACILITY IMPROVEMENTS/CONTROLS & ACT 307 SITE ACTIONS

Sites Along the Saginaw River

Consumers Power Company Karn-Weadock Power Plant. Actions are underway to clean up BTEX contamination at this Act 307 site.

Union Oil Terminal. Soils contaminated with petroleum related pollutants, including BTEX and acetone, have been excavated and contamination issues at this Act 307 site are being addressed.

City of Essexville. The Essexville WWTP has a schedule for upgrading of their wastewater treatment capabilities in their new National Pollutant Discharge Elimination System (NPDES) permit. An upgrade should lessen the frequency/volume of partially treated combined sewage overflows at the facility. It will also improve treatment reliability with a second oxidation tower and extend the plant's outfall into the river. The City is also evaluating an alternative of joining with the West Bay County system. In any case, CSOs will be controlled.

Dow International Terminal (ITI). An interim response is in place at this Act 307 site and there are ongoing site remediation activities taking place to clean up soils contaminated with petroleum related contaminants, BTEX, lead, styrene, and chlorobenzene. Groundwater is being routed to West Bay County WWTP.

City of Bay City. The MDNR escalated enforcement against the City of Bay City in June 1992. The Notice Of Violation cites the city for PCB violations and failure to implement certain requirements of their Industrial Pretreatment Program. Follow-up discussions have occurred in an effort to get the city back into compliance.

General Motors Powertrain (formerly GMC-CPC and then GM Engine Division, Bay City) PCB Control. Numerous clean up and corrective actions have been taken at this Act 307 site at a cost of millions of dollars. A Consent Judgement has been negotiated for a PCB minimization Plan and Remedial Investigation/Feasibility Study. The December 1992 settlement was for $2.5 million. Prior to that, General Motors had installed a 65 ft deep bentonite slurry wall around a PCB contaminated upland area to prevent PCB migration to the Saginaw River via groundwater flow. Facility sewers were also cleaned to remove PCB contaminated sediments and an ongoing groundwater capture system is in place. New treatment facilities treat the discharges to the Saginaw River and the city with activated carbon.

Surath Scrap Yard (City of Bay City is PRP). Substantial amounts of soil contaminated with petroleum related products and PCBs have been removed from this Act 307 site.

West Bay County WWTP. This facility is developing local limits for their Industrial Pretreatment Program to reduce toluene concentrations in their sludge. Other work continues to evaluate compliance with leachate treatment received at the POTW.

Hirschfields Salvage Yard. A Remedial Investigation is underway to address soils contaminated with petroleum related pollutants and heavy metals.

CSX Property (formerly Defoe Shipyard). A Remedial Investigation is underway.

Bay City Electric Department. A Remedial Investigation is underway to address soils with petroleum contaminants.

Prestolite Motor. This facility has been closed. Site remediation of solvent contamination has included groundwater capture and rerouting to the Bay City WWTP.

Middlegrounds Landfill (City of Bay City). The landfill has been closed, capped, and groundwater monitoring wells installed. Interim Response activities to address dissolved phase PCB movement to the river from groundwater are currently being discussed. There is considerable contamination at the site and it is expected to be placed on the federal superfund list in February 1995. Beginning fall 1994, the U.S. EPA and MDNR will conduct an engineering evaluation/cost analysis study on the clean-up of the most contaminated part of the landfill. The EPA plans to clean up this portion of the site (Monitor Well 8 Area) next spring under a non-time critical removal action. The EPA plans to address the rest of the site under the EPA remedial program, which requires a lengthier investigation before the rest of the site can be cleaned up.

Morley Park (City of Saginaw). This Act 307 site has been cleaned up and is expected to be delisted soon if latest groundwater samples confirm no contamination remains.

Sargeant Docks and Terminal. An Act 307 Remedial Investigation of PNA contamination is underway.

General Motors Grey Iron (Central Foundry) Wastewater Treatment. A new wastewater pretreatment system was constructed at this facility in 1989 to treat wastewater before delivery to the Saginaw WWTP, eliminating the direct discharge to the Saginaw River. PCB oils were detected in a building basement and cleaned up under Act 307.

General Motors Nodular Iron Plant (Central Foundry). Remediation of contaminated groundwater and termination of the NPDES permit are still pending at this Act 307 site. Groundwater and some storm waters are temporarily being sent to the City of Saginaw WWTP during demolition of the facility.

The Zilwaukee-Carrollton Township-Saginaw Township WWTP. The wastewater treatment plant in Zilwaukee was shut down in the fall of 1991. Wastewaters are now sent to the City of Saginaw WWTP for treatment. The city maintains the same phosphorus loading they had before the regionalization. The Zilwaukee plant site was analyzed for contamination and the tankage was demolished.

Michigan Sugar Company, Carrollton. The MDNR resolved the contested case hearing issue granted to Michigan Sugar Company-Carrollton in 1988. The company is implementing a program to achieve complete control and eliminate discharge of bacterial slime flocs to the Saginaw River. A revised NPDES permit was issued requiring additional controls on other parameters, including a 1.0 mg/l phosphorus limitation on both of the company's outfalls. A Toxicity Identification/Reduction Evaluation (TI/RE) has been required to identify and eliminate the cause of aquatic toxicity on the company's discharge.

General Motors Malleable Iron. This Act 307 site is a known source of PCB contamination to the Saginaw WWTP. Negotiations are ongoing to establish and implement a site RI/FS.

City of Saginaw Combined Sewer Overflow Corrections. The city's discharge permit (issued October 1989) mandated a phased construction schedule for six new retention treatment basins (there is already one) at an estimated cost of $90 million. Two basins went into operation in 1992 and construction of the other four will be completed in 1995. In addition, a 1.9 million gallon in-line storage system is planned. The 14th Street retention basin won the First Place Design Award by the Michigan Consulting Engineers Council in the 1993 Engineering Excellence Competition, and the city has been nominated for the 1994 National Combined Sewer Overflow Control Program Excellence Award. The city has commenced an intensive monitoring and modeling program of the basins and remaining CSO outfalls. The city also has a new chlorination/dechlorination system, and a new computerized control center for the plant and the seven basins is currently being installed.

Weiss Street Retention Basin. One of six storm water retention basins being constructed by the City of Saginaw to control CSOs. Work to evaluate treatability of contaminated soils and develop a Remedial Action Plan for this Act 307 site continues. Treatability studies were conducted in fall 1992 for 150,000 cubic yards of soils now stored for remediation at the site. Remediation activities will apply to additional soils from all the retention basin site excavations, which will be transported to the Weiss Street site. A remedial action plan was submitted to MDNR's Environmental Response Division in July 1994. Review discussions have begun.

Fraternal Order of Police. An Act 307 Remedial Investigation of PNA and benzo(a)anthracene contamination is underway.

Ferro Met Salvage Yard. An Act 307 Interim Response is being conducted to clean up the most contaminated areas.

Natural Resource Damage Assessment. A NRDA was filed June 29, 1994 for the Saginaw River and Saginaw Bay by the Michigan Attorney General and the MDNR Director. Settlement discussions are ongoing.

Sites Along the Tittabawassee River

Saginaw Township WWTP. This municipality constructed a new $9 million WWTP (to replace the old one) in 1988. The system has one CSO outfall, but in June 1991 a new $3.25 million retention basin was made operational to reduce the frequency of overflows, preventing 43 MG of excess raw sewage flow from reaching the river in 1991 alone.

Dow Chemical Company (Midland). The company is operating under a Final Order to conduct additional end-of-pipe treatment technology studies on further reducing dioxin discharge to the Tittabawassee River from the current level of approximately 0.1 gram/year. The NPDES permit is being developed for reissuance in 1995.

Dow Corning - Midland. Spills of hazardous materials have occurred from the plant site to the Tittabawassee River via Lingle Drain. Various cleanups have been conducted.

City of Midland WWTP. The facility was upgraded to improve treatment and increase capacity to 10 MGD. The new preliminary treatment processes, oxidation ditch, sludge digester, chlorination and dechlorination facilities, and other improvements allow the city to meet permit limits and accommodate growth needs.

City of Midland CSOs. The city and the MDNR resolved the contested case issues for their NPDES permit issued in 1989. The reissued NPDES permit sets a schedule to complete combined sewer separation in the remaining 5-10% of the combined sewer district. Separation is to be completed by December 1995 and will eliminate frequent CSOs in the city.

Other Sites

Portsmouth Township. In 1994, the township completed construction of a new collection system with connection to the Bay City treatment plant. MDNR SWQD staff repeated sanitary surveys there in 1990, which led to a Director's Order and agreement by the township and Bay County to complete the construction. SRF funds were used to assist local financing.

Community of Bay Port. This Fairhaven Township, Huron County, community has constructed a new collection system of pressure sewers and a wastewater stabilization pond system. Residential connections were to be made in fall 1992 and spring 1993.

Village of Caseville. The village's new collection and treatment system became fully operational in fall 1991.

Enforcement Against Barrel Dumping. A settlement for $10,000 plus costs was reached in 1992 with a Saginaw area commercial establishment for dumping contaminated waters from barrels into parking lot catch basins. This action should serve as a deterrent to other industry and businesses to not dispose of wastewaters or wastes improperly or illegally.

Hemlock Semiconductor. In spring 1991, the company improved the operation and maintenance of their wastewater stabilization lagoon which discharges to McClellan Run. They had been repeatedly violating their NPDES permit since 1986. The changes have significantly improved effluent quality. The facility is conducting ongoing tests on its 002 outfall to identify the source of intermittent aquatic toxicity.

City of Marlette WWTP. The City entered into a consent judgment in 1988 to implement a Corrective Action Plan (CAP) to improve the WWTP influent flows and reduce and alleviate CSOs. The City failed to complete all of the required items and in 1994, they entered into an amended consent judgment and agreed to pay stipulated penalties of $10,000. The City recently secured a $700,000 loan to complete the remaining construction, which is scheduled to begin in the fall of 1994.

Buena Vista Township. Construction is partially complete for a project to handle wet weather flows and prevent raw sewage bypasses in Buena Vista Township, Saginaw County. The township is under a Director's Final Order issued in October 1991 which established a fixed date schedule for correction of bypasses and upgrading the township's WWTP. New relief pump stations, forcemain, and expanded retention basin was completed in 1994. WWTP upgrades began in 1994. The township received SRF loan financial assistance.

ENVIRONMENTAL ASSESSMENT/RESEARCH PROJECTS

EPA Saginaw Bay Watershed Ecocriteria Project. 1993-1995. A research characterization of the Saginaw Bay watershed (approximately 36 locations) on a stream order basis in order to determine watershed attributes that control stream features, identify associations among upstream habitat refugia and biological community structure, and develop a landscape model for predicting habitat and chemical quality and biotic composition. This project builds on the data results obtained in the 1990-1994 EPA biocriteria project.

MSU Cass River Watershed Project. 1993-1994. This Michigan State University project models agricultural nonpoint source pollution potential to identify critical risk areas for implementation of water quality programs. It is an integrated model that assesses the combined loading potential of sediments (including streambank, wind and land erosion), animal manure, pesticides, and fertilizers at the watershed scale.

NOAA Saginaw Bay Zebra Mussel Project. 1990-1995. A National Oceanic and Atmospheric Administration (NOAA) multi-year project to determine the impact of zebra mussel colonization on Saginaw Bay water chemistry and biological communities. During 1991 and 1992, 26 stations throughout Saginaw Bay were sampled monthly from April through November for nutrients, phytoplankton, zooplankton and benthos. The project continued at a reduced level in 1993 and 1994 with 12 stations. At selected stations measurements were made on various community functions (e.g. primary production, zooplankton production and grazing, zebra mussel growth rates, etc.) and physical characteristics such as current patterns and sediment mixing. The project is expected to continue for another year, though the level of effort and specific activities undertaken may vary depending on the previous years' results and funding levels. Computer modeling of the results will also be conducted to predict future conditions in Saginaw Bay based on various nutrient loading and zebra mussel colonization scenarios.

University of Michigan Saginaw Bay Tributary Data Analysis. 1993-1994. A project to improve the utility of recent water quality datasets by analyzing and jointly interpreting nutrient, suspended solids, and contaminant data from several of the studies of Saginaw Bay tributaries described below. This multi-dataset comparison of concentrations, transport and loads will complement the NOAA modeling study of Saginaw Bay described above.

MDNR Atmospheric Transport Study. 1991-1994. A statewide project, of major importance to Saginaw Bay, to investigate the levels, transport, and sources of toxic contaminants in the atmosphere.

University of Michigan Study of Atmospheric Transport of Mercury. 1991-1994. A second statewide air project, of major importance to Saginaw Bay, to assess the magnitude, seasonal variation, and sources of atmospheric mercury in Michigan.

MSU Multimedia Inventory of Bioaccumulative Chemicals of Concern. 1994. Development of an inventory of the distribution, quantities and sources in the Saginaw Bay watershed of the 28 BCCs identified in the EPA Great Lakes Initiative.

MDNR Tributary Load Sampling. 1991-1992. The Michigan Department of Natural Resources temporarily expanded its tributary sampling effort on Saginaw Bay tributaries in spring/summer 1991 and fall 1992, to provide data on nutrient loads to Saginaw Bay. This work was conducted to provide data for the nutrient modeling to be done as part of the NOAA zebra mussel project described previously. Eleven tributaries (12 stations) were sampled for nutrients a minimum of twice a month with additional sampling taking place during high river flow conditions following storm events. Special effort was directed at obtaining water discharge volumes from the coastal basin tributaries.

ECMPDR/U-M/SVSU Tributary Load Sampling. 1991-1992. The East Central Michigan Planning and Development Region (ECMPDR), the University of Michigan (U-M) and Saginaw Valley State University (SVSU) took over the MDNR expanded tributary sampling effort, described above, in October 1991 and continued this effort through September 1992. ECMPDR sampled the same 11 tributaries every two weeks. They collected samples from 26 tributaries an additional nine times during high flow conditions following storm events. U-M and SVSU conducted the laboratory analysis of samples.

MDNR/ECMPDR Pesticide Monitoring Project. 1991-1992. In the course of conducting the above two projects, the MDNR and ECMPDR collected water samples for pesticide analyses at selected streams tributary to Saginaw Bay following a limited number of storm events that occurred after pesticide application.

MDNR Act 307 Toxics Project. 1988-1989. A survey of organic and heavy metal contaminants in the sediments, water and biota of the Saginaw River and Saginaw Bay to identify the extent and magnitude of the toxic material problems (including the impact of contaminated sediments), identify contaminant source areas, determine the effect of the September 1986 flood on known contaminated sediment areas in the Saginaw River, identify remedial alternatives, and conduct a feasibility study for implementing remedial alternatives. Specific activities included sediment sampling at over 200 sites throughout the Saginaw River and Saginaw Bay, and mouths of tributaries to each; evaluating relative ambient water concentrations of 130 organic, 21 metal and 29 conventional parameters at tributary mouths; and assessing CSO impacts on the Saginaw River.

EPA ARCS Project. 1988-1994. The U.S. Environmental Protection Agency conducted an Assessment and Remediation of Contaminated Sediments (ARCS) project in the Saginaw River. The Saginaw River was one of five AOCs selected (the only one in Michigan) under this national demonstration program to assess the nature, extent and impact of bottom sediment contamination; evaluate and demonstrate remedial options; and provide guidance or tools for the assessment of contaminated sediment problems and the implementation of necessary remedial actions in other AOCs. Specific activities in the Saginaw River (lower 10 miles) included sediment sampling and acoustic profiling; sediment bioassays (acute toxicity, chronic toxicity, mutagenicity, bioaccumulation); benthic community structure evaluation; Toxicity Identification Evaluation (TIE) tests to identify the contaminant, or class of contaminants, causing acute toxicity in the sediment; evaluation of remedial technologies; sediment hazard assessments focusing on human health, aquatic life, and wildlife endpoints; fish tumor survey; mini mass balance modeling (exposure, foodchain, sediment resuspension/transport); fish tissue analysis; water column sampling; and development of a remediation concept plan describing logistical and engineering considerations that would be part of a full scale clean-up of contaminated sediments under a variety of scenarios.

EPA ARCS Sediment Treatment Technology Pilot Demonstration. 1991-1992. A sediment treatment technology was tested on the confined disposal facility in Saginaw Bay as part of the EPA ARCS program described above. Bergmann USA, demonstrated a hydrocyclone particle separation process to separate dredged sediments into two major fractions: the relatively clean sand, and the contaminated fine-grained silts and clays. This technology could potentially reduce the volume of contaminated dredge material that would need to be confined or treated.

Eco Logic International, Thermal-Chemical Hydrogenation Project. 1991-1992. Eco Logic International, a Canadian firm, tested a treatment technology for water and sediments contaminated by toxic organics. This technology uses extremely high temperatures to destroy the molecular structure of chlorinated hydrocarbons, reducing them to water, methane and HCL, without using oxygenation. The test was conducted on Middlegrounds Island in the Saginaw River and was funded by EPA's Superfund Innovative Technology Evaluation program.

EPA Saginaw Bay Watershed Biocriteria Project. 1990-1994. A research characterization of the Saginaw Bay watershed (approximately 70 locations) on a stream order basis in order to develop diagnostic procedures for analyzing aquatic biota impacts from impaired stream reaches and formulate methods to evaluate regulatory strategies in clean-up activities. Specific activities include toxicity testing of sediment pore water and ambient river water; assessing benthic macroinvertebrate community structure; general habitat characterization; water and sediment chemical analysis; and evaluation of sediment transport.

EPA Zebra Mussel Contaminant Level Survey. 1992-1993. EPA collected zebra mussels from navigation buoys throughout the length of Saginaw Bay and part way up the Saginaw River to measure tissue contaminant levels.

EPA Study of Saginaw Bay Confined Disposal Facility (CDF). 1987-1989. A study to determine whether contaminants are being transported through the dike walls and if so, whether transported contaminants are present in sufficient quantities to be bioaccumulated by biota surrounding the facility. The results indicated that distinct transport phenomenon could not be demonstrated.

MDNR Fisheries Inventory and Classification Study of Warmwater Streams. 1987-1994. New electrofishing data is supplementing historical rotenone collections from up to 15 years ago to describe fisheries resources and correlate these with watershed and habitat characteristics. Data from approximately 85 sites in the Saginaw Bay basin will be included in this project, which is expected to cover about 330 sites throughout lower Michigan. Headwater locations are being investigated along with tributary and mainstream areas.

EPA Great Lakes Ecological Process Pilot - Saginaw Bay. 1991-1994. This project will develop a multi-resolution digital database for characterizing Saginaw Bay and its coastal zone land area utilizing a multi-stage remote sensing approach. The database will be evaluated for use in regulatory programs, habitat inventories, watershed analyses, and environmental monitoring programs. The database will also be used to develop sampling frames for 1994 ecosystem process studies on origin-transport-fate modeling scenarios.

Michigan State University Study of Saginaw Bay Wetlands. 1990-1992. Measurements focused on wetland zooplankton communities.

ECMPDR/U-M/MSU Sediment Transport Project. 1990-1992. The East Central Michigan Planning and Development Region, University of Michigan and Michigan State University conducted an assessment of tributary bedload and suspended sediment transport characteristics and loads in the Saginaw River, its four major tributaries, and eleven direct tributaries to Saginaw Bay.

NOAA Benthic Macroinvertebrate Survey of Saginaw Bay. 1987-1989. A three-year characterization of benthic macroinvertebrate communities at 40 stations throughout Saginaw Bay.

MDNR Benthic Macroinvertebrate Survey of Saginaw Bay. 1986-1988. A three-year assessment of the benthic macroinvertebrate forage base for Saginaw Bay fish populations, which was coordinated with the NOAA project.

MDNR Fixed Station Ambient Water Monitoring Program. 1990-1994. The program was expanded from six stations to thirteen stations in the Saginaw Bay watershed during 1990. Stations are sampled monthly. All 28 tributaries to Saginaw Bay were sampled under this program at least once during the five-year period.

MDNR Air Monitoring Project. 1990-1991. This one-year project monitored ambient air sampled at Bay Port for five pollutant groups (PCBs, PAHs, HCB, dieldrin and trace metals) to develop current baseline data.

MDNR Caged Fish Studies. 1988 and 1993. Caged channel catfish were used to measure contaminant uptake rates and trends in the Saginaw River and its tributaries.

NOAA Sediment Bioassay Project. 1988. Conducted Saginaw Bay sediment bioassays on the amphipod Pontoporeia.

U.S. Fish and Wildlife Service Sediment Bioassay Project. 1987-1988. Conducted Saginaw Bay sediment bioassays on the Hexagenia mayfly.

MDNR Sediment Bioassay Project. 1988. Measured in situ survival of the Hexagenia mayfly in selected areas of Saginaw Bay. Good survival rates were documented.

MDNR and University of Michigan Larval and Young-of-the-Year Walleye Surveys. 1987-1988. Surveys of the Saginaw River, selected Saginaw Bay tributaries, and Saginaw Bay to evaluate extent of walleye natural reproduction.

MDNR Hexagenia Mayfly Stocking. 1989-1992. An attempt to re-establish this historically abundant benthic macroinvertebrate by stocking eggs or nymphs at selected locations in Saginaw Bay.

MDNR Fish Contaminant Monitoring Program. 1988-ongoing. Fish tissue analysis to (1) assess contaminant levels relevant to public health fish consumption, (2) determine body burden trends, and (3) check for any emerging toxicant problems or newly impacted areas. The following Saginaw Bay watershed locations have been sampled since 1988: Cass River, Cheboyganing Creek, Kawkawlin River, Pine River (Gratiot Co.), Rifle River, Saginaw Bay, Saginaw River, Sanford Lake, Sebewaing River, Tawas River, and Tittabawassee River.

MDNR Walleye Egg Contaminant Assessment. 1989. Contaminant concentrations in walleye eggs collected from Tittabawassee River brood stock were found to be generally the same or less than those from Muskegon River brood stock that were used as controls.

MDNR Whole Effluent Toxicity Testing Program. 1988-ongoing. Designed to assure that discharges do not cause unacceptable toxicity, 54 whole effluent toxicity tests were conducted at 28 facilities in the Saginaw Bay watershed from 1988 through 1990.

MDNR Biological Stream Assessment Surveys. 1988-ongoing. Designed to determine stream water quality as indicated by resident biological community structure. Twenty-six rivers have been surveyed in the Saginaw Bay watershed since 1988 including the following: Allen Drain, Au Gres River, Bad River, Big Creek, Big Salt River, Birch Run Drain, Cass River, Chippewa River, North Branch Chippewa River, Gregory Drain, Johnson Drain, South Branch Kawkawlin River, McClellan Run, Northwest Drain, Pigeon River, Pinconning River, Pine River (Arenac), Pine River (Gratiot), Quanicassee River, Railroad Drain, Rifle River, Saganing Creek, Shiawassee River, Sturgeon Creek, Swan Creek, Tebo Drain, Tittabawassee River, Tobacco River, White River, Whitefeather Creek and Wiscoggin Drain.

U.S. Army Corps of Engineers Saginaw River Sediment Survey. 1988, 1992 and 1993. Surveys of sediment contaminant concentrations in the Saginaw River navigation channel.

U.S. Fish and Wildlife Service Bald Eagle Recovery. Ongoing. Various projects related to the assessment of contaminant impacts on bald eagle reproduction.

Ecological Research Services, Inc. Colonial Waterbird Monitoring Project. 1986-1988. A survey of Caspian Terns at the Saginaw Bay CDF, and of Double-crested Cormorants at Little Charity Island, to evaluate reproductive success.

EDUCATION

Saginaw Public School's Project Jo. 1989-ongoing. An environmental education/monitoring project, originally supported jointly by the school district, General Motors Corporation, and the University of Michigan, to help increase student awareness of the water conditions in the Saginaw River system. The program provides a means for high school, junior high, and elementary students to monitor the water quality of local rivers and learn about the environment. It was the first program of its type in the Saginaw Bay watershed. The projects are multidisciplinary, extend throughout the year, pair older students with younger ones, and include participation in a joint River Project Congress meeting in the spring.

SBWC School River Monitoring Program. 1992-ongoing. This Saginaw Basin Watershed Council program provides a means for high school students to monitor the water quality of local rivers and learn about the environment. The SBWC provides schools with equipment to test nine standard water quality parameters, with the intention that the schools develop long-term, self-sustaining monitoring programs. The projects are multidisciplinary, extend throughout the year, and include participation in a joint River Project Congress meeting in the spring. Forty schools are currently participating in the basin-wide program.

Pigeon Conservation Club Fertilizer and Pesticide Usage Project. 1992. This area-wide conservation project was conducted in the western portions of Huron and Tuscola counties. It educated agricultural producers on the proper use of fertilizers and pesticides including handling, application and disposal. Methods included public meetings, demonstrations by major pesticide manufacturers, field demonstrations, a display booth at the Mother Nature Folk Festival held at Bay City State Park, and distribution of educational materials.

MSU Extension - Huron County, Agriculture Video. 1993. A new MSU Extension video "Agriculture in Transition" illustrates agricultural practices that are being changed to reduce sediment, nutrient and pesticide loads to Saginaw Bay.

Michigan Geographic Alliance Watershed Education Material Development. 1992. This $37,454 joint effort with Central Michigan University and the Institute of Water Research at MSU, was to develop teaching aids and train teachers to educate students about the watershed.

U.S. FWS Management of Green Point Environmental Learning Center.
1993-ongoing. The U.S. Fish and Wildlife Service provided funds to reopen the city of Saginaw's Green Point Nature Center as an environmental learning center, and now manages the facility.

MDNR Development of the Jennison Nature Center. 1992. A $90,000 project to develop new exhibits for the nature center focusing on the ecology of Saginaw Bay and the effects of development in the watershed.

MSU Sea Grant Program Saginaw Bay Poster Development. 1992. A $60,000 project to develop a color poster of the Saginaw Bay basin to educate the public about the watershed and the scope of activities and problems inherent in effectively restoring and protecting the watershed.

Saginaw Bay National Watershed Initiative Watershed Action Grants. 1992-1994. In 1994, the SBNWI will award variety of small grants (approximately $50,000 total) to fund projects, products or services that will take direct action toward restoring or protecting the Saginaw Bay watershed. The emphasis of the Action Grants is on promoting active public participation and educating the public about the need to prevent and control water pollution. The following grants (about $50,000 total) were awarded in 1992.

- Kingston High School, Tuscola County - Test and evaluate water quality of the Cass River.
- Odyssey Alternative High School, Isabella County - Develop wetland interpretive for students.

- Delta College - Develop watershed monitoring station for students.
- Reid Elementary, Genesee County - Develop urban nature preserve.
- Reese High School, Tuscola County - Test and evaluate water quality.
- Mitten/Bay Girl Scout Council, Saginaw County - Hands-on ecological student workshops.
- Hartley Outdoor Education Center - Beaver Creek water quality study.
- Huron County Extension Service - Produce video about agricultural practices that reduce nutrients, pesticides and sediment loads to Saginaw Bay.
- Isabella County RC&D - Produce a county watershed protection guide.
- Alma College - Create Friends of the Pine River organization to promote citizen concern for water quality.
- Saginaw Basin Alliance - Educate citizens about the watershed through environmental displays at a local arts festival.
- St. Charles River Management Committee - Update equipment for citizen involvement in clean-up activities on the Bad River.
- St. Charles High School - Test and evaluate water quality.
- Mid-Michigan Water Quality Consortium, Gladwin County - Test and evaluate water quality and participate in water related field trips.
- Midland SCD - Develop watershed filing system; survey sub-watersheds; participate in watershed planning committees.
- Iosco SCD - Develop watershed slide show to educate citizens about the watershed and its associated problems and to create a sense of responsibility for restoring and protecting the watershed.
- Gladwin SCD - Promote advantages of farm nitrate testing in an effort to reduce nitrate load in the Tittabawassee River watershed.
- Mecosta SCD - Provide manure analysis and soil samples for livestock producers in an effort to reduce fertilizer application and credit nutrients in soil and animal wastes to be applied to cropland.
- Isabella County 4-H - Test and evaluate water quality in the Chippewa, Pine and Salt rivers and share data with groups in other counties.
- Dillon Elementary/Carman-Ainsworth Community Schools - Develop study units regarding watershed endangered plants and endangered plants and animals, water pollution, soil contamination and related career opportunities.

EPA Supercomputer. 1992-ongoing. Bay City is the site of EPA's new supercomputer. EPA is making use of this computer available to local high school students for computer training through special classes or internships.

Consortium for International Earth Science Information Network (CIESIN). 1989-ongoing. CIESIN is a nonprofit corporation founded to facilitate access to, and use of, global change information worldwide. The interim headquarters are located at Saginaw Valley State University and CIESIN is developing an integrated workstation for the Saginaw Bay watershed.

Saginaw Bay National Watershed Initiative Wetland Education. 1991. Two projects focusing on the environmental importance of area wetlands: development of a Saginaw Bay watershed education program; and wetland education training for local officials.

Michigan Sea Grant Saginaw Bay Research Institute. 1990-ongoing. This Sea Grant subprogram is housed at Saginaw Valley State University (SVSU) and its sole focus is Saginaw Bay. Its goal is to foster new research, education and demonstration projects that emphasize common objectives and joint ventures involving pooled resources. One project conducted by this office (funded by MDNR, Michigan Sea Grant, and SVSU) was the development of a comprehensive bibliography of over 700 past research studies/reports on the Saginaw Bay watershed. Copies of approximately 80% of the documents are on hand at SVSU. Efforts are being made to place the bibliography on an electronic network so that researchers can peruse the bibliography from computers at their home institutions. Additionally, project staff are looking into the possibility of scanning the reports into computer memory, enabling users to view or print the actual documents at their own computer stations.

Saginaw Basin Alliance RAP Pamphlet. 1994. The SBA developed an 8-page information pamphlet on the status of the Saginaw River/Bay AOC and the RAP process for distribution to the public.

Saginaw Basin Alliance Radio Announcements. 1994. The SBA put together a series of 20 brief environmental radio "spots" that were played on local stations to help educate the general public on preventing water pollution and enhancing habitat.

Saginaw Basin Alliance Traveling Exhibit. 1994. The SBA constructed a panel display to be used at festivals, river days, etc. to educate the public on environmental issues in the Saginaw Bay watershed.

MISCELLANEOUS ACTIVITIES

CIESIN Computerized Watershed Management System. 1994-1995. The Consortium for International Earth Science and Information Networks (CIESIN) has received $200,000 from EPA to develop and demonstrate a computerized decision-making system using the Saginaw Bay watershed as the demonstration area. The primary focus is to develop a user-friendly computer interface that will be able to access numerous environmental data bases on a watershed basis, retrieve data and meta information from them, and display the information graphically on the screen.

MDA Michigan Clean Stream Program. 1994-ongoing. A new statewide, voluntary, environmental stewardship program, with strong relevance to the Saginaw Bay watershed, intended to provide assistance to rural communities in reducing or eliminating the impact of pesticides, fertilizers, sediments, and other pollutants to surface water. Local partnerships will be established to respond to water quality issues. This program is intended to complement and enhance existing water quality initiatives.

Genessee County Household Hazardous Waste Collection Program. 1994-1995. The Genessee County Health Department is working with the MSU Extension Service, University of Michigan-Flint, GMI Engineering and Management Institute, and the Genessee County Recycling Coalition on this $75,000 project to develop and implement a multi-site consortium driven collection program aimed at establishing necessary support and infrastructure to set up a permanent collection program for Genesee county in the future. The multi-year project will allow these organizations to gain experience in working together, acclimate and educate citizens, and establish mechanisms to generate dollars from municipalities to sustain and on-going program.

Saginaw Basin Watershed Council Adopt-A-Stream Program. 1992-ongoing. This program promotes citizen participation in river clean-up activities in the watershed. "River Days" are typically held in the spring and summer with activities such as clean-ups, macroinvertebrate monitoring, picnics, bands and other entertainment.

Water Watchers Program. 1993-1994. This program, originally developed by the Saginaw Basin Alliance and continued by the Saginaw Bay Watershed Council, trains and certifies local citizens to undertake community projects to protect water quality. Participants are trained on technical and practical water quality issues affecting them including septic systems, stream biology, debris, wetlands, contaminant spills, best management practices, storm water runoff, pesticides, fertilizers and boating.

Bay County Strategy for Expediting Remediation at Sites of Environmental Contamination. 1993-1994. This project will investigate innovative funding approaches, risks and benefits, and state policies, for reuse of contaminated upland sites.

Bay County GIS Demonstration Project. 1993-1994. This project will design and implement a GIS data system to be used in rural planning and management to demonstrate the use of GIS for expediting local progress in addressing issues of concern.

Saginaw Basin Alliance Environmental Congress. 1992-1993. A $35,000 project to form an Environmental Congress with the primary purpose of establishing a core group of interested citizens and interest groups to provide citizen direction to the Saginaw Bay National Watershed Initiative process.

Saginaw Basin Alliance and Bay Arts Council Mother Nature Folk Festival. 1992. SBA organized an environmental display tent at this June 27-28th festival held at the Bay City State Park. Nearly two dozen organizations staffed tables/displays at the tent to educate the public and promote environmental stewardship.

SBNWI Soils and Watershed Encoding. 1991-1994. The Saginaw Bay National Watershed Initiative has provided funding for the encoding of soil series into the MDNR GIS system (MIRIS) for 12 counties in the Saginaw Bay watershed including Tuscola, Huron, Bay, Arenac, Isabella, Livingston, Oakland, Midland, Genessee, Lapeer, Gratiot and Gladwin. Also, all subwatersheds within the Saginaw Bay basin have been encoded.

U.S. Army Corps of Engineers Upper Saginaw River Confined Disposal Facility. 1980s-ongoing. Work continues on the potential siting and construction of a new CDF near Cheboyganing Creek to contain sediments dredged from the federal navigation channel in the Saginaw River.

Michigan Water Resources Commission (WRC) Restrictions on Overflow Dredging in the Saginaw River. 1989-ongoing. In 1989 the WRC expanded the area in the Saginaw navigation channel where hopper dredge overflow is prohibited in order to reduce the exposure of the aquatic community to contaminated bottom sediments during channel maintenance dredging operations. This restriction now applies to two river reaches: (1) between river miles 15.5 and 13.2 downstream of the city of Saginaw, and (2) between river mile 8.6 (upstream end of Middle Ground Island) and the Saginaw Bay CDF.

Saginaw County River Partners Project. 1990-1991. This project was designed to promote local involvement and support for the Saginaw River -- its water quality, natural resource value, and importance to local communities. One outcome of the project was the creation of the Saginaw River Basin Watershed Council of local governments described earlier. A curriculum (for elementary and junior high age students) was also developed for the Saginaw River watershed to increase river awareness. Tittabawassee Township was used as a model community for the development of a storm water retention element in local zoning ordinances.

PROGRESS STATUS

The Saginaw River/Bay RAP process has been very successful to date and has moved forward at a rapid pace. Significant remedial actions are being taken, extensive studies are underway to fill important data gaps, and comprehensive coordination efforts continue among local, state and federal organizations.

For the first time in over a decade, several studies on the environmental status of the Saginaw River, Saginaw Bay and their tributaries, have been recently completed or are currently underway. These projects (1) examine the magnitude of water quality improvements obtained as the result of extensive pollution control actions implemented throughout the watershed over the last decade, (2) determine the areal extent and severity of the remaining problems, (3) identify the sources and causes of these problems, and (4) target priority areas for remediation. Some of these studies are reported on in this RAP document and were used to help identify what additional remedial actions are needed.

Much remains to be done. As with most any issue, available funds are not sufficient for conducting desired levels of effort. Consequently, though many actions are currently being implemented, few of these are being fully implemented due to limited funds. Extensive efforts continue in seeking funding for and ways to expand implemented activities, where necessary, and to begin unimplemented actions.

A new problem, the colonization of Saginaw Bay by zebra mussels, has the potential to significantly impact biological communities and contaminant cycling in Saginaw Bay. This may result in changing remedial actions over time.

All the activity taking place within the scope of the Saginaw River/Bay RAP indicates (1) the enhanced interest in this area since inception of the RAP process; and (2) the belief among local, state and federal organizations that this valuable natural resource can be significantly enhanced. Restoring beneficial uses that are currently impaired will benefit indigenous aquatic life and wildlife as well as the quality of life for basin residents. The support of local communities, general public, private sector, and local, state and federal agencies, for the RAP to date is commendable. By continuing to work together, we can have a substantial impact on restoring impaired beneficial uses in the Saginaw River and Saginaw Bay.

CHAPTER III: LAND USE PLANNING

1. Problem Definition

Many of the ecosystem problems in the Saginaw Bay watershed are the result of land use practices. However, there are numerous gaps and barriers within the institutional framework for land use control and environmental protection that inhibit ecosystem restoration, enhancement and protection. An analysis of the linkages between land use decisions and environmental problems in the Saginaw Bay watershed was needed to identify ways to improve local coordination and implementation of land use planning and zoning decisions. The Saginaw Bay National Watershed Initiative funded the Michigan United Conservation Clubs (MUCC) to carry out this study. MUCC conducted a historic and geographic overview of the Saginaw Bay watershed; a review of the social influences on watershed resources; and, investigated trend information on key economic, demographic, and environmental quality data.

The 1993 study noted two critical points. First, local land use decisions, and the social and economic factors contributing to them, are seldom an important factor in the development and execution of state and federal environmental policies and programs. Similarly, broader statewide and national environmental concerns rarely come up in local land use deliberations. Since each is in some way dependent upon the other, their continued separation will remain counterproductive. In order for the local land use decision forum to become an effective tool for environmental quality management, the linkages between national, state and local institutions need to be better understood and mechanisms for merging their similar policy goals developed.

2. Key Issues and Trends

a. Demographics

1) Population increases in watershed communities have more to do with population shifts than actual population growth. People are migrating from urban and suburban areas to more rural areas in the watershed.

2) Continued new development is occurring in spite of an overall loss of population in the watershed of about 4%. Still, many watershed communities experienced dramatic population increases. As an example, Butman Township in Gladwin County had a population increase of over 43% between 1980 and 1990, while the state overall only had a 0.4% increase.

3) The trend of agricultural land consumption is an indicator of urban sprawl and continues in the watershed. Rural farm populations have decreased an average of 86% in the watershed in 50 years, the number of farms has

decreased by over 70% in just over 40 years, and acreage in farms fell nearly 40% in forty years. While some of the decrease can be attributed to farm consolidation and smaller families, a portion of it is an indication of agricultural land consumption.

4) Fewer people are taking up more space and consuming more land in the watershed. If a community loses population the assumption may be that there is no new development or demand for raw land. This is not the case. Many local governments in the watershed which lost population between 1980 and 1990 actually gained households.

5) The demand for raw land for residential development continues in the watershed. The 22-county area saw some 125,000 new housing units built in the decade of the 1980s, even in light of a recession during that time. The desire for new single family homes on large lots is prompting scattered residential development in suburban and rural townships. The highest value, newer homes are in urban fringe communities. This is yet another indicator of the movement to abandon urban/suburban cores and relocate in rural areas.

6) Scattered development in rural areas of a watershed can contribute to water quality degradation in new and often unexpected ways. As people move from suburban and urban areas to rural areas, they consume land and change the nature of the watershed. Destruction of vegetation, alteration of natural drainage courses, increases in impervious surfaces, soil compaction, erosion, and increased use of commercial fertilizers and pesticides are all by-products of development that impact water quality.

7) Shifts in the population prompt shifts in commercial development as establishments attempt to follow their markets. Consequently, infrastructure in older urban or suburban areas is abandoned and new infrastructure is created in rural areas on previously raw land.

8) Rural townships experiencing large population increases from immigration often do not have the facilities or expertise to cope with emerging land use and environmental quality issues. They are placed in a reactive position and often focus on public service provision rather than water quality issues.

9) Scattered consumption of agricultural, forest and open space land (primarily for residential development) threatens the viability of these lands for future production.

10) Households are increasing in number faster than the population overall. The land consumption unit for residential development is a household, therefore, less people are taking up more space and accelerating environmental deterioration processes like loss of habitat and water quality degradation.

11) Population shifts are leaving more minorities and low income elderly in urban cores without the resources to serve them and more affluent families with children who move to rural areas place high service demands on governmental units which also lack adequate tax dollars.

b. Economy and Transportation

1) A majority of workers in the watershed commute outside their community for work. Many commute outside their county of residence.

2) The number of vehicle miles traveled and the number of vehicle registrations have steadily increased since 1970, even as the population begins to decline.

3) Sprawl places increased demands on the transportation system by increasing travel distances and traffic volumes. Upgrades to the transportation system in response to increasing travel times lead in turn to additional sprawl.

4) Increasing commuting in single occupancy vehicles increases air pollution and resultant atmospheric deposition of pollutants in water.

5) A larger labor force and more employment establishments contributes to an increased consumption of land.

c. Environment

1) Sprawl induced land conversions accelerate the loss of habitat and increase the nonpoint pollutant loads to surface waters.

2) Groundwater contamination in the watershed is increasingly evident.

3) Continued loss of critical aquatic and terrestrial habitats resulting from land conversion may threaten ecosystem viability.

4) Point sources of pollutants are more tightly controlled, increasing the relative contribution of essentially uncontrolled nonpoint sources.

d. Local Land Use Management

1) The land base continues to be divided into increasingly smaller parcels.

2) Rural area population densities are increasing.

3) Local officials do not perceive environmental quality as a critical local issue.

4) Local management activities are poorly coordinated and lack a broader regional perspective.

5) Market forces continue to promote large-lot, single family, residential development in rural areas.

6) Communities are often in direct competition for development and associated infrastructure development funding.

7) Conversion of raw land places increasing tax burdens on remaining undeveloped parcels in a community.

8) Division of land into small parcels increases the difficulty of managing land use activities.

9) Rural townships frequently do not have the administrative capabilities to effectively manage growth.

10) Outdated local plans and regulations, and inconsistent application of existing land use management tools, promotes ineffective land use control.

11) The perceived unimportance of water quality issues at the local level insures a lack of attention to these issues.

3. State Programs

The state of Michigan, primarily through the Department of Natural Resources, offers the broadest range of regulatory and management programs dealing directly or indirectly with land resources. These programs include the combined permitting program involving the Great Lakes Submerged Lands Act, Inland Lakes and Streams Act, Floodplain Regulatory Act and

Wetland Protection Act, the air water quality regulatory and management activities under delegated federal authority, and the coastal zone program, also with the heavy involvement of the federal government.

While each of these programs have their respective strengths and weaknesses, there are some problems with them that appear to show up with some consistency.

-- A failure to recognize the relationship between local land use decisions and broader societal goals involving environmental protection.

-- An inability to effectively deal with the cumulative impacts of numerous individual decisions.

-- The liberal use of loopholes and exemptions that permit some critical land use activities to escape regulatory control.

-- Inadequate funding and staff resources to consistently administer an effective program over the long term.

-- A failure to recognize the interrelationships between regulatory programs and the various compartments of the environment like air, surface water, groundwater and soil.

4. Local Programs

Local land use management is accomplished through planning and regulatory programs authorized by the state. Michigan currently has four planning enabling acts that permit, but do not require, planning at the local level. These acts authorize planning and zoning activities by cities and villages, townships, counties, or on a regional basis. These acts also set forth the administrative structure and procedures required for planning and zoning activities at the local level, and define the scope of regulatory authority. It is important to emphasize that communities are not required to adopt a master plan or to adopt and enforce a zoning ordinance.

In order to review local land use programs in the Saginaw Bay watershed, a sample of 61 communities was drawn from all local jurisdictions in the watershed using a cluster sampling technique. Subsamples were drawn for each community type in the watershed: agricultural, coastal, northern recreational, urban fringe, and urban. All large urban areas were selected because of their size and relative impact on regional land use. Approximately 79% of the sample communities (48) responded to requests for local plans and ordinances. Very few responded to repeated requests for subdivision and other related land use control ordinances, so this analysis focuses on land use, master or comprehensive plans, and zoning ordinances, which are the primary tools for local land use control.

Assuming the sample of watershed communities is representative of the watershed, many watershed communities have no master plans in place. Still others have outdated plans likely no longer appropriate for the community. The oldest master plan reviewed was adopted in 1971 and the most recent in 1992. It is unlikely, even in a community experiencing limited growth or development, that a plan adopted before 1985 is still completely applicable for the community it is supposed to serve. No community is static; shifts in demographics, local priorities and issues occur with some regularity, particularly in light of ever changing regional, state, national and global issues.

In general, for sampled communities, the ties between specific master plan goals and objectives and the zoning ordinance were weak. If this link between land use policies and regulation is not clear in text, it is not likely it is clear in the minds of people influencing land use. Likewise, decision-makers may have difficulty being consistent in implementing public policy. As an example, most of the plans for watershed townships express a desire to preserve agricultural lands, yet all but three communities allow non-farm, single family residences in agricultural zones on large lots (having from 1 to 20 acre minimum lot sizes). Permitting nonfarm development in agricultural areas promotes conversion of agricultural land by increasing development pressures on them. This is a classic case where public policy and public practice are in direct contradiction.

Any planning program implemented without the benefit of having the proper conceptual links, role analysis, and policy foundation are likely to be ineffective. Of those plans reviewed, only four communities actually called out specific goals and objectives for environmental protection. Two plans specifically mentioned water quality. Assuming that the sample communities are representative, only 5% of watershed communities formally recognize water quality as an issue in their master plans. Furthermore, most introductory statements in the plans emphasized that the master plan is a reflection of community needs and desires. Conspicuous in their absence are similar statements focusing on a community responsibility to protect the environment. With respect to goals and objectives formulation, most community plan objectives focused on economic development, housing, service provision; and for townships, agricultural lands preservation. Most plans fall short in developing implementation strategies for stated goals and objectives.

As might be expected, given the general lack of focus on water quality and natural resource issues in master plans, local zoning ordinances reflected a general absence of specific measures to protect water quality. There are several existing tools that are available to Michigan communities to do so. However, none of the watershed communities had a clear, integrated, comprehensive regulatory scheme to address water quality issues. On the other hand, some communities had techniques that offered promise for water quality protection, but did not have clear objectives for such in their plans. Those regulations that did address water quality appeared piecemeal, somewhat incomplete, and were not particularly well integrated in the regulatory scheme.

If communities are to successfully address land use and water quality issues in local planning and zoning programs, there must be a logical progression of events that precedes any implementation process. A community needs to do the following.

-- Recognize environmental and water quality management issues as a part of local public responsibility.

-- Understand the interrelationship of environmental systems and human impacts on them (especially land use).

-- Assess local issues and the communities ability to act with respect to environmental protection.

-- Inventory sensitive natural resources.

-- Create a foundation for environmental natural resource protection policies that clearly and specifically articulate how to proceed.

-- Know which land use tools are available for use in Michigan communities.

-- Enact defendable, appropriate tools and coordinating mechanisms to meet stated policy objectives in the master plan.

Based on an analysis of sample local plans and zoning ordinances, this planning progression has apparently not taken place in most watershed communities.

5. Recommendations

Through the survey of Saginaw Bay watershed communities, it was established that local planning and zoning authority is not a particularly effective management tool in the region. While some communities have availed themselves of this authority and use it wisely, many communities do not have modern zoning ordinances soundly based on updated master plans. Some communities have plans or ordinances that actually promote land use activities that are detrimental to water quality. Few communities had, either explicitly or implicitly, identified water quality or environmental protection as important. In short, most communities in the watershed do not adequately employ existing tools to effectively manage community growth or protect environmental quality.

Previous analysis of trends feeding land use problems, like urban sprawl, land base fragmentation, consumption of agricultural lands, and degradation or destruction of critical habitat, would suggest that the current land use planning system in Michigan is ineffective. In many ways this is true. In fact, the system, if it can be called that, often exacerbates existing problems.

What has emerged from the analysis of state, federal and local land use and environmental management policies is a picture of outdated legislation, poor coordination, piecemeal approaches, and lack of administrative capabilities, for various reasons, at virtually all levels. Substantial gaps in the overall management framework, from top to bottom, were identified. A failure, particularly at the local level, to utilize the authority available to them was also apparent. The clear conclusion that emerged was this: in order to bring the full range of land use programs to bear on water quality issues, the entire framework needs to be reexamined, some adjustments made, and administrative capabilities at the local level strengthened.

The MUCC Saginaw Bay Land Use and Zoning study identified some of the specific changes that should be made to improve the quality of local land use decisions and minimize their negative effect on water quality. These include some recommendations for changes in existing state and federal policies and programs, and also some new management tools, such as growth management legislation, purchase and transfer of development rights, and unified planning and zoning legislation. Also recommended is a broad education component at the local level, in recognition of the highly personal nature of most land use decisions. Communities are also urged to take constructive actions to protection environmental quality that are already within their existing authority. Specific recommendations are listed in Chapter IX: Actions Needed.

6. Conclusions

A critical factor in growth management is the availability of technically able individuals to implement both land use policy and land use regulations. Most communities in the watershed, and Michigan, have limited technical and professional support. Technical support is critical at two levels: 1) for oversight for consistent application and coordination between planning documents and land use regulations; and 2) for knowledge of modern planning practice (design, regulatory options, etc.) that are available to a community.

Effective water quality management is a complex interplay of law, policy, management, and investment of financial resources. Historically, water quality management has not recognized the importance of the cumulative impacts of individual land use decisions within the management framework. The most effective water quality management program will incorporate environmentally sensitive land use planning and regulatory tools into its management scheme. Failure to add the local decision component to the broader water quality management framework will diminish its effectiveness and leave many water quality goals unmet.

CHAPTER IV: WATERSHED PRIORITIZATION

A. APPROACH

One objective of the Saginaw Bay National Watershed Initiative and Saginaw River/Bay RAP processes is to ensure that the programs and projects undertaken by participants are directed toward actions that will have the greatest benefit within the watershed. In an effort to better define problem areas and sources of impacts, a subwatershed prioritization process for the Saginaw Bay watershed was begun in February 1993.

Simply put, the purpose of the Saginaw Bay watershed prioritization process is to evaluate the subwatersheds in the basin based on the level of impact on the resource and the value of the resource. The information is used to improve coordination of monitoring, planning and implementation activities among local, state, and federal agencies, as well as local businesses and public organizations, in their efforts to describe, protect, restore, and enhance the natural resources of the Saginaw Bay watershed.

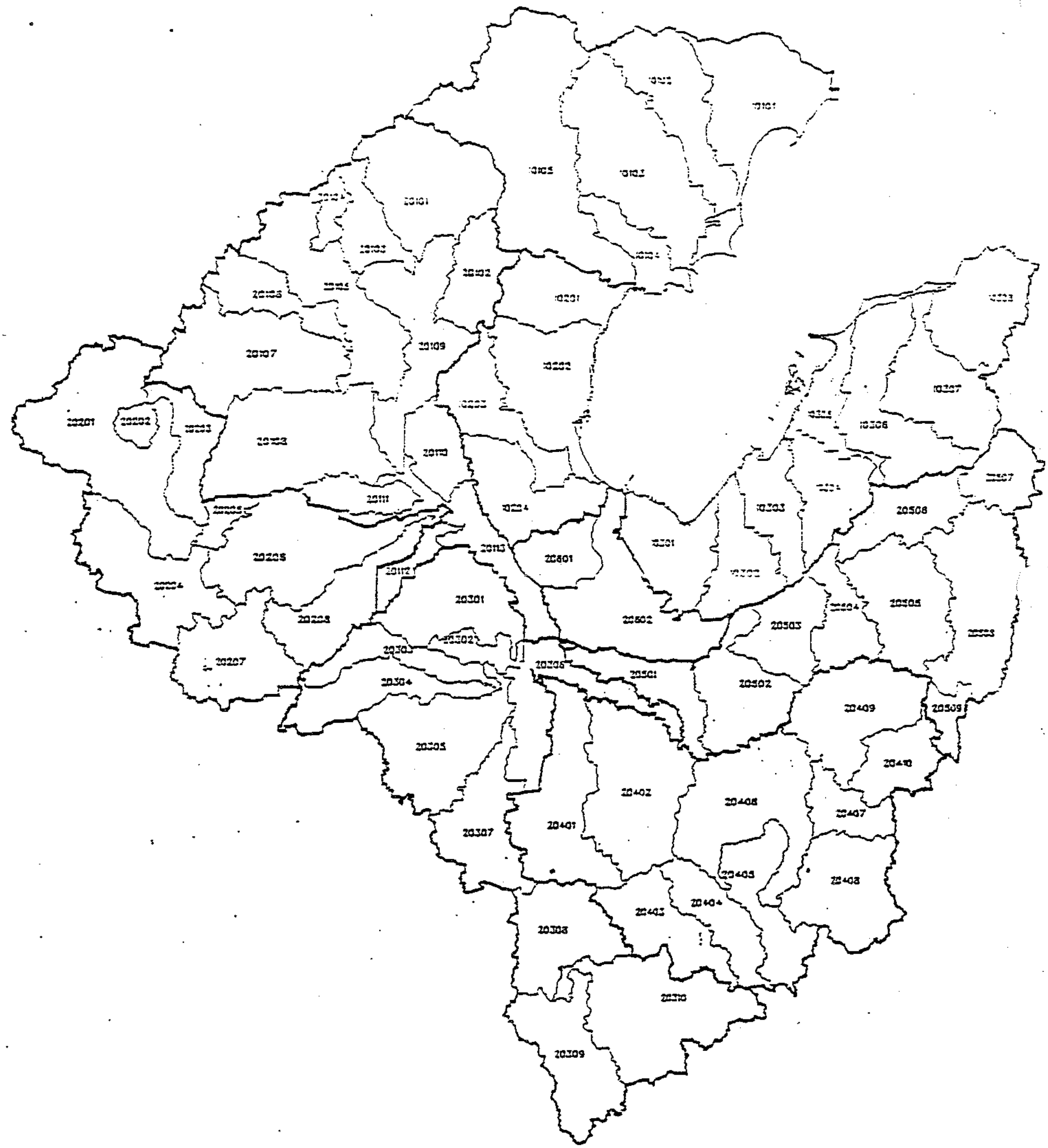
The Saginaw Bay watershed presents numerous challenges to prioritization efforts. One of the most significant is the large size of the watershed, which presents a variety of difficulties for data management/integration, coordination, and education. Consequently, the initial step of the prioritization process was to divide the Saginaw Bay watershed into management units that were of a more appropriate size for data collection/summarization, impact assessment, source identification, and resource valuation.

Watershed delineation was based on three criteria: hydrologic integrity, size, and urban land use. A total of 69 management units were defined (Map 1). The management units are hydrological units roughly delineated by topographic contour, and range in size from 13,448 acres to 242,534 acres.

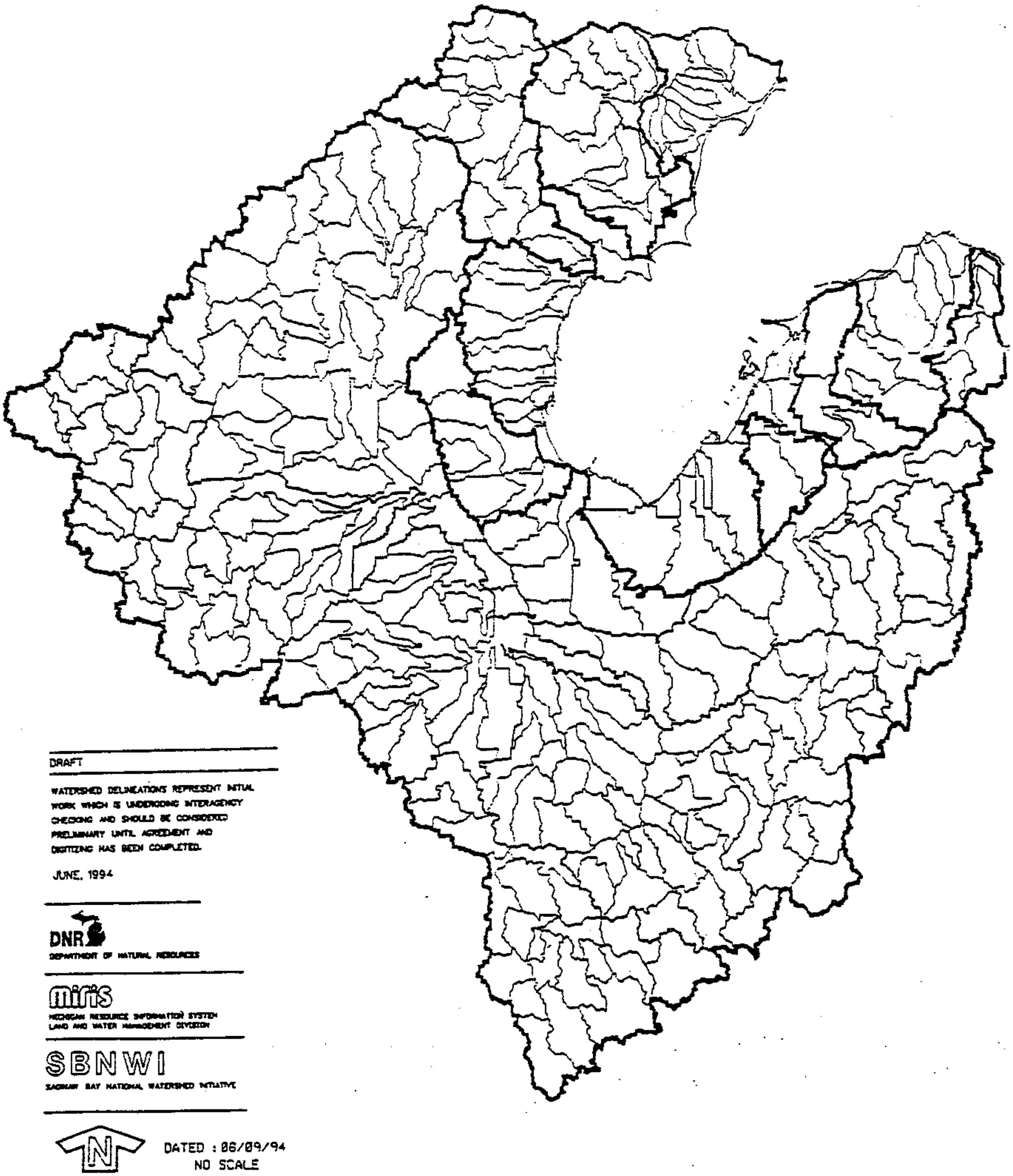
The Saginaw Bay watershed was further divided into 309 subwatersheds, 20-50 square miles in size, based on a methodology developed through a multi-agency agreement between MDNR, SCS, and USGS (Map 2). The subwatershed boundaries were interpreted from 7.5 minute USGS quadrangle maps. Once the boundaries were delineated and checked, they were entered into the Michigan Resource Information System (MIRIS). The subwatershed delineation for the Saginaw Bay watershed was completed in summer 1994.

The larger hydrologic management unit boundaries align with these subwatershed boundaries. A hydrologic management unit may contain several smaller subwatersheds. For the purposes of this prioritization process, these hydrologic management units were referred to

Map 1. Saginaw Bay Watershed management units



Map 2: Saginaw Bay Watershed Prioritization - Small Watershed Boundaries



as watersheds, although some boundaries may only delineate hydrologic similarities. As more information becomes available in the future, it may be that the smaller subwatersheds will become the actual management units.

Once the watershed boundaries were defined, work began on problem definition. Criteria development was based on availability of data, and what information was needed to identify an environmental problem and, if possible, determine the source and magnitude of the problem. This criteria development and summarization is the active phase of the prioritization process to date.

Integration of these data and incorporation of other sources of information to determine resource value will take place next. This will be followed by an evaluation of subwatersheds with respect to watershed goals and likelihood of success to identify where actions should be implemented to obtain the most desirable environmental benefit.

B. PROCESS STRUCTURE

1. Overview

The Saginaw Bay watershed prioritization process currently includes four phases (see Figure 1).

Phase 1 is the collection/summarization of data on the following topics: ecological indicators (effects), source delineation (causes), habitat evaluation, and public interest.

Phase 2 involves the integration of the source delineation and ecological indicators sections to derive an impact assessment of the subwatershed; and the integration of public interest and habitat evaluation sections to derive a resource value.

Phase 3 evaluates the resource value and the impact assessment with watershed goals to derive a technical rating for the subwatershed.

Phase 4 provides information on the probability that the outlined technical needs of the subwatershed, derived in Phase 3, can or can not be effectively addressed at a given time. This subwatershed ranking is derived through the filtering of Phase 3 technical rating through a likelihood of success section.

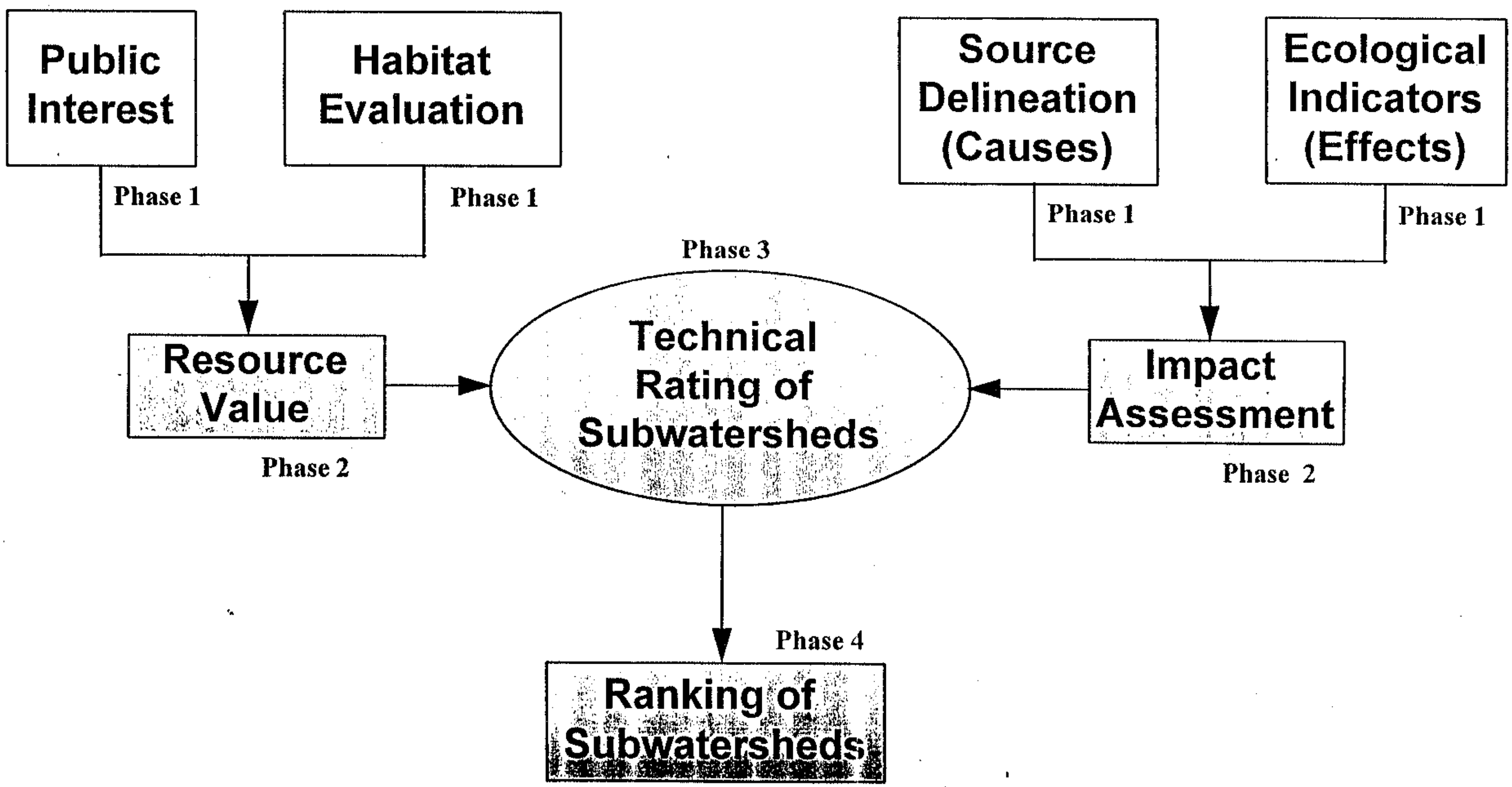
The implementation schedule for each phase is resource dependent (Table 1). Completion dates are based on the current level of resources available (Fiscal Year 1994).

Table 1: Prioritization Process Implementation Schedule

Phase	Product	Projected Completion Date (Year)
1	Criteria development complete; watershed mngt. units finalized; initial rating for individual criteria completed	1997
2	Procedures established for evaluating sections; impact assessment and resource value completed	1998
3	Procedures established for evaluating impact assessment and resource value to derive technical subwatershed rating	1999
4	Procedures established for review of technical rating with regard to likelihood of success; Ranking of subwatersheds	2000
REVIEW	Process needs review/update procedures	

Figure 1

Saginaw Bay Watershed:
Subwatershed Prioritization Process



2. Phase 1

Phase 1 involves the initial collection and summarization of data in several subject areas germane to restoring, protecting and enhancing the environmental quality of the Saginaw Bay watershed. The primary categories are: ecological indicators (effects), source delineation (causes), habitat evaluation, and public interest.

Draft initial prioritizations for certain portions of Phase 1 have been completed and are included in the Water Quality, Soil Erosion & Sedimentation, and Habitat chapters of this report. A full discussion of the prioritization process and the methods used to determine the categorizations discussed in these chapters can be found in the October 1994 draft Saginaw Bay Watershed Prioritization Process report.

Future efforts during Phase 1 will involve increased local government and public input. A public interest section will be developed in order to determine resident interest in local resources, and to balance the multi-objective uses of the resources. Additionally, results from the draft prioritization will undergo further review by the various technical advisory committees, the Program Advisory Committee, the Saginaw Basin Alliance, and the Saginaw Bay Watershed Council.

3. Phase 2

By the end of Phase 1, sufficient information should have been interpreted to allow a comprehensive analysis to be performed in Phase 2 to determine resource value and impact assessment.

The impact assessment will rate stream environmental health by correlating the hydrologic, water quality, aquatic biology, and pollutant source data summaries. The assessment should be able to rate the pollutant sources in order of impact within a watershed, rate a particular pollutant source among watersheds, rate overall impact among watersheds, rate individual types of impacts within and among watersheds, and allow relationships to be determined between pollutant source contributions and the level and type of impact within a watershed.

The resource value determination will rate the value of the watercourse based on habitat potential and resource use by combining public benefit information with fish and wildlife habitat status. The valuation should be able to rate the multiple resource uses in order within a watershed (fishing, canoeing, swimming, aesthetics, etc.), rate uses among watersheds (fishing is more important in x than y watershed), rate overall use among watersheds (resource use is greater in x than y watershed), rate individual habitat potential within and among watersheds (x habitat is better for y species than z habitat within zz watershed; and x habitat is better for y species in z watershed than in zz watershed), rate overall habitat potential among watersheds (work in x watershed is more likely to improve habitat than in y watershed), and allow relationships to be made between multiple resource uses and habitat potential within a watershed.

A corresponding objective for Phase 2 is to develop a process to facilitate the integration and analysis of the Phase 1 results. Several activities are currently being conducted to enhance this effort.

- A draft Data Integration/Management Strategy is being developed for the Saginaw Bay watershed by the Data Integration/Management TAC.

- The Consortium for International Earth Science Information Network (CIESIN) is designing a prototype environmental information and decision support system using the Saginaw Bay watershed as a demonstration site. This decision support system is being designed to work on the Internet and thereby by assessable to most interested users.

Because most of the integration of data will be based on georeferenced points of information, the need for a standard means of collecting and entering this information will become greater in the near future. It is important that this concept be addressed with regard to current data sets, as well as in the development of future data sets.

Further, it may be necessary for many agency/organization participants to modify their applicable standard operating procedures to facilitate the updating of information upon which the process relies. This would support a dynamic system that can change as the resource changes, thereby identifying priorities based on the most current information available.

4. Phase 3

In Phase 3, the resource values and the impact assessments identified in Phase 2 will be evaluated with respect to watershed goals to derive technical ratings for the subwatersheds.

While some goals have been developed to date, and were identified earlier in the Introduction chapter, there is need for further review and development, particularly with regard to goals for individual subwatersheds. For instance, should implemented actions emphasize watersheds with the worst impacts, or should the focus be on protecting/enhancing areas that have the highest resource value? Such questions may produce goals that differ markedly among watersheds, and with respect to the various uses identified in the watersheds.

5. Phase 4

In Phase 4, resource availability factors are reviewed to determine the probability that the outlined technical needs of the subwatershed, derived in Phase 3, can or can not be effectively addressed at a given time. This subwatershed ranking is derived through the filtering of Phase 3 technical rating through a likelihood of success section.

This phase will evaluate the potential that needed actions can be implemented in a effective manner and that they are consistent with the subwatershed goals. For example, if agricultural best management practices are needed, what is the likelihood that area producers will embrace the practices? If instream habitat restoration is being considered, is the stream likely to be dredged in the future. If local funds are needed to cost-share a proposed project, does the local community have the necessary resources?

CHAPTER V: WATER QUALITY

A. OVERVIEW

This chapter provides a brief discussion on the water quality conditions in the Saginaw Bay watershed focusing on nutrients and suspended solids. Associated information on hydrology, sediment quality, biological communities, and nutrient sources and loads, are also discussed. This information was summarized for the watershed prioritization process discussed in the preceding chapter and the initial watershed rankings are included here. It is anticipated that metals and organic parameters will be discussed in the next RAP biennial report.

Most of this information was taken from three appendices prepared by the Water Quality Technical Advisory Committee: Appendix Four, Aquatic Ecosystem Conditions -- Conventional Parameters and Nutrients; Appendix Five, Aquatic Biota; and, Appendix Six, Nutrient Sources and Loads. These appendices not only describe the material presented here in much greater detail, but include discussions on numerous parameters and topics not included in this chapter summary.

B. SUSPENDED SOLIDS AND NUTRIENTS

1. Introduction

Little water quality information is available for Saginaw Bay prior to 1974. Several cooperating agencies conducted a comprehensive survey of the chemical, physical and biological parameters in Saginaw Bay during 1974-1975 to establish baseline water quality data. Less intensive monitoring continued from 1976 to 1979, and another series of intensive studies was conducted in 1980. Most recently, several agencies began assessing Saginaw Bay conditions again in 1991, as part of a National Oceanic and Atmospheric Administration (NOAA) study to determine the impacts of zebra mussel colonization on Saginaw Bay. Some initial results from this project are included.

The chemical water quality data for rivers discussed in this chapter are primarily from monthly samples collected by the MDNR. However, some data were collected on an event response sampling basis. The time period over which samples were collected varied with each station dependent upon data needs and the budget for monitoring activities.

Coincident with the NOAA Saginaw Bay study mentioned above, an intensive water sampling effort was undertaken from spring 1991 through spring 1993 on the tributaries to Saginaw Bay and the Saginaw River. It was the most comprehensive tributary monitoring effort ever implemented on a scale large enough to simultaneously include all the major tributaries to Saginaw Bay. Monitoring was conducted on an event-response basis in addition to periodic scheduled sampling.

Caution should be used in interpreting the 1991-1993 tributary sampling results however, because some years and rivers had many more data points than others. Additionally, because of the large size of the watershed, each sampling run often took two or more days to complete, resulting in samples being taken at different times following a storm event. There could also be large variations in the amount of rainfall among portions of the watershed for a single storm event.

The following discussions on tributary means, medians, and frequency distributions on total suspended solids and total phosphorus is for the whole 1991-1993 data set lumped together, except where noted, to provide a rough characterization of water quality conditions. The frequency intervals used were determined by using mean and maximum goals established for total suspended solids and total phosphorus parameters by the Water Quality Technical Advisory Committee. More detailed analyses on annual means, and plots of the raw data, are presented and discussed in Appendix Four (Aquatic Ecosystem Conditions: Conventional Parameters and Nutrients).

2. Suspended Solids

Three coastal tributaries had measured total suspended solids concentrations of 700 mg/l or higher during the 1991-1993 sampling project. All three tributaries were in the east coastal basin -- Northwest Drain (1825 mg/l), Pigeon River (1048 mg/l) and Columbia Drain (799 mg/l) (Figure II-7) -- and all three measurements were made in the spring. Four other east coastal basin tributaries had maximum concentrations that exceeded 500 mg/l, including State Drain, Pinnebog River, Shebeon Creek, and Allen Drain.

Five east coast tributaries (Northwest Drain, Columbia Drain, Quanicassee River, State Drain, and Wiscoggin Drain) exceeded the mean total suspended solids goal of 50 mg/l (Table 1). Four of these tributaries had more than 30 percent of their values above the goal mean (Figure 1). However, several of these tributaries had relatively small data sets and had a high mean from an extreme high value. Caution should be used in interpreting results from these data sets, denoted by an asterisk (*) in Table 3.

Among west coastal basin tributaries, three had maximum concentrations that exceeded 500 mg/l, including Pinconning River, South Branch Kawkawlin River, and Kawkawlin River. Though west coastal basin tributaries generally had annual average concentrations below 50 mg/l, three rivers -- Au Gres, Rifle and South Branch Kawkawlin -- exceeded the goal mean of 50 mg/l, and had more than 30 percent of their values above the goal mean (Figure 2). Additionally, the S.B. Kawkawlin R. and Rifle R. exceed the goal maximum of 400 mg/l.

At the mouth of the Saginaw River, total suspended solids concentrations never exceeded 400 mg/l and topped 200 mg/l only three times during the 1991-1993 period. Among Saginaw River tributaries, the highest maximum concentrations were reported from the Cass and Shiawassee rivers.

In the Saginaw River basin only the Saginaw River station at Saginaw exceeded the 50 mg/l goal mean for total suspended solids. The Flint River, however, was approaching the goal mean, and had greater than 30 percent of its values above the goal mean (Figure 3).

The highest suspended solids concentrations in the east coastal basin tributaries during 1991-1993 occurred on the dates that the greatest river flows were recorded. The Pigeon, Pinnebog and Quanicassee rivers all had maximum flows recorded over 1500 CFS. Among west coastal basin tributaries, the greatest peak flows were in the Au Gres and Rifle rivers, both of which had flows over 2000 CFS on at least two dates.

During this same time period, the peak flow measured on the Saginaw River at the time samples were collected was over 42,000 CFS. Of the major tributaries to the Saginaw River, the Tittabawassee River had the highest maximum flow with a flow rate of over 12,000 CFS. The Cass River had the next highest maximum flow at 6,000 CFS. Both the Shiawassee and Flint rivers never exceeded 3,000 CFS. The increase in suspended solids concentrations above

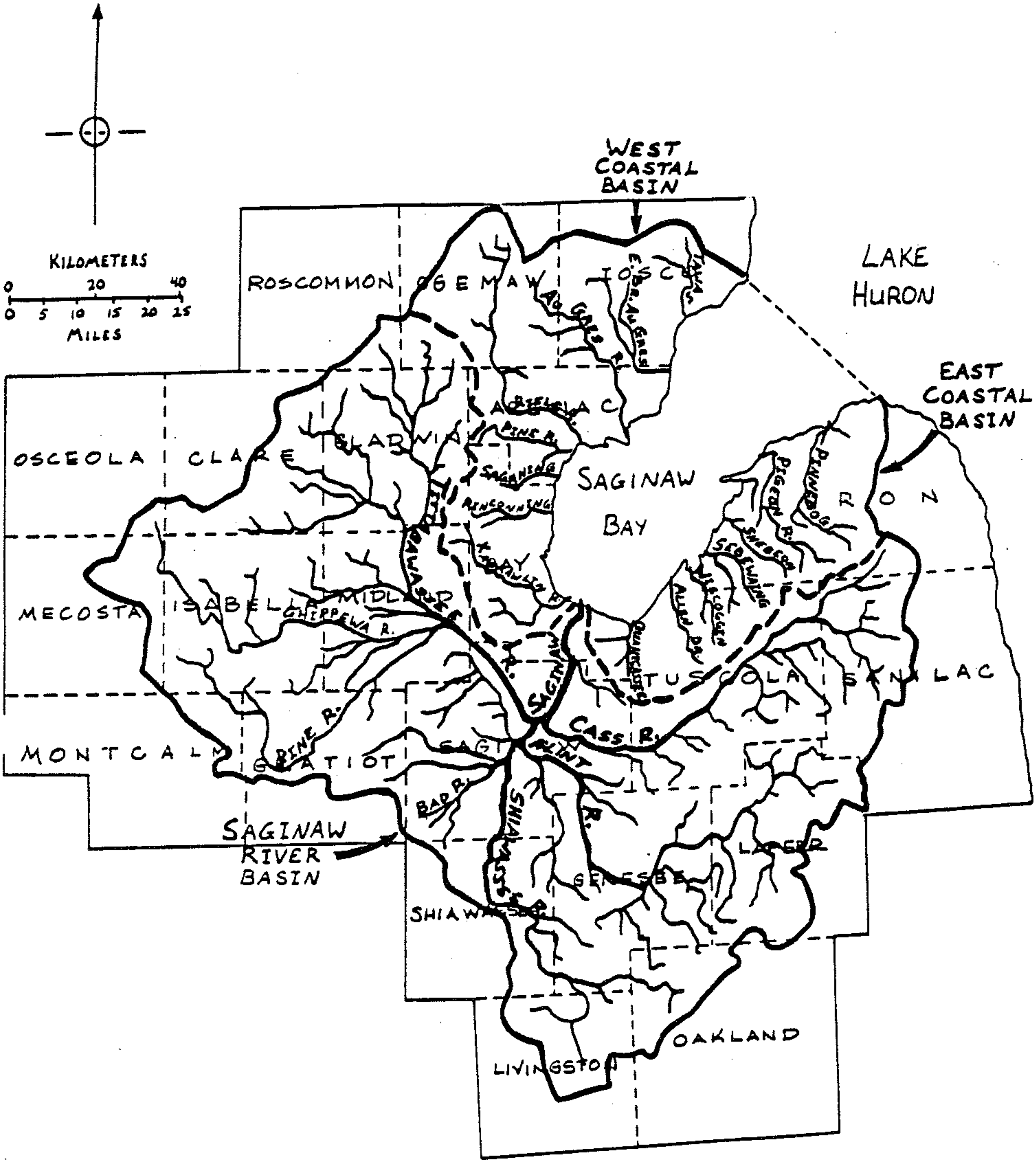


Figure II-7. Major tributaries to Saginaw Bay.

Table 1: Frequency Distribution of Saginaw Bay Tributary Monitoring Data (1991-93) for Total Suspended Solids

Tributary	n	Mean	Median	Max.	% in Range			
					0-50 mg/l	50-200 mg/l	200-400 mg/l	> 400 mg/l
Allen	53	49	15	540	83	11	2	4
AuGre	27	70	26	237	60	33	7	0
BigCr	13	18	13	54	92	8	0	0
Bird	14	43	12	282	79	14	7	0
Cass	46	37	28	204	85	13	2	0
Colum	14	96	17.5	799	64	29	0	7
Flint	46	47	43	130	59	41	0	0
KawKw	53	49	18	552	83	13	0	4
MudCr	14	19	16	56	93	7	0	0
Nrthw	13	212	55	1825	46	31	15	8
Pgeon	86	33	8	1048	89	10	0	1
Pincn	52	38	10.5	648	90	6	2	2
Pine	14	42	24.5	260	86	7	7	0
Pinnb	55	39	20	552	87	9	2	2
Quani	13	67	58	184	46	54	0	0
Rifle	53	67	31	488	70	17	11	2
Sagan	13	9	9	25	100	0	0	0
SagHd	76	51	40.5	234	70	29	1	0
SagMo	153	47	32	372	79	18	3	0
SBKaw	40	68	43	588	63	33	3	3
Shebe	56	39	10	532	86	9	4	2
Shiaw	46	41	32.5	240	83	15	2	0
State	54	55	9.5	568	81	9	4	6
Taft	14	36	15	133	71	29	0	0
Tawas	55	11	7	57	98	2	0	0
Titta	29	37	23	151	79	21	0	0
Whit	55	48	20	343	76	20	4	0
Wiscg	13	51	26	215	69	23	8	0

AVG. MAX. = 404

Shaded Areas - indicate exceedence of goal mean

Eastern Coastal Basin Total Suspended Solids (1991-93) : Frequency Distribution

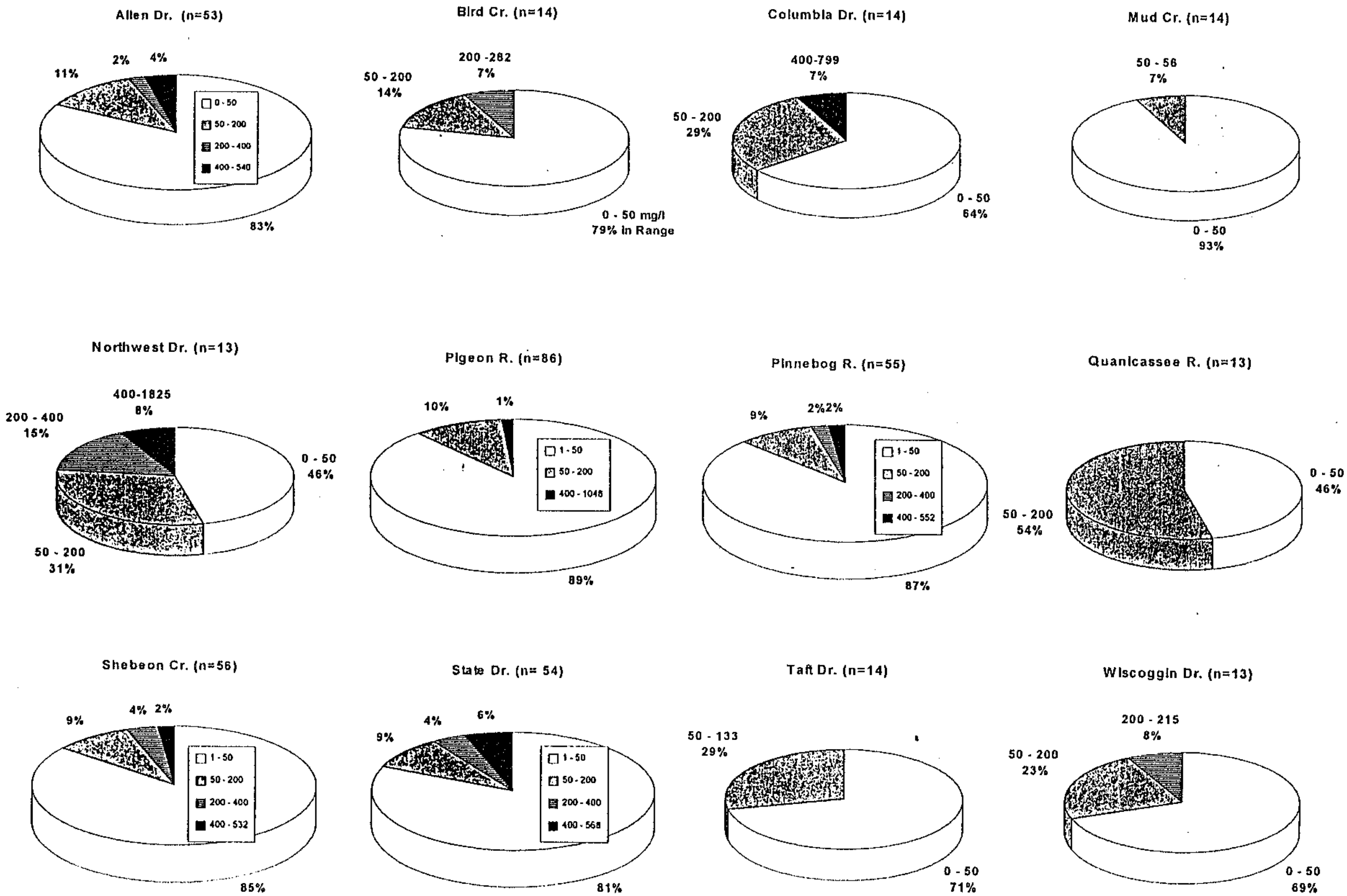


Table 3: Frequency Distribution for Saginaw Bay Tributary Monitoring Data (1991-93): Total Suspended Solids Summary

Tributaries Above Goal Mean (50 mg/l)

Western Coastal Basin		Eastern Coastal Basin		Saginaw R. Basin	
Tributary	Mean	Tributary	Mean	Tributary	Mean
AuGres R.	70	Northwest Dr. *	212	Saginaw R. - Saginaw	51
S.B. Kawkawlin R.	68	Columbia Dr. *	96		
Rifle R.	67	Quanicassee R. *	67		
		State Dr.	55		
		Wiscoggin Dr. *	51		

Tributaries Approaching Goal Mean (50 mg/l)

Western Coastal Basin		Eastern Coastal Basin		Saginaw R. Basin	
Tributary	Mean	Tributary	Mean	Tributary	Mean
Kawkawlin R.	49	Allen Dr.	49	Flint R.	47
Whitney Dr.	48			Saginaw R. - Bay City	47

Tributaries Above Goal Maximum (400 mg/l)

Western Coastal Basin		Eastern Coastal Basin		Saginaw R. Basin	
Tributary	Max	Tributary	Max	Tributary	Max
Pinconning R.	648	Pigeon R.	1048		
S.B. Kawkawlin R.	588	Northwest Dr.	1025		
Kawkawlin R.	552	Columbia Dr.	799		
Rifle R.	488	State Dr.	568		
		Pinnebog R.	552		
		Allen Dr.	540		
		Shebeon Cr.	532		

Tributaries Approaching Goal Maximum (400 mg/l)

Western Coastal Basin		Eastern Coastal Basin		Saginaw R. Basin	
Tributary	Max	Tributary	Max	Tributary	Max
Whitney Dr.	343			Saginaw R. - Bay City	372

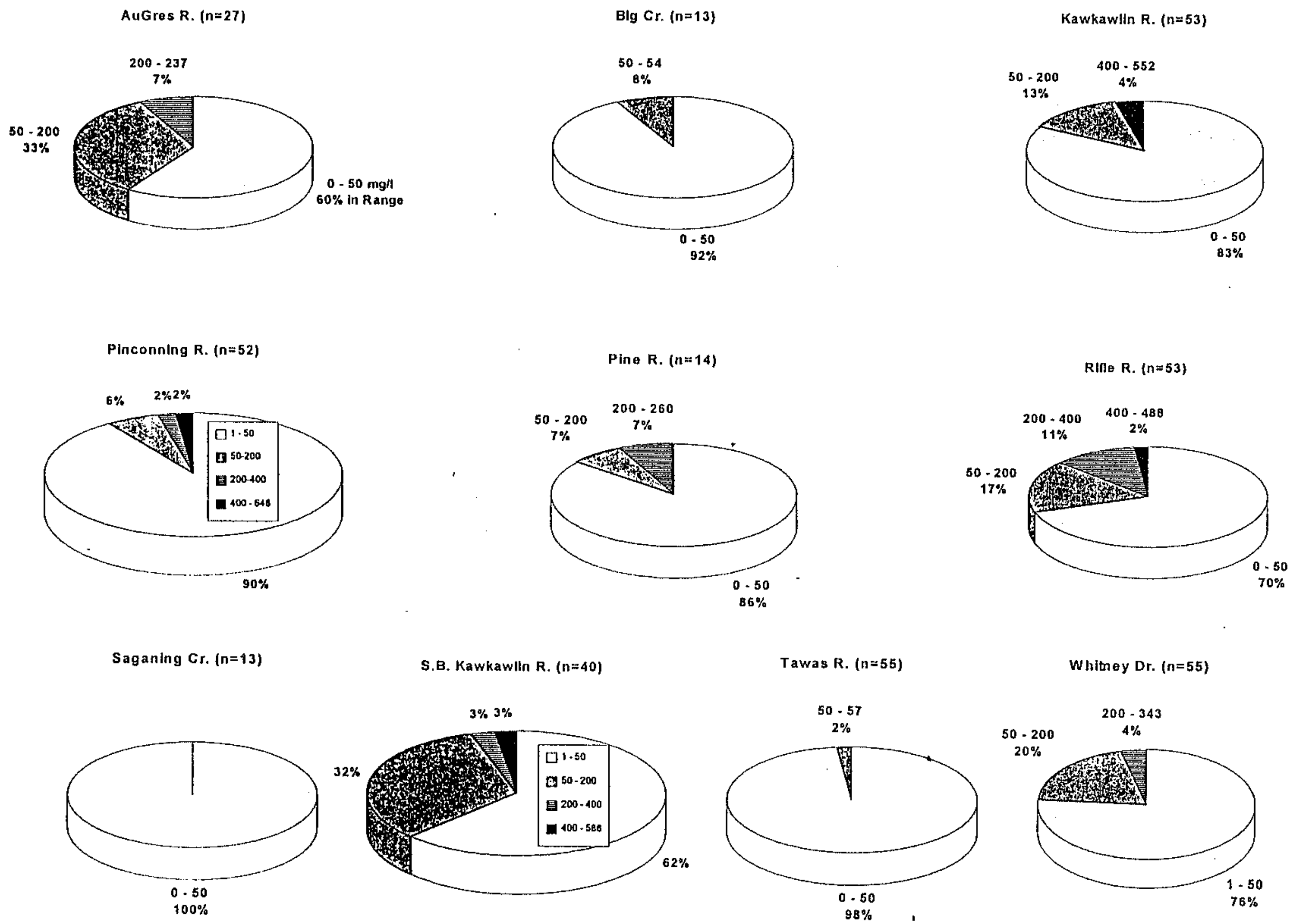
Tributaries with > 30% of samples above 50 mg/l

Western Coastal Basin		Eastern Coastal Basin		Saginaw R. Basin	
Tributary	% above	Tributary	% above	Tributary	% above
Au Gres R.	40	Northwest Dr.	54	Flint R.	41
S.B. Kawkawlin R.	39	Quanicassee R.	54	Saginaw R. - Saginaw	30
Rifle R.	30	Columbia Dr.	36		
		Wiscoggin Dr.	31		

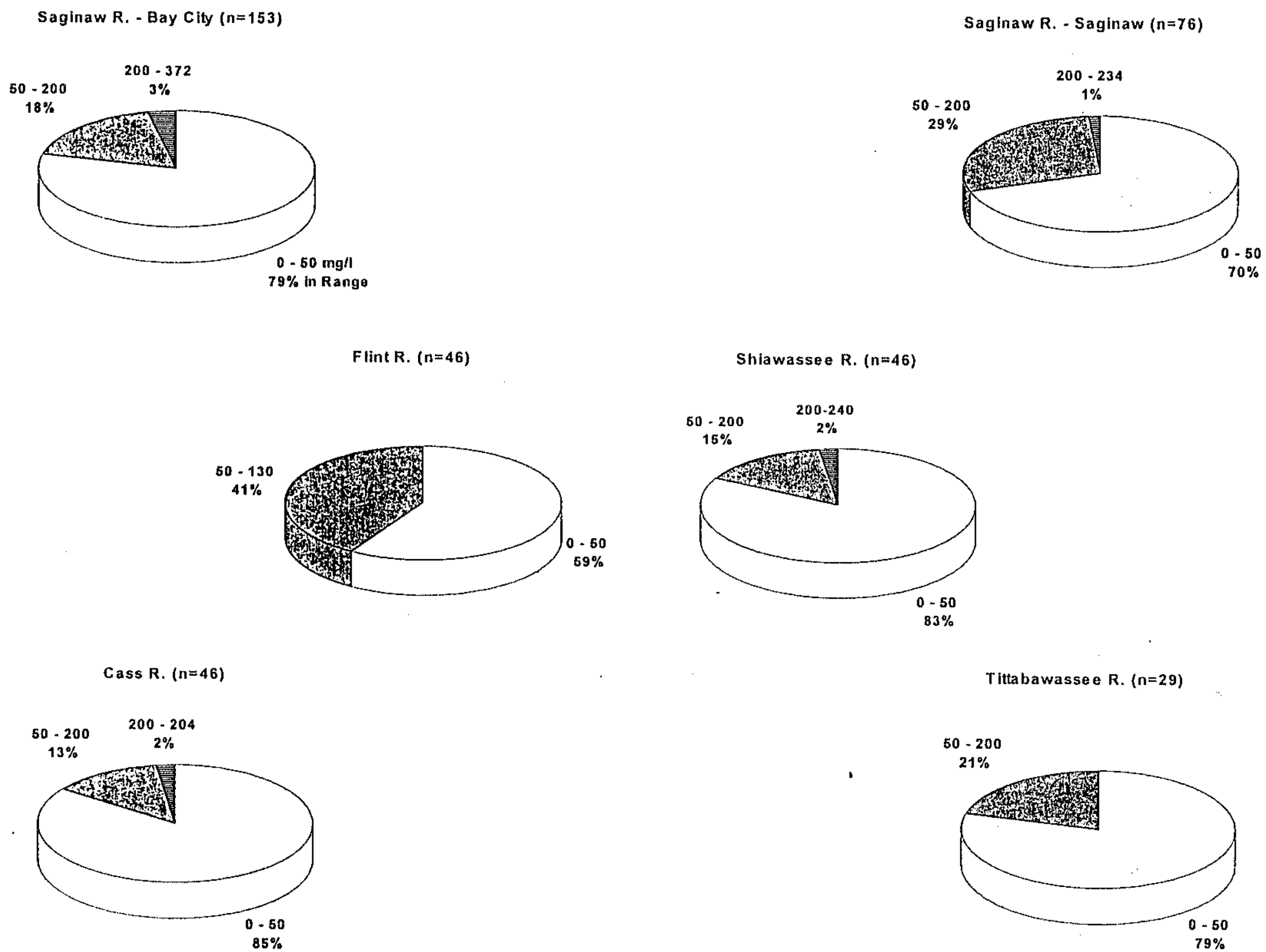
Tributaries with > 5% of samples above 400 mg/l

Western Coastal Basin		Eastern Coastal Basin		Saginaw R. Basin	
Tributary	% above	Tributary	% above	Tributary	% above
		Northwest Dr.	8		
		Columbia Dr.	7		
		State Dr.	6		

Western Coastal Basin Total Suspended Solids (1991-93) : Frequency Distribution



Saginaw River and Tributaries
Total Suspended Solids (1991-93) : Frequency Distribution



base flow conditions following storm events was much less for the large Saginaw River tributaries and the Saginaw River itself, than for the smaller coastal basin tributaries.

3. Nutrients

a. Taste and Odor

Taste and odor in municipal water supplies drawn from Saginaw Bay have historically been one of the principal water quality issues for Saginaw Bay. Although these problems have diminished in recent years, tastes and odors still occur and remain a concern to public water suppliers using the bay. Water treatment plant operators monitor taste and odor qualitatively by periodically tasting and smelling water samples and describing the odor as musty, grassy, fishy or in other similar terms. Odor is generally caused by blue-green algae, actinomycete bacteria, and blue-green algae decomposition. High nutrient levels in Saginaw Bay water, primarily elevated phosphorus concentrations, have been identified as the cause of nuisance blue-green algae populations.

b. Phosphorus

i) Saginaw Bay

Eutrophication is presently a water quality problem in Saginaw Bay. Eutrophic waters are high in organic or nutrient matter that promote biological growth and reduce dissolved oxygen in the hypolimnion. Accelerated eutrophication can lead to turbidity, taste and odor problems, growth of nuisance blue-green algae, filter clogging in water intakes, aesthetic impairments, and fish kills. Nutrients often accumulate in the inner bay water column due to current patterns that inhibit the mixing of inner and outer bay water. The two nutrients that have a major role in eutrophication are phosphorus and nitrogen. Since phosphorus is usually the limiting nutrient for algal growth in lakes and rivers, it is the nutrient of greatest concern for the control of eutrophication.

Average values of total phosphorus concentrations measured in the inner bay between 1974-1980 reached the highest level of 47.3 ug/l during the spring of 1978. Concentrations in the inner bay declined from 1978 levels to 26.8 ug/l and 24.8 ug/l in the spring and fall of 1980, respectively. When the bay was next surveyed in 1991, total phosphorus concentrations measured were about the same as those observed in 1980.

However, a dramatic decline to around 17 ug/l was noted in 1992, with levels remaining at about that level in 1993 as well. It is thought that this decline in 1992 was due to the initial colonization of Saginaw Bay by zebra mussels, a newly introduced exotic species that feeds by filtering large amounts of water, and it is not presently known if the reduced phosphorus levels will be maintained once zebra mussel populations have stabilized. Additional phosphorus monitoring was conducted in 1994 and is planned for 1995 to track this issue. Though Saginaw Bay is still considered to be eutrophic, both the 1992 and 1993 mean total phosphorus concentrations for the inner bay fell, for the first time, within the mesotrophic range.

ii) Coastal Tributaries

Among Saginaw Bay coastal tributaries, the highest annual mean total phosphorus concentration during 1991-1993 was measured at Mud Creek, which had a mean of 0.43 mg/l (Table 2). Four tributaries (Mud Creek, Pigeon River, Shebeon Creek and Pinnebog River exceeded both the total phosphorus mean (0.1 mg/l) and maximum (0.6 mg/l) goals (Table 4), and had a predominance of their values (93%, 50%, 46%, and 42%, respectively) above the mean goal (Figure 4). Additionally, Allen Drain and State Drain exhibited peak values above the goal maximum, and 77% of the Quanicassee River values were above the goal mean.

The greatest total phosphorus concentrations among west coastal basin tributaries were found in the Pinconning, South Branch Kawkawlin, and Kawkawlin rivers. All three tributaries exceeded both the goal mean and the goal maximum. Both the Pinconning River and South Branch Kawkawlin River had a predominance of their values (60% and 70%, respectively) above the goal mean (Figure 5).

For the most part, annual mean orthophosphorus concentrations were substantially higher in the east coastal basin tributaries during 1991-1993 than in the west coastal basin tributaries. Again, the greatest concentrations were found in Mud Creek (over 0.25 mg/l), followed by Shebeon Creek, Pigeon River and Quanicassee River.

iii) Saginaw River and Tributaries

During 1991-1993, annual mean total phosphorus concentrations at the mouth of the Saginaw River ranged from 0.101 mg/l to 0.149 mg/l. There was little difference between concentrations observed at the mouth to those measured upstream of the city of Saginaw at the head of the Saginaw River. Both stations on the Saginaw River exceeded the total phosphorus goal mean, and had a predominance of values above 0.1 mg/l (Figure 6). However, there has been a definite decline from 1973 levels of total phosphorus that were near 0.3 mg/l. Orthophosphorus values declined to an even greater extent from about 0.15 mg/l in 1973 to 0.03 mg/l in 1993.

Total phosphorus concentrations were higher in the Flint River in all three years than any of the other three Saginaw River tributaries, ranging from 0.139 mg/l to 0.158 mg/l, exceeding the total phosphorus mean goal. The Flint River also had the highest annual average orthophosphorus concentrations of 0.02-0.05 mg/l.

Table 2: Frequency Distribution of Saginaw Bay Tributary Monitoring Data (1991-93) for Total Phosphorus

Tributary	n	Mean	Median	Max.	% in Range			
					0 - .1 mg/l	.1 - .3 mg/l	.3 - .6 mg/l	> .6 mg/l
Allen	53	0.106	0.058	0.920	77	17	2	4
AuGre	27	0.101	0.052	0.466	63	30	7	0
BigCr	13	0.058	0.046	0.133	92	8	0	0
Bird	14	0.098	0.049	0.320	64	29	7	0
Cass	46	0.088	0.080	0.241	70	30	0	0
Colum	14	0.094	0.054	0.414	64	29	7	0
Flint	46	0.148	0.150	0.300	30	70	0	0
KawKw	53	0.137	0.080	0.880	64	26	6	4
MudCr	14	0.428	0.354	1.638	7	36	43	14
Nrthw	13	0.135	0.072	0.506	61	31	8	0
Pgeon	86	0.162	0.101	1.820	50	40	7	3
Pincn	52	0.219	0.129	1.210	40	37	17	6
Pine	14	0.118	0.088	0.520	72	21	7	0
Pinnb	55	0.124	0.091	0.920	58	36	4	2
Quani	13	0.191	0.185	0.359	23	62	15	0
Rifle	53	0.070	0.038	0.510	77	21	2	0
Sagan	13	0.058	0.050	0.130	92	8	0	0
SagHd	76	0.119	0.105	0.390	47	51	1	0
SagMo	153	0.121	0.110	0.590	41	56	3	0
SBKaw	40	0.174	0.131	0.970	30	60	5	5
Shebe	56	0.180	0.090	1.588	54	32	9	5
Shiaw	46	0.097	0.082	0.294	65	35	0	0
State	54	0.093	0.044	0.830	77	15	6	2
Taft	14	0.108	0.081	0.236	57	43	0	0
Tawas	55	0.038	0.031	0.242	98	2	0	0
Titta	29	0.082	0.073	0.188	72	28	0	0
Whit	55	0.054	0.027	0.291	87	13	0	0
Wiscg	13	0.090	0.074	0.224	69	31	0	0

AVG. MAX. = 0.612

Shaded Areas - indicate exceedence of goal mean

Table 4: Frequency Distribution for Saginaw Bay Tributary Monitoring Data (1991-93): Total Phosphorus Summary

Tributaries Above Goal Mean (0.1 mg/l)

Western Coastal Basin		Eastern Coastal Basin		Saginaw R. Basin	
Tributary	Mean	Tributary	Mean	Tributary	Mean
Pinconning R.	0.219	Mud Cr. *	0.428	Flint R.	0.148
S.B. Kawkawlin R.	0.174	Quanicassee R. *	0.191	Saginaw R. - Bay City	0.121
Kawkawlin R.	0.137	Shebeon Cr.	0.180	Saginaw R. - Saginaw	0.119
Pine R. *	0.118	Pigeon R.	0.162		
AuGres R.	0.101	Northwest Dr. *	0.135		
		Pinnebog R.	0.124		
		Taft Dr. *	0.108		
		Allen Dr.	0.106		

Tributaries Approaching Goal Mean (0.1 mg/l)

Western Coastal Basin		Eastern Coastal Basin		Saginaw R. Basin	
Tributary	Mean	Tributary	Mean	Tributary	Mean
		Bird Cr. *	0.098	Shiawassee R.	0.097
		Columbia Dr. *	0.094		
		State Dr.	0.093		
		Wiscoggin Dr. *	0.090		

Tributaries Above Goal Maximum (0.6 mg/l)

Western Coastal Basin		Eastern Coastal Basin		Saginaw R. Basin	
Tributary	Max	Tributary	Max	Tributary	Max
Pinconning R.	1.210	Pigeon R.	1.820		
S.B. Kawkawlin R.	0.970	Mud Cr.	1.638		
Kawkawlin R.	0.880	Shebeon Cr.	1.588		
		Allen Dr.	0.920		
		Pinnebog R.	0.920		
		State Dr.	0.830		

Tributaries Approaching Goal Maximum (0.6 mg/l)

Western Coastal Basin		Eastern Coastal Basin		Saginaw R. Basin	
Tributary	Max	Tributary	Max	Tributary	Max
Pine R.	0.520	Northwest Dr.	0.506	Saginaw R. - Bay City	0.590
Rifle R.	0.510				

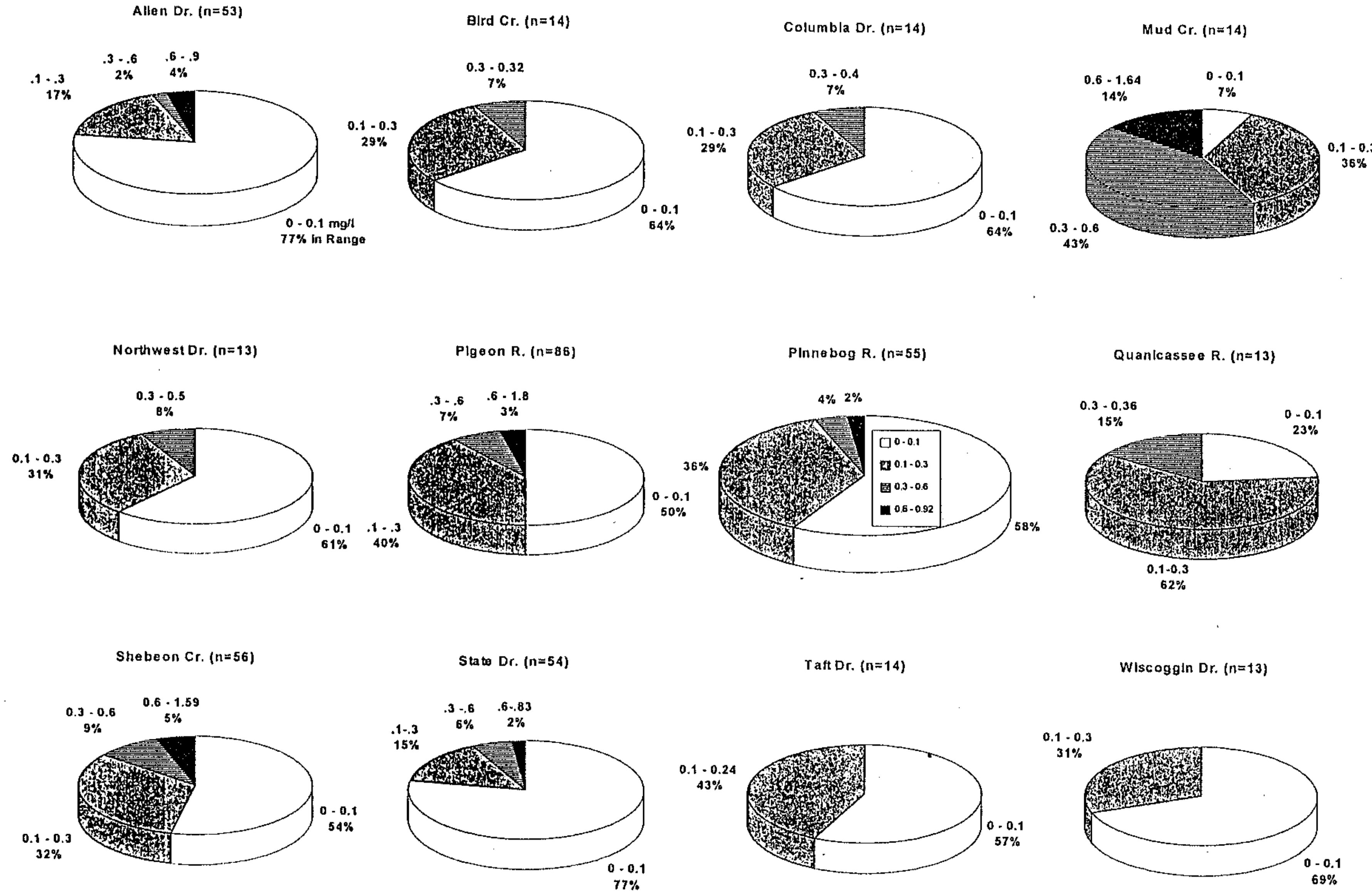
Tributaries with > 40% of samples above 0.1 mg/l

Western Coastal Basin		Eastern Coastal Basin		Saginaw R. Basin	
Tributary	% above	Tributary	% above	Tributary	% above
S.B. Kawkawlin R.	70	Mud Cr.	93	Flint R.	70
Pinconning R.	60	Quanicassee R.	77	Saginaw R. - Bay City	59
		Pigeon R.	50	Saginaw R. - Saginaw	52
		Shebeon Cr.	46		
		Taft Dr.	43		
		Pinnebog R.	42		

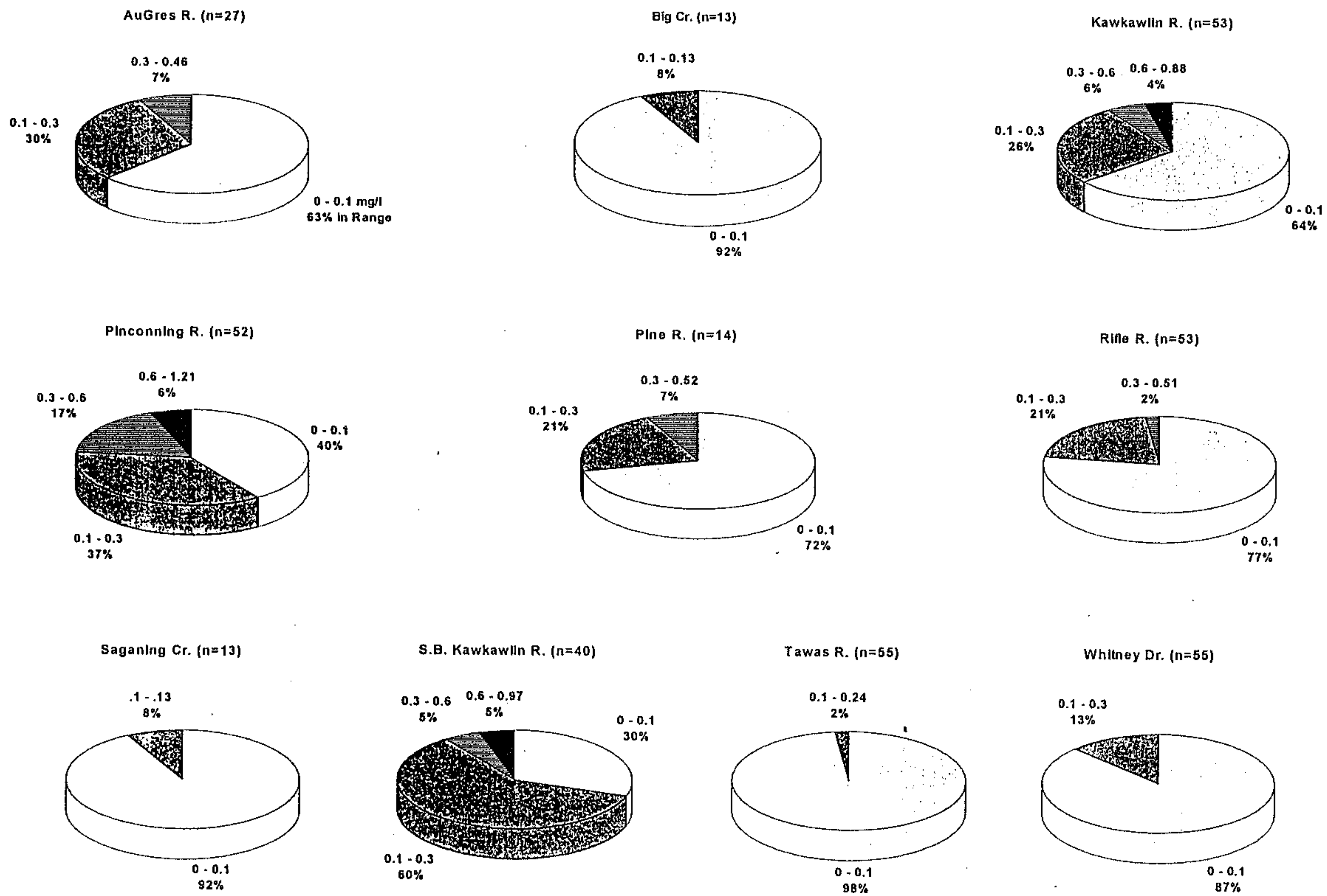
Tributaries with > 5% of samples above 0.6 mg/l

Western Coastal Basin		Eastern Coastal Basin		Saginaw R. Basin	
Tributary	% above	Tributary	% above	Tributary	% above
Pinconning R.	6	Mud Cr.	14		
S.B. Kawkawlin R.	5	Shebeon Cr.	5		

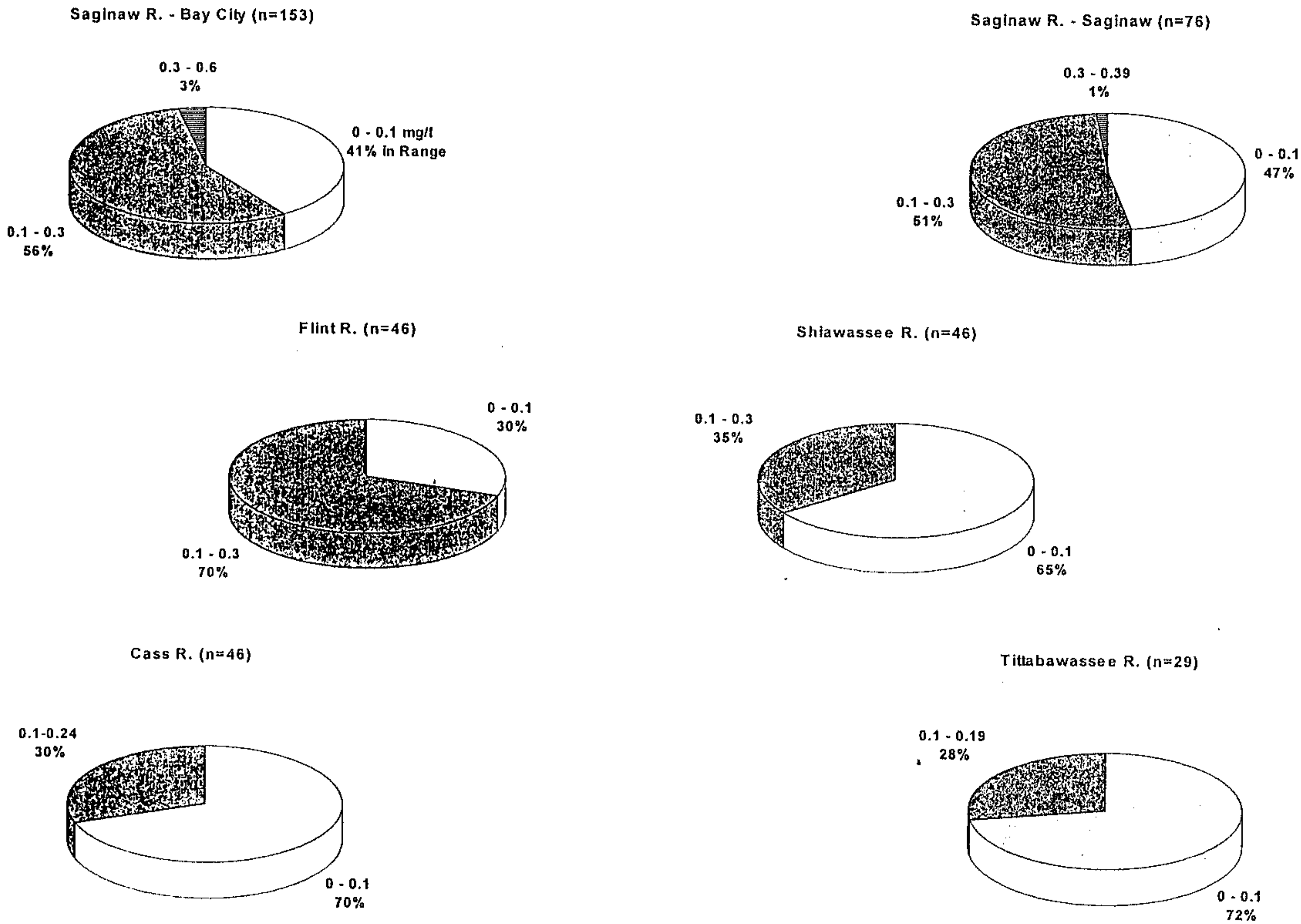
Eastern Coastal Basin Total Phosphorus (1991-93) : Frequency Distribution



Western Coastal Basin Total Phosphorus (1991-93) : Frequency Distribution



Saginaw River and Tributaries
Total Phosphorus (1991-93) : Frequency Distribution



c. Nitrogen

i) Saginaw Bay

Nitrogen can also promote eutrophication in the Great Lakes when phosphorus is not limiting, although to a lesser extent than phosphorus when nitrogen is limiting. The ratio of available nitrogen to phosphorus (N:P) in one surveyed area of Saginaw Bay increased between 1974 and 1980. The N:P ratio increased from 20.2:1 in 1974 to 26.2:1 in 1976 to 28.3:1 in 1980. Although nitrogen levels decreased from 1974 to 1980, the decrease in phosphorus levels was much greater and resulted in an increase in the N:P ratio. When the N:P ratio goes above 29:1, conditions are no longer favorable for blue-green algae. The N:P ratio of 28.3:1 in 1980 for Saginaw Bay may account for the decreases in blue-green algae which occurred between 1974 and 1980.

Nitrogen data has also been collected in Saginaw Bay since 1991 as part of the NOAA zebra mussel project, but the data have not been summarized yet.

ii) Coastal Tributaries

Annual mean nitrogen concentrations during 1991-1993 were substantially higher in the east coastal basin tributaries than the west coastal basin tributaries. As an example, dissolved NO2+NO3 concentrations were typically 6 mg/l or higher among the eastern tributaries, whereas among the western tributaries, only the Pinconning and South Branch Kawkawlin rivers had levels that high.

Annual mean dissolved ammonia concentrations were much more similar between the east and west coastal basin tributaries, with the striking exception of Mud Creek, which had values of over 1.2 mg/l compared to less than 0.5 mg/l for any other coastal tributary.

iii) Saginaw River and Tributaries

Annual mean dissolved nitrite-nitrate concentrations at the mouth of the Saginaw River during 1991-1993 ranged from 1.47 mg/l to 1.87 mg/l, which was substantially less than the levels observed in the coastal basin tributaries. In contrast to phosphorus levels in Saginaw River tributaries, where the Flint River had the highest values, dissolved nitrite-nitrate concentrations were highest in the Cass River for two of the three years.

Also in contrast to the notable decline in phosphorus levels observed in the Saginaw River, no discernable trend could be detected for total NO2+NO3 concentrations over the last 20 years. Among the tributaries to the Saginaw River, however, apparent increases in total nitrite-nitrate were observed in the Cass and Shiawassee rivers. The highest annual means were measured in the Cass and Flint rivers, where total NO2+NO3 reached 3 mg/l or higher. Mean levels in the Shiawassee and Tittabawassee rivers never surpassed 1.5 mg/l.

Another observation to note was that dissolved ammonia concentrations increased substantially between the head and mouth of the Saginaw River in both 1991 and 1992. This did not occur with any of the other nutrient parameters discussed previously.

4. Watershed Prioritizations

a. Methodology

This section compares the water quality of rivers within the Saginaw Bay watershed to each other and, where applicable, Michigan's water quality standards. Rivers identified as high priority are those with the worst water quality conditions.

The following prioritizations have been based on ambient stream water quality data assessed by the Water Quality Technical Advisory Committee (TAC) of the Saginaw Bay National Watershed Initiative. To date, the water quality TAC has focused on conventional parameters and nutrients, so these are the categories discussed here. Metals and organic parameters will be prioritized at a later date when they are addressed by the TAC.

Six basic water chemistry parameters were used as indicators of overall water quality including total suspended solids, total phosphorus, total dissolved nitrite+nitrate nitrogen (NO_2+NO_3), dissolved oxygen, biochemical oxygen demand (BOD), and chlorophyll a.

Individual measurements and annual mean concentrations were used in the prioritization. The raw data and annual means are important criteria for assessing water quality conditions in the streams themselves and for prioritizing them with respect to improving instream conditions. However, to assess a river's impact on Saginaw Bay, the total mass or "load" of a given substance contributed by the river to the bay is the most important factor. Unfortunately, though annual loads are currently being calculated, the results are not yet available. When the load calculations have been completed, they will be added to this process.

In order to compare water quality among rivers, it is important that the data set used be as homogenous as possible. That is, samples from the various rivers being compared should have been collected at roughly the same time, using the same methodology, and analyzed at the same laboratory. Additionally, the data set should represent recent conditions, cover an annual period, and include a large number of rivers located throughout the Saginaw Bay basin. Therefore, the chemical water quality data for rivers discussed in this section are from two sources: (1) monthly samples collected by the MDNR under the statewide Fixed Station Monitoring Program; and (2) an intensive 1991-1993 Saginaw Bay tributary sampling project.

Using the above criteria and sources, the best overall data set for nutrients and total suspended solids was found to be for calendar year 1992. During 1992, sampling was conducted throughout the Saginaw basin and was performed periodically throughout the year with additional samples collected at most stations following storm events. The data set for 1991 was very good also, but there were fewer samples collected in the spring and summer than in the fall, creating a seasonal bias in that data set. The 1993 data set was also strongly seasonally biased because fewer samples were collected in the fall. None of the other years included as extensive sampling of the direct tributaries to Saginaw Bay as was done during 1991-1993. Therefore, the annual mean concentration discussions on total suspended solids and nutrients that follow are for 1992.

However, dissolved oxygen, BOD and chlorophyll a were not sampled as part of the Saginaw Bay tributary project, and were dropped from the parameter list for the MDNR Fixed Station Monitoring Program in 1992. Therefore, for these three parameters, the data set best meeting the selection criteria was the 1991 calendar year.

Specific instream prioritization criteria for each parameter were as follows.

Total Suspended Solids: 1992 average concentrations were compared to the 25-80 mg/l range in which good to moderate fisheries are found, and the 50 mg/l goal established by the TAC.

<25 mg/l	=	low priority (L)
25-50 mg/l	=	medium priority (M)
51-80 mg/l	=	high priority (H)
>80 mg/l	=	very high priority (HH)

Total Phosphorus: 1992 average concentrations were compared to the 0.100 mg/l or less goal established by the TAC to prevent nuisance algal growths in streams.

<.070 mg/l	=	low priority (L)
.070-.100 mg/l	=	medium priority (M)
.101-.130 mg/l	=	high priority (H)
>.130 mg/l	=	very high priority (HH)

Total Dissolved NO_2+NO_3: 1992 average concentrations were used to determine priority based on relative comparisons among watersheds.

<3.0 mg/l	=	low priority (L)
3.0-7.0 mg/l	=	medium priority (M)
>7.0 mg/l	=	high priority (H)

Dissolved Oxygen: 1991 raw data and average concentrations compared to Michigan's water quality standards.

minimum conc ≥ 7.0 mg/l	=	very low priority (VL)
minimum conc ≥ 5.0 mg/l, but < 7.0 mg/l	=	low priority (L)
minimum conc < 5.0 mg/l, but annual avg ≥ 5.0 mg/l	=	medium priority (M)
annual avg conc < 5.0 mg/l	=	high priority (H)

BOD: 1991 average concentrations were used to determine priority based on relative comparisons among watersheds.

<2.5 mg/l	=	low priority (L)
2.5-3.0 mg/l	=	medium priority (M)
>3.0 mg/l	=	high priority (H)

Chlorophyll a: 1991 average concentrations were used to determine priority based on relative comparisons among watersheds.

<10 ug/l	=	low priority (L)
10-20 ug/l	=	medium priority (M)
>20 ug/l	=	high priority (H)

b. Results and Discussion

Even though the 1992 data set was the most comprehensive ever collected for nutrients and total suspended solids in the Saginaw Bay watershed, caution should still be used in interpreting the results because some rivers had more data points than others. Additionally, because of the large size of the watershed, each sampling run (in both sampling programs used to collect the data) often took two or more days to complete, resulting in samples being taken at different times. This could dramatically affect the results when sampling was conducted following a storm event because of samples being collected at different points in the flow hydrograph. Also, the 1992 data set represents only one year's conditions, and does not reflect year-to-year variability. Despite these shortcomings, the 1992 data set is the "best case" data set available and is considered to be adequate for rough comparisons of water quality conditions throughout the watershed. The same can be said for the 1991 data set used to evaluate dissolved oxygen, BOD, and chlorophyll a concentrations.

Two points were quite apparent when the data set was examined. First, over half of the high priority rankings were attributed to watersheds in the east coastal basin (Table 1). Of all watersheds sampled, the only high priority rankings that occurred outside the coastal basins were

Table 1. Water Quality Priority Rankings for Saginaw Bay Basin Rivers by Parameter Based on Annual Means for 1991 or 1992.

			Suspended Solids (1992)		Total Phosphorus (1992)		Total NO2+NO3 (1992)			BOD (1991)		Chlorophyll a (1991)	
SET	SHED #	Watershed	mg/l	Priority	mg/l	Priority	mg/l	Priority	DO (1991)	mg/l	Priority	ug/l	Priority
WC	10101	Tawas R	10.56	L	0.032	L	0.168	L	L			3.8	L
WC	10102	EB.AuGrs R	40.44	M	0.040	L	0.193	L	L			2.7	L
WC	10103	AuGres R	59.00	H	0.076	M	1.201	L					
WC	10104	Big Creek	15.28	L	0.047	L	0.846	L					
WC	10105	Rifle R	48.67	M	0.042	L	0.280	L				4.7	L
WC	10201	Pine R	47.09	M	0.119	H	2.526	L					
WC	10202	Pinconn R	31.07	M	0.175	HH	6.571	M				20.5	H
WC	10203	N.Kakawl R											
WC	10204	Kakawl R	29.44	M	0.094	M	3.917	M	M			16.4	M
ECB	10301	Quanic R	77.35	H	0.200	HH	7.192	H					
ECB	10302	NW Drain	320.62	HH	0.175	HH	12.419	H	M			1.8	L
ECB	10303	Wiscog D	62.80	H	0.093	M	8.886	H					
ECB	10304	Sebewaing R	65.48	H	0.094	M	9.550	H	VL			3.2	L
ECB	10305	Shebeon C	43.84	M	0.144	HH	10.004	H				4.4	L
ECB	10306	Pigeon R	17.62	L	0.098	M	6.991	M				10.1	M
ECB	10307	Pinebog R	31.44	M	0.084	M	6.158	M				14.4	M
ECB	10308	Bird Cr	61.73	H	0.106	H	4.403	M					
TIR	20101	U.Tib R											
TIR	20102	Molases R											
TIR	20103	Sugar R											
TIR	20104	U.Cedar R											
TIR	20105	L.Tobac R											
TIR	20106	U.Tobac R											
TIR	20107	SB.Tobac R											
TIR	20108	Salt R											
TIR	20109	Sanford L	9.45	L	0.032	L			L	1.91	L	7.5	L
TIR	20110	Sturgen C											
TIR	20111	Carroll C											
TIR	20112	Bullock C	10.91	L	0.058	L			VL	2.13	L	13.7	M
TIR	20113	L.Tib R	27.77	M	0.067	L	1.242	L	VL			12.0	M
TIR	20201	U.Chipwa R	38.50	M					L				
TIR	20202	Coldwtr R											
TIR	20203	NB.Chipw R											
TIR	20204	Pine R											
TIR	20205	L.Chipwa R	16.57	L	0.044	L							
TIR	20206	Salt Cr											
TIR	20207	U.Pine R											
TIR	20208	L.Pine R	19.14	L	0.051	L							
SHR	20301	Swan Cr											
SHR	20302	Marsh Cr											
SHR	20303	Beaver Cr											
SHR	20304	Bad River											
SHR	20305	S.FrkBad R											
SHR	20306	Birch Run											
SHR	20307	L.Shiaw R	43.24	M	0.098	M	1.979	L	L	1.80	L	8.3	L
SHR	20308	M.Shiaw R	11.00	L	0.024	L			VL				
SHR	20309	SB.Shia R											
SHR	20310	U.Shiaw R											
FLR	20401	Mstguay C											
FLR	20402	L.Flint R	46.56	M	0.139	HH	2.028	L	VL	3.10	H	22.7	H
FLR	20403	Swartz Cr											
FLR	20404	Thread Cr											
FLR	20405	Kearsly C											
FLR	20406	M.Flint R	16.50	L	0.055	L			VL	2.82	M	20.7	H
FLR	20407	LSB.Flnt R											
FLR	20408	USB Flnt R											
FLR	20409	NB.Flnt R											
FLR	20410	Cedar Cr											
CSR	20501	L.Cass R	50.10	M	0.090	M	3.457	M	L	2.42	L	13.7	M
CSR	20502	Perry Cr											
CSR	20503	M.Cass R	19.50	L	0.084	M							
CSR	20504	U.Cass R											
CSR	20505	White Cr											
CSR	20506	MB.Cass R											
CSR	20507	NB.Cass R	9.25	L	0.070	M							
CSR	20508	SB.Cass R											
SGR	20601	U.Sagin R	43.94	M	0.100	M	1.993	L	VL	2.77	M	21.2	H
SGR	20602	L.Sagin R	37.42	M	0.101	H	1.868	L	L	2.94	M	18.6	M

for the Saginaw and Flint rivers (both were high priority for total phosphorus and chlorophyll a, and the Flint River ranked high for BOD also).

The second major point was that for many watersheds there were no data. This is not surprising since the Fixed Station Monitoring Program focused on the mouths of major tributaries to monitor trends and loads to the Great Lakes. Some data on the upstream watersheds have been collected as part of MDNR biological surveys or other investigations. Though these data often cover only a single time period, they may need to be included in this prioritization process given the lack of comprehensive data sets comparable to those for the tributary mouth stations.

Total Suspended Solids: The highest annual average total suspended solids concentration by far was 320 mg/l in Northwest Drain. The four next highest concentrations (62-77 mg/l) were also found in east coastal basin tributaries, with three of these in watersheds adjacent to Northwest Drain. This is not surprising since these watercourses flow linearly through intensively farmed crop land. Storm events generate high volume flows with relatively high velocities that can carry large amounts of soil eroded from adjacent land and the drain banks.

Total Phosphorus: The highest total phosphorus annual means were also found in the southern portion of the east coastal basin. The highest concentration of 0.200 mg/l was found in the Quanicassee River, followed by 0.175 in both Northwest Drain and the Pinconning River. These concentrations are nearly twice as high as the 0.101 mg/l level found in the Saginaw River. Among tributaries to the Saginaw River, the Flint River concentration of 0.139 mg/l was substantially higher (42%) than the next highest value of 0.098 mg/l in the Shiawassee River.

Total Dissolved NO_2+NO_3: The southern portion of the east coastal basin also had the highest annual average concentrations of total dissolved nitrite-nitrate, ranging from 7.2 mg/l in the Quanicassee River to a high of 12.4 mg/l in Northwest Drain. This area included all the high priority ranked watersheds, though the Pigeon, Pinnebog and Pinconning rivers were close behind with concentrations over 6.0 mg/l. Among Saginaw River tributaries, the Cass River had the highest concentration at 3.5 mg/l, which was 75% higher than the 2.0 mg/l levels observed in both the Flint and Shiawassee rivers.

Dissolved Oxygen: The data on dissolved oxygen are applicable only for rough comparisons among rivers. Even in that application the data are of limited use because concentrations were measured at only a small number of stations. Furthermore, the sampling procedure was recently evaluated and determined to not be very useful (because it was taken at a single point in time and did not account for diurnal variation) and was discontinued in early 1992. Nevertheless, the data did indicate that of the rivers sampled, minimum dissolved oxygen concentrations fell below 5.0 mg/l in only two watercourses, Northwest Drain and the Kawkawlin River, both of which are coastal basin tributaries.

BOD: Even fewer data points were available for biochemical oxygen demand, and there were no data on coastal basin tributaries. Once again, among Saginaw River tributaries, the Flint River had the highest concentration with an annual average value of 3.1 mg/l.

Chlorophyll a: The data for chlorophyll a were more extensive than for either dissolved oxygen or BOD and included a fair number of coastal basin tributaries. Of the coastal tributaries, only the Pinconning River's 20.5 ug/l chlorophyll a concentration ranked it as a high priority stream, though not far behind were the Kawkawlin River (16.4 ug/l) and Pinnebog River (14.4 ug/l). The highest annual average chlorophyll a concentration overall was 22.7 ug/l found in the Flint River. The Flint River value was 66% higher than the 13.7 ug/l in the Shiawassee River, which was the next highest concentration among Saginaw River tributaries. The Saginaw River also ranked as a high priority stream with a value of 21.2 ug/l reported for the head of the river, dropping to 18.6 ug/l at the mouth.

c. Conclusions

- Water quality conditions are most degraded, with respect to total suspended solids and nutrients, in the east coastal basin tributaries, especially the drains in the southern portion of the basin among which Northwest Drain had the worst conditions.

- The Flint River had the most degraded water quality among Saginaw River tributaries. When compared among all rivers, the Flint ranked as a high priority river for total phosphorus, BOD and chlorophyll a. It also had the highest concentrations among Saginaw River tributaries for all parameters except total suspended solids and nitrite-nitrate, which were both higher in the Cass River.

- The best water quality was found in the Tittabawassee River basin and the northern rivers of the west coastal basin.

C. NUTRIENTS IN SEDIMENT

1. Areas Surveyed

The MDNR conducted an extensive sediment survey of the Saginaw Bay watershed in 1988. Over 300 sediment samples were collected. Most were surficial grab samples of the top 2-3 cm. Four major areas of the watershed were assessed including Saginaw Bay, the mouths of Saginaw Bay tributaries, the Saginaw River, and Saginaw River tributaries. Tributary samples were collected in depositional zones. Saginaw River samples were collected in depositional zones outside the federally maintained navigation channel.

2. Total Phosphorus

Total phosphorus concentrations in most of Saginaw Bay sediments were below 300 mg/kg and would be considered to be non-polluted (<420 mg/kg) if compared to the 1977 U.S. EPA Interim Guidelines for the Disposal of Great Lakes Harbor Sediments. However, elevated concentrations were found near Quanicassee and the Maisou Island/Wildfowl Bay area, where one sample exceeded the heavily polluted criteria of 650 mg/kg.

The highest total phosphorus concentration in Saginaw Bay tributary sediments was over 750 mg/kg in Mud Creek. Concentrations were generally greater in the east coastal basin tributaries. Levels above 420 mg/kg were observed in the Pinnebog River, Sebewaing River, Wiscoggin Drain, Quanicassee River, and Kawkawlin River.

Only four of the 30 sediment samples (13%) collected from the Saginaw River exhibited total phosphorus concentrations below the 650 mg/kg heavily polluted criteria. Though the maximum concentration of 2,000 mg/kg was found immediately downstream on the city of Saginaw WWTP, high concentrations were found throughout the length of the Saginaw River.

U.S. Army Corps of Engineers (ACOE) surveys of the Saginaw River navigation channel in 1983 and 1988 also found the highest total phosphorus concentration at the station immediately downstream of the Saginaw WWTP, 1,500 mg/kg and 1,900, respectively. However, these surveys also detected increased levels of total phosphorus in stations downstream of the Bay City WWTP relative to stations between Bay City and Saginaw. And in the 1992 ACOE survey, total phosphorus concentrations were higher downstream of the Bay City WWTP than they were below the Saginaw WWTP.

Of all the sediment samples collected throughout the watershed in the MDNR 1988 survey, the highest overall total phosphorus concentration of over 2,700 mg/kg was found in the Flint River. Concentrations above the 650 mg/kg level were also found in the Cass, Shiawassee and Tittabawassee rivers.

3. Orthophosphate

Orthophosphate sediment concentrations were generally highest at the same locations where total phosphorus concentrations were greatest. The lowest values were found in Saginaw Bay, where most concentrations were below 30 mg/kg and none were over 70 mg/kg. Among Saginaw Bay tributaries, the highest concentration was again at Mud Creek (>95 mg/kg) followed by Wiscoggin Drain (78 mg/kg). The largest concentration noted in the watershed was in the Saginaw River (1,800 mg/kg) below the city of Saginaw WWTP. All other samples in the Saginaw River were under 1,000 mg/kg, though all except one were over 200 mg/kg. Of the tributaries to the Saginaw River, the Flint River had substantially higher concentrations than the others, reaching 1,200 mg/kg.

4. Total Kjeldahl Nitrogen

Over one-half the total kjeldahl nitrogen concentrations measured in the sediments of inner Saginaw Bay exceeded the heavily polluted criteria of 2,000 mg/kg, with the maximum value reaching 4,000 mg/kg. Concentrations were also elevated in the Maisou Island area, where one sample measured over 4,700 mg/kg.

There was less difference among the eastern and western coastal basin tributaries for total kjeldahl nitrogen than there had been for total phosphorus. The highest value was observed in the Pinnebog River (1,500 mg/kg) followed by the Kawkawlin River (1,400 mg/kg). All other rivers had concentrations below 1,100 mg/kg.

As was the case for total phosphorus, total kjeldahl nitrogen concentrations showed no upstream/downstream trends in the Saginaw River. Two-thirds of the samples measured 1,000 mg/kg or greater, with the highest values observed at Weiss Street Drain (3,300 mg/kg) and Middle Grounds Island (3,200 mg/kg).

Again for Saginaw River tributaries, the Flint River had the highest concentrations of total kjeldahl nitrogen, reaching a high of 4,700 mg/kg.

5. Ammonia Nitrogen

The maximum ammonia nitrogen sediment concentration detected in the watershed was 340 mg/kg in Saginaw Bay near Maisou Island. Ammonia concentrations above 200 mg/kg are classified as heavily polluted. All other Saginaw Bay stations had concentrations less than 45 mg/kg except for three other nearshore stations: 140 mg/kg near Wigwam Bay, 100 mg/kg at Nayanquing Point, and 80 mg/kg near Quanicassee. Ammonia concentrations between 75 mg/kg and 200 mg/kg are considered to be moderately polluted for dredge disposal purposes. All four of these samples were collected at the edges of coastal marshes.

The highest ammonia nitrogen concentrations found in the coastal tributaries was 44 mg/kg in the Kawkawlin River, followed by 37 mg/kg in the Sebewaing River, and 30 mg/kg at Mud Creek. All other tributaries had concentrations below 30 mg/kg, and all other west coast tributaries had values below 10 mg/kg.

Ammonia nitrogen concentrations in the Saginaw River were substantially greater at stations sampled in the city of Saginaw than downstream, with a high value of 140 mg/kg. The stations downstream of the city of Saginaw had concentrations of 25 mg/kg or less, with many around 10 mg/kg.

Once again, among the Saginaw River tributaries, the Flint River had the highest concentration of ammonia nitrogen, reaching 160 mg/kg. Both the Tittabawassee and Shiawassee rivers had concentrations that exceeded 100 mg/kg. Cass River samples were both below 30 mg/kg.

D. HYDROLOGY

1. Watershed Characteristics

Saginaw Bay receives an average total tributary input of about 154 cubic meters per second. Of this, approximately 115 cms (75%) is contributed by the Saginaw River.

Rivers within the Saginaw Bay drainage basin can generally be described as low slope and event responsive. Both characteristics reflect the long-term inundation of the area by post-glacial lakes, which deposited thick layers of relatively impermeable lacustrine sediments before retreating. Because the soils that developed from these materials are generally very fertile, agricultural development succeeded the logging era of the mid to late 19th century and, accompanied by the construction of drains, ditches and field tile systems, encroached upon many of the wetlands that border the bay. Besides the known water quality implications, such changes increase the speed with which water is delivered downstream and the potential for downstream flooding.

Some areas of the Saginaw Bay drainage basin have more permeable soils than those in the agricultural areas and their soils impart a less hydrologically responsive character to local drainage systems. The Rifle River is perhaps the best example, along with some of the upstream portions of the Tittabawassee River and other northern or western rivers.

2. Hydrologic Watershed Prioritization

a. Methods

Hydrologic characteristics relating to drainage area, base flow, and flow stability were estimated for the 69 watersheds that have been identified in the Saginaw Bay Watershed Prioritization Process.

Drainage Area

Watershed boundaries for the Saginaw Bay Watershed were delineated on 7.5 minute USGS quadrangle maps and put into MIRIS. Some of the watersheds along the coastal areas include more than one tributary.

Base Flow

Base flow is an estimate of the degree to which a stream may dry up in the summer and the degree to which it is supported by groundwater. In order to estimate the base flow, summer

95% exceedence flows were estimated for the 69 watersheds. The lowest monthly 95% value (usually August) was chosen as the base flow indicator. The 95% value means that over a long period, 95% of the time flows higher than this would be expected and 5% of the time values lower than this would be expected for that month. In order to compute the 95% exceedence flow, the following criteria were used.

- If a stream had a USGS gauging station on it near the subwatershed in question, then a direct relationship to the flow statistics for that gage was used.

- If the stream had no gauging station on it, but some miscellaneous streamflow measurements had been made on it, then a correlation was used relating the miscellaneous measurements to the flow statistics at a long-term gauging station.

- If the stream had no gauging station and no miscellaneous measurements had been made on it, then a drainage area relationship to a gage with similar geology was used.

The following criteria were used to rank the watersheds based on base flow yields. The ranking criteria were provided by Paul Seelbach of Fisheries Division.

1 - High Base Flow	$x > .57$ cfs/mi^2
2 - Medium Base Flow	$.38 < x < .57$ cfs/mi^2
3 - Low Base Flow	$.06 < x < .38$ cfs/mi^2
4- Very Low Base Flow	$x < .06$ cfs/mi^2

Flow Stability

Flow stability is an estimate of the flashiness of a stream. The wider the fluctuations in flow, the more flashy or unstable the stream is assumed to be. To estimate flow stability, a comparison between the highest average monthly mean flow to the lowest average monthly mean flow was made. Monthly average flows were estimated for each watershed. Usually, April represented the month with the highest average monthly flow.

The following ranking categories were used to rank the flow stability of the watersheds. These ranking categories were provided by Paul Seelbach of Fisheries Division.

1 - Stable Stream	$x < 2$
2 - Variable Stream	$2 < x < 7$
3 - Flashy Stream	$7 < x$

b. Results and Discussion

Base Flow

Base flow is predominantly affected by drainage area and geology (i.e. clay vs. outwash). The lowest base flow yields occur in those watersheds that contain a lot of lake bed clay. Other factors that affect base flow include tile drainage, storm drains, and the amount of imperviousness surfaces.

For each of the 69 watersheds, base flow was listed in cubic feet per second (cfs) and in terms of yield (cfs per square mile) (Table 11). Yields allow a comparison of one Saginaw Bay watershed to another and to other streams in the state. The amount of base flow can also be related to the type of stream (i.e. coldwater, coolwater, warmwater).

Base flow yields in the Saginaw Bay Watershed varied from 0 to 0.39 cfs per square mile (Table 11). Most of the Saginaw Bay watershed has streams with low to very low base flow.

Flow Stability

Flow stability is predominantly affected by the geology, land use, and stream slope. A stream with a steep slope, clay soils, and crops or heavily urbanized, will be much more flashy than a stream that is flatter, has sandy soils, and is predominantly covered with forests or meadows.

For each of the 69 watersheds, the flow stability (flashiness) was computed (Table 11). The lower the number, the more stable and less flashy the stream is estimated to be. The more flashy a stream, the more strongly it is influenced by runoff events. Such streams tend to have large seasonal flow variations and lower base flow. As a comparison to other streams in the state, the Au Sable River near Grayling has a flow stability value of 1.7. Flow stability can also be related to the type of stream (i.e. coldwater, coolwater, warmwater).

Flow stability in the Saginaw Bay Watershed varied from 3.36 in the Sugar River watershed to 71 in the Swartz Creek watershed. As can be seen from the range of flow stability rankings, the watersheds in the Saginaw Bay watershed fall into the variable to flashy categories. Most of the variable rankings are in the northwestern part of the Saginaw Bay watershed.

Flood Potential

An estimate of the flooding potential was not done as part of this evaluation. Several townships or cities in the watershed are in the National Flood Insurance Program and would have floodplain maps available for those streams that were studied, though not all of the streams in a given community were studied. Floodplain areas from studies in Saginaw and Bay counties,

Table 11. Saginaw Bay Watershed Hydrological Assessment, 1993.

Watershed Name	Watershed Number	Drainage Area (sqmi)	Flow Stability (cfs/cfs)	Flow Stability Rating	Base Flow (cfs/sqmi)	Base Flow Rating
Western Coastal Basin						
Tawas R	10101	172	3.76	2	0.26	3
EB.AuGrs R	10102	147	3.47	2	0.29	3
AuGres R	10103	244	8.51	3	0.08	3
Big Creek	10104	61	8.08	3	0.06	4
Rifle R	10105	379	3.76	2	0.37	3
Pine R	10201	103	8.16	3	0.00	4
Pinconn R	10202	157	21.94	3	0.00	4
N.Kakawl R	10203	103	36.15	3	0.00	4
KaKawl R	10204	122	37.36	3	0.00	4
Eastern Coastal Basin						
Quanic R	10301	118	28.81	3	0.00	4
NW Drain	10302	88	28.57	3	0.00	4
Wiscog D	10303	82	28.97	3	0.00	4
State D	10304	104	28.78	3	0.00	4
Shebeon C	10305	72	28.82	3	0.00	4
Pigeon R	10306	157	22.27	3	0.02	4
Pinnebog R	10307	195	22.00	3	0.00	4
Bird Cr	10308	84	28.67	3	0.00	4
Tittabawassee River Basin						
U.Tib R	20101	186	3.56	2	0.32	3
Molasse R	20102	79	8.42	3	0.03	4
Sugar R	20103	67	3.36	2	0.21	3
U.Cedar R	20104	28	3.43	2	0.28	3
L.Tobac R	20105	485	3.44	2	0.28	3
U.Tobac R	20106	76	3.45	2	0.28	3
SB.Tobac R	20107	205	3.47	2	0.39	2
Salt R	20108	221	20.19	3	0.03	4
Sanford L	20109	975	4.54	2	0.22	3
Sturgen C	20110	64	35.76	3	0.00	4
Carrol C	20111	49	36.00	3	0.00	4
Bullock C	20112	32	36.88	3	0.00	4
L.Tib R	20113	2473	6.88	2	0.14	3
U.Chipwa R	20201	301	3.58	2	0.18	3
Coldwtr R	20202	21	3.61	2	0.19	3
NB.Chipw R	20203	81	3.59	2	0.18	3
Pine R	20204	176	5.19	2	0.12	3
L.Chipwa R	20205	409	3.57	2	0.18	3
Salt Cr	20206	1026	5.21	2	0.13	3
U.Pine R	20207	309	5.21	2	0.12	3
L.Pine R	20208	421	5.53	2	0.10	3

Table 11. Saginaw Bay Watershed Hydrological Assessment, 1993.

Watershed Name	Watershed Number	Drainage Area (sqmi)	Flow Stability (cfs/cfs)	Flow Stability Rating	Base Flow (cfs/sqmi)	Base Flow Rating
Shiawassee River Basin						
Swan Cr	20301	133	27.92	3	0.00	4
Marsh Cr	20302	171	28.92	3	0.00	4
Beaver Cr	20303	70	27.84	3	0.00	4
Bad River	20304	346	28.04	3	0.00	4
S.FrkBad R	20305	146	26.82	3	0.00	4
Birch Run	20306	3505	11.43	3	0.07	3
L.Shiaw R	20307	614	7.60	3	0.07	3
M.Shiaw R	20308	492	6.17	2	0.08	3
SB.Shia R	20309	141	6.24	2	0.08	3
U.Shiaw R	20310	361	6.17	2	0.08	3
Flint River Basin						
Mstquay C	20401	174	27.15	3	0.00	4
L.Flint R	20402	1331	7.90	3	0.13	3
Swartz Cr	20403	115	71.00	3	0.00	4
Thread Cr	20404	197	8.83	3	0.01	4
Kearsly C	20405	100	8.57	3	0.06	4
M.Flint R	20406	750	6.02	2	0.00	4
LSB.Flnt R	20407	213	5.95	2	0.10	3
USB Flnt R	20408	152	6.00	2	0.11	3
NB.Flnt R	20409	230	6.02	2	0.08	3
Cedar Cr	20410	71	6.18	2	0.07	3
Cass River Basin						
L.Cass R	20501	908	18.23	3	0.03	4
Perry Cr	20502	825	17.59	3	0.03	4
M.Cass R	20503	710	17.85	3	0.03	4
U. Cass R	20504	621	20.65	3	0.02	4
White Cr	20505	143	24.17	3	0.01	4
MB.Cass R	20506	400	21.41	3	0.02	4
NB.Cass R	20507	69	24.39	3	0.01	4
SB.Cass R	20508	239	27.35	3	0.01	4
	20509	31	27.27	3	0.01	4
Saginaw River						
U.Sagin R	20601	6229	9.19	3	0.09	3
L.Sagin R	20602	64	36.25	3	0.00	4

as well as the coastal areas, are in the MDNR MIRIS system. There are long range plans to put all of the floodplain maps for the state into MIRIS. It should be noted that there are other areas than those which have been mapped that are susceptible to flooding. Local government agencies may be able to identify areas within their jurisdiction that have experienced flooding.

E. AQUATIC BIOTA

1. Plankton

Reductions in fluvial phosphorus inputs to Saginaw Bay between 1975 and 1980 produced qualitative changes in the plankton communities of the bay. The most noticeable phytoplankton change was a decline in the abundance and range of distribution of many species of nuisance blue-green algae in 1980, whose populations were associated with taste and odor problems in the 1970s at water filtration facilities that drew their supplies from Saginaw Bay. Additionally, certain eutrophic-tolerant diatom populations that had been a dominant element of phytoplankton biomass in the bay from 1974-1976 were also virtually eliminated in 1980.

Rotiferan zooplankton also responded dramatically to nutrient load reductions to the bay with substantial decreases in total rotifers and predatory rotifers between 1974 and 1980. The total density of rotifers in the bay decreased from $1,114,500/m^3$ in 1974 to $352,000/m^3$ in 1980. Crustacean zooplankton were moderately reduced in abundance, and fell from a yearly mean of $155,708/m^3$ in 1974 to $96,460/m^3$ in 1980. Rotifer and crustacean zooplankton analyses revealed major water masses interacting with Saginaw River water, impinging primarily on the eastern shore of the bay and Lake Huron water entering the outer western shore.

Certain aspects of the 1980 phytoplankton flora of Wildfowl Bay and Oak Point were highly unusual because these stations supported large blooms of the prokaryote Pelonema. This organism is achlorotic and most of its relatives are found in highly organically enriched and oxygen depleted environments. The presence of this unique flora of in the eastern region of the Saginaw Bay coast indicated that the combination of restricted circulation, loads transported from the southern part of the bay, and local sources of both nutrient and organic loadings severely affected this region.

Despite the fact that there had been substantial water quality improvement in Saginaw Bay, some major problems remained. The phytoplankton flora of the bay still contained large populations of diatoms, green and blue-green algae that indicated eutrophic or disturbed conditions. Furthermore, the seasonal cycle of phytoplankton abundance and major group dominance during 1980 remained more typical of a hypereutrophic system than of one that was balanced and efficiently productive.

Plankton communities were surveyed extensively again in 1991 and 1992, but the results are not yet available.

2. Chlorophyll a

Chlorophyll a concentrations have been used an indicator of phytoplankton production and trophic status. Chlorophyll a concentrations in Saginaw Bay during the 1970s were generally higher and more variable in the inner bay than in the outer, and were substantially higher than levels in Lake Huron. Even though levels had declined by 1980, the chlorophyll a concentration for inner Saginaw Bay in 1980 of 12.2 ug/l, and a spring 1984 value of 10.1 ug/l for the entire bay, were still considered to be eutrophic. When the bay was next sampled in 1991, spring chlorophyll a levels did not appear to differ substantially from earlier concentrations. However, zebra mussels colonized Saginaw Bay in 1991 and preliminary data from the NOAA zebra mussel project indicated that by fall, chlorophyll a concentrations had dropped dramatically to about 4 ug/l, and they remained at about that level in 1992 and 1993.

The most recent data available on chlorophyll a levels in Saginaw Bay tributaries is from 1991. Among the coastal basin tributaries sampled, the Pinconning River had the highest concentration at 20.5 ug/l, followed by the Kawkawlin River with 16.4 ug/l. The east coastal basin tributaries with the highest concentrations were the Pinnebog and Pigeon rivers with values of 14.4 ug/l and 10.1 ug/l, respectively.

Once again, the Flint River had the highest concentration relative to the other three major tributaries to the Saginaw River. The Flint River chlorophyll a mean of 22.7 ug/l was substantially greater than the next highest average of 13.7 ug/l in the Cass River. The Tittabawassee and Shiawassee rivers had similar concentrations of around 8 ug/l. Chlorophyll a concentrations in the Saginaw River were only slightly lower than in the Flint River, averaging 21.2 ug/l at the head of the river and 18.6 ug/l at the mouth.

3. Benthic Macroinvertebrates

Saginaw Bay is a shallow region that once supported a rich riverine invertebrate bottom fauna, but it underwent drastic changes in response to increased inputs of pollutants. High sediment oxygen demands eliminated many species of invertebrates, and these were replaced by pollution-tolerant forms such as aquatic worms Limnodrilus spp. and lakeflies or midge Chironomus species. Between 1956 and 1978, the species composition changed from a mesotrophic to a eutrophic assemblage, and many less tolerant taxa disappeared demonstrating probable organic enrichment. Total densities of macrozoobenthos in 1978 were an order of magnitude higher than those reported for 1956 or 1971.

Burrowing mayfly nymphs (mostly family Ephemeridae, genus Hexagenia), once common members of the Saginaw Bay fauna, decreased in the open bay from $63/m^2$ in 1955, to $9/m^2$ in 1956, to $1/m^2$ in 1965, to $0/m^2$ in 1970. Mayfly nymphs are common in silt bottoms of larger streams and lakes and have been typically identified as clean water, pollution-intolerant species. Their decrease to $1/m^2$ in 1965 and disappearance in 1970 indicate a severe reduction in water quality in the bay between 1955 and 1970. Degraded environmental conditions in Saginaw Bay were further reflected in 1970, when crustaceans and pisidium clams were totally absent and the fauna consisted entirely of pollution tolerant species of aquatic worms (80-94% oligochaetes) and midge (chironomid) larvae. These changes in the benthic community have limited productivity of valuable fish species such as yellow perch.

The Saginaw Bay benthic macroinvertebrate communities were also surveyed extensively again in 1991 and 1992 as part of the NOAA zebra mussel study, but the results are not yet available.

All benthic macroinvertebrate taxa collected from the Saginaw River in 1983 were classified as pollution tolerant. Mature tubificids contributed 13% to 100% of the total macrozoobenthos. Immature Tubificidae comprised between 23% and 80% of the totals at each station. Chironomids were present at 81% of the stations and comprised between 1% and 20% of the totals at those stations.

Between June 1991 and September 1992, 65 subwatersheds within the Saginaw Bay basin were examined in an U.S. EPA study to identify relationships to stream habitat, water quality, and macroinvertebrate communities. The macroinvertebrate communities in the Flint, Shiawassee, and Chippewa river watersheds were found to be fairly similar, but sites within the Kawkawlin River basin and east coastal basin differed considerably from them. Both the east coastal and Kawkawlin basins had higher proportions of depositional taxa and lower proportions of strictly erosional taxa and than the other major basins. Taxa in the east coastal and Kawkawlin watersheds also exhibited lower oxygen tolerance than other major basins. Richness was highest in the Chippewa/Pine watershed and lowest in the east coastal basin.

Macroinvertebrates were most strongly related to channel morphology, substrate characteristics, and nutrient concentrations. At the largest scale, geomorphic differences among watersheds and the extremes of land use (extensive row crop agriculture) had the strongest influence on macroinvertebrate communities, through their influence on stream habitat. At smaller scales, land use patterns (type, heterogeneity) exhibited more influence through their association with water chemistry and habitat alterations.

4. Fish

The shallow waters of Saginaw Bay are among the most productive fish habitats in the Great Lakes (fish densities are about 10 times that found in Lake Huron) and provide outstanding habitat for a wide variety of fish and other aquatic species. The bay is attractive to a broad range of species (over 90 species have been recorded) because of the great diversity of aquatic habitats found there, which provide spawning and nursery areas and plentiful food sources for larval and adult fish. Yellow perch populations in the bay are extremely high and most of the documented spawning grounds of smallmouth bass in the U.S. waters of Lake Huron are in Saginaw Bay, as are all of the known spawning areas of the largemouth bass. Carp and channel catfish populations in the bay support an important commercial fishery, and the production of forage fishes remains high.

However, populations of several important species have declined, and the fish community in the bay is substantially different from that which existed at the turn of the century. Lake herring, once an important part of the commercial fishery in Saginaw Bay, has all but vanished.

Lake trout were also abundant in outer Saginaw Bay at one time, but populations of lake trout are now maintained through stocking of hatchery reared fish. Once the premier commercial species in the region, walleye populations are also now maintained through plantings of artificially propagated fish.

Although mechanisms are not well understood, a number of explanations for the reduction of populations of desired species in the Saginaw Bay fishery have been offered. Toxic materials, conventional pollutants, turbidity, and siltation influence the viability of fish populations directly by altering physiology and behavior, and indirectly by modifying habitat. Nutrient related changes in water quality may affect foraging behavior of some species because nutrient loads can alter zooplankton and phytoplankton availability and benthic communities can be impaired. Recent introductions of white perch and zebra mussels to Saginaw Bay may produce further changes in the fish community.

The Saginaw River and its tributaries provide habitat for various game and non-game fish species. In the Saginaw River itself, recent surveys indicate the presence of a variety of species and a community composition that changes seasonally. The river supports sizeable populations of carp, catfish, quillback and drum, and smaller populations of largemouth bass, yellow perch, black and white crappie, and other species. In addition, moderate to heavy spawning runs of walleye, white bass, suckers and other species pass through the Saginaw River on their way up to the various tributaries, and the lower Saginaw River has been reported to contain excellent spawning habitat for northern pike. Emerald shiners and spottail shiners are also numerous; and gizzard shad, an excellent forage species, occur in tremendous numbers.

Fish communities were surveyed during 1993 in the east coastal, Cass River, Flint River, and Chippewa River basins. The most common fish collected (>5% of catch) were common shiners, bluntnose minnows, creek chubs, white suckers, and Johnny darters. Other species that made up at least 1% of the catch were gizzard shad, hornyhead chub, golden shiner, fathead minnow, blacknose dace, rock bass, green sunfish, pumpkinseed sunfish, and blackside darter. Darters, suckers and shiners occurred more frequently in the Saginaw River watershed. Sunfish and minnows were more common in the east coastal basin samples. Species richness was equivalent between the two major basins, but average abundance was greater in the Saginaw River basin. Overall, more pollution tolerant than intolerant fish species were collected. A greater percentage of tolerant species occurred at the downstream stations. The Chippewa River drainage had a greater occurrence of intolerant species than the other watersheds. Darters were the most abundant group followed by suckers, minnows and sunfish. Darters were especially numerous at the Cass and Flint basin stations. White suckers were common in all four drainages.

5. Aquatic Biota Watershed Prioritization

a. Methodology

The purpose of this assessment was to provide field observed measurements of the fish and aquatic macroinvertebrate communities and physical habitat condition representative of each watershed. The fish community was assessed because this provides a direct measure of the health of the waterbody and information in a form that is familiar to most people. The macroinvertebrate community was assessed to provide a more sensitive measure of the health of the waterbody, a means to identify important causal factors affecting water quality, and a biological indicator to monitor improvement or degradation of water quality over time. The physical habitat evaluations provide a measure of the biological potential of waterbodies assessed.

The data presented are qualitative to semi-quantitative and provide numeric and categorical ratings for each watershed assessed, ranging from excellent (non-impaired) to poor (severely impaired). The results represent a collection of biological surveys conducted by the MDNR Surface Water Quality Division using the Rapid Bioassessment Method (GLEAS Procedure #51). This is a standard survey protocol that includes a comparison with assessments made at reference locations (generally unimpacted or minimally impacted areas) representing major ecoregions and waterbody types (coldwater and warmwater). Additional assessments using similar methods were compiled, evaluated, and included where appropriate if GLEAS Procedure #51 data was not available for a watershed. Typically, a single location on a major stream, usually near the downstream portion of the watershed, was assessed to represent each watershed.

Biological assessment and physical habitat evaluation results available for different portions of each watershed were averaged for that area. The most recent results were used of those collected from the same sample location.

b. Results and Discussion

Results are available for 51 of the 69 watersheds and are presented in Table 9. The macroinvertebrate community assessments were at least as sensitive to water quality impairment as the fish community assessment for all watersheds except Swartz Creek and North Branch Flint River. The biological integrity ratings, determined as the lowest categorical rating of the fish and macroinvertebrate community assessments, and the physical habitat ratings, are summarized in Table 10.

Fifty-nine percent of the watersheds sampled (30 of 51) demonstrated moderately to severely impaired biological communities. Most of these impairments (27 of 30) can be related to impaired physical habitat conditions. Results also indicate that physical habitat conditions in the watersheds of the Saginaw Bay basin were generally more impaired than corresponding

Table 9. Saginaw Bay Watershed Biological Assessment, 1989-93.

Western Coastal Basin						
Criteria	Fish		Macroinvertebrates		Physical Habitat	
	Rating	Score	Rating	Score	Rating	Score
Tawas R. (10101)						
EB AuGres R. (10102)						
AuGres R. (10103)	Good	38	Fair	26	Fair	67
Big Cr. (10104)						
Rifle R. (10105)						
Pine R. (10201)	Good	36	Fair	12	Poor	53
Pincouning R. (10202)			Poor		Poor	
NB Kawkawlin R. (10203)	Good	31	Fair	12	Fair	85
Kawkawlin R. (10204)						

Eastern Coastal Basin						
Criteria	Fish		Macroinvertebrates		Physical Habitat	
	Rating	Score	Rating	Score	Rating	Score
Quanicassee R. (10301)			Low		Low	
NW Drain (10302)	Good	38	Poor	6	Poor	20
Wiscoggin Dr. (10303)	Excellent	46	Poor	8	Poor	56
Sebewaing R. (10304)	Good	37	Fair	23	Fair	76
Shebeon Cr. (10305)	Fair	26	Fair	12	Poor	63
Pigeon R. (10306)	Excellent	43	Fair	26	Fair	65
Pinnebog R. (10307)	Good	38	Fair	28	Fair	67
Bird Cr. (10308)	Excellent	42	Fair	20	Fair	74

Table 9. Saginaw Bay Watershed Biological Assessment, 1989-93.

Tittabawassee River						
Criteria	Fish		Macroinvertebrates		Physical Habitat	
	Rating	Score	Rating	Score	Rating	Score
Upper Tittabawassee R. (20101)	Good	36	Good	40	Excellent	107
Molasses R. (20102)	Excellent	46	Good	44	Good	87
Sugar R. (20103)	Good	40	Good	44	Fair	73
Upper Cedar R. (20104)	Excellent	42	Good	36	Excellent	106
Lower Tobacco R. (20105)	Good	40	Fair	28	Excellent	101
Upper Tobacco R. (20106)	Good	35	Good	38	Fair	81
S.B. Tobacco R. (20107)	Good	28	Good	44	Poor	60
Salt R. (20108)	Excellent	42	Fair	28	Poor	57
Sanford Lake (20109)						
Sturgeon Cr. (20110)	Fair	28	Poor	10	Poor	52
Carroll Cr. (20111)	Good	32	Fair	20	Poor	44
Bullock Cr. (20112)						
Lower Tittabawassee R. (20113)			Good	30		
Upper Chippewa R. (20201)	Excellent	45	Good	38	Excellent	100
Coldwater R. (20202)	Excellent	44	Fair	33	Excellent	105
N.B. Chippewa R. (20203)	Good	39	Fair	32	Fair	77
Pine R. (20204)	Good	38	Good	34	Good	99
Lower Chippewa R. (20205)	Excellent	44	Good	42	Fair	77
Salt Cr. (20206)	Excellent	44	Good	40	Good	98
Upper Pine R. (20207)			Good		Fair	
Lower Pine R. (20208)	Good	32	Good	32	Fair	

Shiawassee River						
Criteria	Fish		Macroinvertebrates		Physical Habitat	
	Rating	Score	Rating	Score	Rating	Score
Swan Cr. (20301)	Good	36	Fair	13	Fair	72
Marsh Cr. (20302)						
Beaver Cr. (20303)	Good	37	Fair	17	Fair	62
Bad R. (20304)	Good	38	Fair	24	Poor	60
S. Fork Bad R. (20305)	Good	38	Fair	22	Poor	43
Birch Run (20306)	Poor	20	Poor	6	Poor	26
Lower Shiawassee R. (20307)	Good		Good		Good	
Mid Shiawassee R. (20308)						
S.B. Shiawassee R. (20309)						
Upper Shiawassee R. (20310)	Good	31	Fair	21	Good	94

Table 9. Saginaw Bay Watershed Biological Assessment, 1989-93.

Flint River						
Criteria	Fish		Macroinvertebrates		Physical Habitat	
	Rating	Score	Rating	Score	Rating	Score
Mistegnay Cr. (20401)						
Lower Flint R. (20402)	Good	32	Fair	26	Fair	66
Swartz Cr. (20403)	Poor		Fair	28	Poor	59
Thread Cr. (20404)						
Kearsley Cr. (20405)						
Mid Flint R. (20406)	Good	35	Good	34	Good	84
Lower S.B. Flint R. (20407)						
Upper S.B. Flint R. (20408)	Good	39	Good	37	Good	91
N.B. Flint R. (20409)	Fair	26	Good	30	Poor	24
Cedar Cr. (20410)	Good	31	Fair	14	Poor	25

Cass River						
Criteria	Fish		Macroinvertebrates		Physical Habitat	
	Rating	Score	Rating	Score	Rating	Score
Lower Cass R. (20501)	Good	37	Good	38	Poor	51
Perry Cr. (20502)	Good	38	Fair	26	Fair	71
Mid Cass R. (20503)	Excellent	44	Good	42	Good	82
Upper Cass R. (20504)	Good	40	Good	37	Good	[illegible]
White Cr. (20505)	Good	41	Good	38	Good	90
Mid Branch Cass R. (20506)	Good	34	Good	30	Fair	77
N.B. Cass R. (20507)	Good	41	Good	34	Good	81
S.B. Cass R. (20508)	Good	34	Fair	24	Poor	60
Columbus Dr. (20509)						

Saginaw River						
Criteria	Fish		Macroinvertebrates		Physical Habitat	
	Rating	Score	Rating	Score	Rating	Score
Upper Saginaw R. (20601)						
Lower Saginaw R. (20602)						

Table 10. Summary of Saginaw Bay Basin Biological Integrity and Physical Habitat Condition, Years 1989-1993, by Watersheds.

	Physical Habitat Condition			
Biological Integrity	POOR	FAIR	GOOD	EXCELLENT
POOR (Severely Impaired)	6	0	0	0
FAIR (Moderately Impaired)	9	12	1	2
GOOD (Slightly Impaired)	2	6	10	3
EXCELLENT (Non-Impaired)	0	0	0	0

biological communities. There were six instances where the physical habitat assessment demonstrated higher ratings than the corresponding biological assessments. Three of these instances (Lower Tobacco River; Coldwater River; and Upper Shiawassee River) demonstrated moderately impaired biological communities despite good to excellent physical habitat conditions and may indicate potential chemical contamination.

Generally, the Cass and Tittabawassee river systems maintained higher quality biological communities than other major Saginaw River tributaries and the west and east coastal basin streams.

Major waterbodies in most of the watersheds have been assessed. More than half of the watersheds were represented by moderately to severely impaired biological communities. Moderately to severely impaired physical habitat conditions may be responsible for up to 90% of the biological impairment demonstrated. MDNR biological survey reports connect much of the physical habitat impairment to improper land use practices.

Aquatic macroinvertebrate and physical habitat assessments conducted by other investigators in the Saginaw Bay basin support the assessments presented in Table 9. Another recent survey found that Saginaw River basin streams maintained higher quality macroinvertebrate communities than west and east coastal basin streams. Macroinvertebrate community impairment was attributable to physical habitat degradation, particularly substrate quality.

F. NUTRIENT SOURCES

1. Sources

a. Point Sources

Permits regulating direct industrial and municipal discharges to Michigan surface waters are issued under the National Pollutant Discharge Elimination System administered by the MDNR. Submittal of monthly Discharge Monitoring Reports (DMRs) is required for most surface water discharge permit holders. Summarized DMR information is available on the U.S. EPA Permit Compliance System (PCS). The PCS database can provide an inventory of the parameters being monitored by dischargers and is suitable for loading calculations. The MDNR also inputs DMR reporting information to the EPA STORET computer system.

Discharges of wastewater that require permits originate from a wide variety of practices in the Saginaw Bay watershed including such diverse activities as mining, manufacturing, storm water runoff, and sewage waste treatment.

Currently, there are 273 NPDES permitted municipal and industrial dischargers to surface waters in the Saginaw Bay watershed. These are divided into 29 major and 244 minor dischargers (Table 1). Major municipal systems are generally defined as plants that treat one million gallons of wastewater per day or more. Major industrial systems are those that score 80 points or more in EPA's facility rating system, which considers such factors as the potential for the pollutants to be toxic, the size and type of the waste stream, potential health impacts, and whether the effluent limits are water quality or technology based.

There are 11 major industrial and 180 minor industrial dischargers in the Saginaw Bay watershed. Among municipal dischargers, there are 18 majors and 64 minors. The Flint River basin has the largest number of dischargers (66), but the Tittabawassee River basin has the most major dischargers (8) (Table 1).

The distribution of facilities within each of the seven major Saginaw Bay watershed, and the receiving water, is presented in Appendix Six: Nutrient Sources and Loads, along with information on the Standard Industrial Classification (SIC) codes that identify the type of activities conducted at each facility.

In addition to industrial and municipal dischargers, there are 84 other permitted dischargers in the Saginaw Bay Watershed that are not classified as industrial or municipal.

The 1991/1992 total point source load estimate for total phosphorus to Saginaw Bay of 189 mt/yr was a reduction of 128 mt/yr from the 317 mt/yr calculated for 1982. Phosphorus loads to surface water in the Saginaw Bay watershed from major municipal wastewater treatment

Table 1: Number of Direct Industrial and Municipal Dischargers to the Saginaw Bay Watershed by Drainage Basin.

Drainage Basin	Facility Description			Total
	Type	Major	Minor	
Cass R.	Industrial	1	11	12
	Municipal	2	8	10
East Coastal	Industrial	1	8	9
	Municipal	0	14	14
Flint R.	Industrial	0	55	55
	Municipal	4	7	11
Saginaw R.	Industrial	3	15	18
	Municipal	4	2	6
Shiawassee R.	Industrial	1	33	34
	Municipal	3	10	13
Tittabawassee R.	Industrial	4	34	38
	Municipal	4	15	19
West Coastal	Industrial	1	24	25
	Municipal	1	8	9
Saginaw Bay	Industrial	11	180	191
	Municipal	18	64	82
Total # of Facilities		29	244	273

plants have decreased significantly since 1974, falling from 800 mt/yr to 108 mt/yr in 1992. It is estimated that more than half of the total decrease in phosphorus loads to Saginaw Bay between 1974 and 1979 was due to phosphorus removal efforts by WWTPs in the Saginaw River basin and to the 1977 phosphate detergent ban in Michigan. On the other hand, total phosphorus loads from municipal sewage lagoons nearly tripled, increasing from less than 8 mt/yr in 1982 to over 22 mt/yr in 1992. The total phosphorus load from industrial point sources also decreased substantially dropping from 56 mt/yr in 1982 to 20 mt/yr in 1992.

b. Agricultural Sources

Wind and water erosion of agricultural land is the major source of sediment in the Saginaw River and Saginaw Bay. Erosion rates are influenced by a variety of factors such as soil type, water infiltration rates, vegetative cover, management techniques, and climate. Agricultural crop lands generally have higher erosion rates than permanently vegetated lands and subsequently deliver a greater amount of eroded material to Saginaw Bay. Recent efforts have been made to identify areas susceptible to erosion in the Saginaw Bay basin. Soil erosion is discussed in greater detail, and priority watershed rankings presented, in Chapter VI.

Wind and water erosion of agricultural land is also the major source of nutrients in the Saginaw River and Saginaw Bay. One of the primary reasons is the use of phosphorus and nitrogen fertilizers to increase overall soil fertility and productivity. But, not all of the fertilizer applied is utilized by the crops. The Michigan Department of Agriculture (MDA) has estimated that the average phosphorus application in the Saginaw Bay watershed is more than twice what is needed for crops. Excess fertilizer is subject to surface water runoff or can percolate into groundwater. Ultimately, the excess nutrients can be transported to Saginaw Bay and contribute to eutrophication problems.

Nonpoint phosphorus loads to Saginaw Bay are influenced by many of the same factors that affect sediment delivery rates since much of the phosphorus moved off-site is bound to soil particles. However, the extensive use of drainage tiles in the Saginaw Bay watershed makes phosphorus transport more complex. Though subsurface drainage tiles increase water percolation through the soil, and thereby generally reduce soil transport, they can contain higher concentrations of soluble phosphorus than surface water runoff. Conservation tillage has been found to reduce edge-of-field losses of total phosphorus by reducing sediment erosion, but has not proved as effective for reducing losses of soluble phosphorus.

Animal wastes are another significant source of phosphorus to Saginaw Bay. Cattle, sheep and pigs total over 500,000 animals within the Saginaw Bay watershed. Often these animals are located near surface waters. Nonpoint sources of animal wastes include animal waste from pastures, confinement facilities and indiscriminate manure spreading. It has been estimated that over 3,700,000 metric tons of animal waste is produced in the Saginaw Bay basin annually.

Additional information on nutrient and sediment agricultural sources, as well as atmospheric deposition, can be found in Appendix Six: Nutrient Sources and Loads.

c. Urban Storm Water Runoff

Storm water runoff from urban areas is also a source of both nutrients and sediments. Most of the soil erosion occurs in construction areas where the land has been disturbed. Nutrient sources are lawns and golf courses where fertilizers have been applied. Illegal sewage connections to storm drains also serve as a source of nutrients. There has been little quantification of urban sources in the Saginaw Bay watershed, but based on studies in other areas, it is thought that the loads are significant.

d. Streambank Erosion

Recent studies in southern Michigan have shown that erosion of stream banks can be a major source of sedimentation. Though no data exist for the Saginaw Bay area, this could be a significant source of sediments because of the flashy flow characteristics of the extensive system of linear drains throughout the area that are periodically disturbed by dredging maintenance activities. The U.S. Soil Conservation Service examined the potential for streambank erosion in the Saginaw Bay watershed and that information is presented in Chapter VI.

e. Transportation

Again, though little data are available on the Saginaw Bay area, erosion of gravel road beds and stream road crossings have been shown to contribute substantial amounts of sediments to watercourses.

2. Loads

Estimates of total sediment loads to Saginaw Bay are limited. In 1980, the suspended solid loads to the inner bay were estimated to be 252,000 metric tons, with agricultural nonpoint sources contributing approximately 88% of the load. Sediment loads by tributary in the Saginaw Bay drainage basin are currently being calculated for 1991 and 1992, as part of watershed prioritization effort.

Total phosphorus loads to Saginaw Bay averaged 1700 metric tons/year from 1973 through 1975. The Great Lakes Phosphorus Task Force estimated that the total phosphorus load to Saginaw Bay had dropped to about 665 metric tons by 1982. The 665 mt represented what was considered to be an average load over the preceding couple of years, though the task force noted that actual calculated loads had been higher in more recent years. When this estimate was investigated recently in a historical analysis by MDNR, it was found that the 665 metric ton average annual load estimate used for 1982 was substantially less than the 1844 metric tons calculated by MDNR for 1982 (Table 5), and the over 1700 metric tons recently estimated to have been contributed by the Saginaw River alone in 1982 in a retrospective analysis conducted by Limno-Tech.

The large discrepancy between the task force estimate and the newer calculations is the result of the task force averaging several years of prior data to obtain an "typical" load for use in the 1982 estimates. In fact, the task force had noted that between the time the estimate was developed and the report printed, that loads from more recent years had been substantially higher than 665 metric tons. Indeed, during 1974-1990 period, annual loads fluctuated dramatically, and appeared to be related to annual average discharge.

The MDNR conducted some rough estimates of 1991 and 1992 total phosphorus loads from the intensive tributary monitoring done in conjunction with the NOAA Saginaw Bay zebra mussel study. The calculated loads were 2158 metric tons in 1991 and 946 metric tons in 1992 (Table 5), indicating that substantial year-to-year fluctuations are continuing. On a per acre basis, total phosphorus loads in 1992 were greatest in Mud Creek, followed by Quanicassee River and Northwest Drain. The lowest per acre phosphorus loads were from watersheds in the west coastal basin. These data should be considered preliminary, however, since Limno-Tech will be performing more detailed calculations on these data as part of the modeling component of the Saginaw Bay zebra mussel project.

Relative to point sources, the nonpoint source contribution to Saginaw Bay annual total phosphorus loads was quite large, ranging from 80% to 91% and averaging 85% (Table 5). This percentage contribution was substantially greater than the 52% contribution estimated by the Great Lakes Phosphorus Task Force for 1982. Atmospheric deposition represented less than 2% of the total phosphorus load.

A more in-depth discussion of nutrient loads can be found in Appendix Six: Nutrient Sources and Loads.

3. Phosphorus Reduction Strategy

The 1983 amendments to Annex 3 of the Great Lakes Water Quality Agreement required the development of a phosphorus reduction strategy to meet the phosphorus goal for Saginaw Bay. Attainment of the target load of 440 mt/yr (calculated from an estimated annual average load of 665 mt/yr for the 1982 base year) for Saginaw Bay would result in maintaining a bay phosphorus concentration of 15 micrograms of phosphorus per liter of water (ug/l) and reduce other indicators of eutrophication, including excessive algal growths, taste and odor problems and filter clogging at water filtration plants, and increased turbidity.

Table 5. Total Point Source and Nonpoint Source Phosphorus Loads (mt/yr) to Saginaw Bay for 1982, 1991 and 1992.

Category	G.Lakes Task Force Estimate (Late 70s avg)	MDNR Estimates 1982	1991	1992
Point Sources				
Major Municipal WWTPs	200		108	108[a]
Minor Municipal WWTPs	25		10	10[a]
Municipal Sewage Lagoons	8		22	22[a]
Industrial Facilities	56		20	20[a]
Combined Sewer Overflows	28		28[b]	28[b]
Total Point Sources	317	317	188	188
Nonpoint Sources	348[c]	1527[d]	1970	758
Total Load	665[c]	1844[d]	2158	946
% Nonpoint	52%	83%	91%	80%
GL Task Force Target Load	440			

[a] 1992 Point source discharges were essentially unchanged from 1991, therefore 1991 estimates were used.

[b] Lacked reliable method to estimate 1992 loads, therefore 1982 estimates were used for 1992 as well.

[c] Average load for the preceding several years used to represent baseline.

[d] Actual calculated load for 1982.

Michigan has made substantial progress in implementing the phosphorus reduction strategy through both point and nonpoint source phosphorus load reductions. The total phosphorus reduction through May 1991 was estimated to be 300.9 metric tons, or 134% of the total needed to meet the goal for Saginaw Bay (Table III-27). Planning and installation of soil resources management systems resulted in an estimated phosphorus reduction of 60 metric tons. Residual management generated reductions of another 120 metric tons, even though the SCS Conservation Tillage Report estimated that only 21% of the cropland in the Saginaw Bay watershed was conservation tilled in 1993. Total reductions in point source phosphorus loads, since the 1982 base year, were 68 metric tons, substantially exceeding point source goals for Saginaw Bay.

Although Michigan has exceeded the phosphorus reduction goals for Saginaw Bay, it is unknown what changes in water quality have occurred in the bay as a result of the estimated load reductions. Furthermore, as discussed previously, it appears that the 1982 base load used in the strategy may have been an underestimate of actual loading conditions.

In order to determine if the phosphorus reduction goal has really been met, or if new phosphorus reduction goals should be established to meet the desired uses identified for Saginaw Bay, an updated nutrient budget needs to be defined. Work began in 1991 on a multi-agency, multi-year project to assess nutrient loads to, and concentrations in, Saginaw Bay. However, rapid colonization of Saginaw Bay by the zebra mussel -- an invasive, exotic, European species accidently introduced into the Great Lakes in 1986 -- may complicate interpretation of the new data. The recent data are currently being modeled to answer some of these questions, and the results are expected in early 1995.

In light of the absence of definitive information on the nutrient conditions in, and loads to, Saginaw Bay, and the continued impairment of nutrient related beneficial uses, Michigan is currently continuing to further reduce phosphorus inputs.

Point sources will continue to be regulated with NPDES permits, with all municipal discharges limited to 1 mg/l. This approach continues that advocated in the phosphorus reduction strategy due to significant previous investments in point source discharges and the high cost of additional treatment. This position was reaffirmed with a recent analysis of the impact of reducing the discharge limits of the largest Saginaw Bay watershed WWTPs to 0.5 mg/l. Based on 1991 data, this change would result in a total phosphorus load reduction to Saginaw Bay of only 2.4%, while achieving a point source load reduction of 18%. Because significant additional costs would be incurred by affected WWTPs to achieve a relatively small reduction in phosphorus loads, to date this has not been determined to be cost beneficial. However, substantial point source phosphorus reductions are expected in the next several years due to CSO improvements specified in current NPDES permits, which set time schedules for eliminating or providing adequate treatment of all CSOs.

Table III-27. Progress toward the Michigan Phosphorus Reduction Goals in Saginaw Bay through May 1991.

Source	Progress to Date (MT)[1]	Expected Reduction (MT)
Point Sources		
Municipal	35.5	4.5
Industrial	32.5	6.9
Nonpoint Sources		
Residue Management	120.5	182.2
Resource Management Systems	60.1	---
Fertilizer Management	25.0	30.8
Accelerated Soil Savings	16.4	---
Animal Waste Management	10.9	4.4
Total	300.9	228.8
Phosphorus Reduction Goal		225.0

[1] MT - Metric Tons

Most of the future phosphorus load reductions will need to focus on nonpoint sources. Activities identified under the nonpoint source portion of the strategy will continue to be implemented. The selection of particular actions should be improved by the ongoing small watershed prioritization process, which will facilitate the identification of critical areas for nutrient reduction and focus implementation actions where the most benefit can be obtained. In addition, it appears that increased emphasis will be placed on reducing erosion and sediment delivery, and thereby phosphorus loads, in riparian stream corridors.

Further discussion on the Phosphorus Reduction Strategy can be found in Appendix Six: Nutrient Sources and Loads.

4. Nonpoint Source Watershed Prioritization

a. Methodology

It has been difficult to empirically evaluate nonpoint sources of pollution in the Saginaw Bay watershed to date because of the large size of the watershed. Different methodologies were used in an effort to assess these diffuse pollution sources. Currently these include a subjective best professional judgement survey of field agencies in the watershed, establishment of a Soil Erosion and Sedimentation Technical Advisory Committee, and GIS modeling of several parameters. The information gained from these methods are useful, but field verified information is necessary in order to provide an accurate description of these sources and their potential impacts. Efforts have been initiated to develop a standard nonpoint source watershed assessment field survey to collect this type of information. The following discussion describes the field agency survey.

Broad categories of nonpoint source pollutant criteria were developed by the prioritization committee and a field agency survey developed that provided participants an opportunity to rate each criteria. Results varied based on an individual's knowledge of nonpoint source pollution, level of effort put into survey completion, and the number of respondents to the survey from any given geographic area. The survey was not designed to be statistically valid. Ratings should be looked at only as a means to initiate further discussion of these criteria with local field agencies.

The survey was sent to county agencies in the 22 counties making up the Saginaw Bay watershed. Selected county agencies receiving the survey were: drain commissions, road commissions, Soil Conservation Service/Districts (SCS/SCD), Agricultural Stabilization and Conservation Service (ASCS) field offices, Michigan State University Cooperative Extension Service (CES) field offices, planning commissions, public health departments. These field agencies represent the organizations most likely to manage the selected criteria at the local level. The survey was also completed by a regional basin committee comprised of representation from MDNR Fisheries and Surface Water Quality Division district staff, Saginaw Bay National Watershed Initiative staff, and Huron Pines and Saginaw Bay Resource and Conservation

Development coordinators. This internal committee was surveyed to provide a more regional perspective on the resource.

Ratings were converted from a high-medium-low scale to a numerical 3-2-1 scale respectively. Ratings were determined for each criterion within each watershed. Agency responses for a given criterion were added to derive a county rating for that criterion in the given watershed. Because many watersheds extended beyond county boundaries, county ratings for each criterion were added for the various counties comprising a watershed to derive a single field agency rating for that criteria within the given watershed.

b. Results and Discussion

Overall agency response to the survey was approximately 33%, 50 of 154 agencies responded. Ratings of the basin committee are reported alongside the field agency ratings for comparative purposes (Table 5). Field agency, Basin Committee, and combined overall nonpoint source pollution potential ratings by basin (Table 6) were derived by adding the ratings of all nonpoint source categories in a watershed. The combined rating is the summation of the field agency and Basin Committee overall ratings for that watershed. The highest score possible for Field Agency and Basin Committee ratings is 30, for combined rating 60. Blank spaces in either table indicates no response.

Results show general perspective on nonpoint source problems in the Saginaw Bay watershed. Since results are not statistically verified, caution should be used when interpreting ratings. Also, perceived problems do not necessarily translate into problem areas, and it is necessary to compare the results from this survey with the physical and chemical data summarized in other sections of the prioritization process in order to provide a representative overall rating of the watersheds. However, where field agency, basin committee and combined ratings correspond closely with one another, it shows some consensus on the level of concern surrounding these issues and/or geographic areas.

Table 5: Saginaw Bay Watershed Prioritization: Field Agency/Basin Committee Survey Ratings

Western Coastal Basin Criteria	Watershed Rating	Western Coastal Basin Criteria	Watershed Rating	Western Coastal Basin Criteria	Watershed Rating
Tawas R. (10101)		**Big Cr. (10104)**		**Pinconning R. (10202)**	
Livestock Access/Runoff	M/L	Livestock Access/Runoff	L/L	Livestock Access/Runoff	L/L
Streambank Erosion	L/L-M	Streambank Erosion	L/M	Streambank Erosion	L/M
Wind Erosion	M/L	Wind Erosion	M/L	Wind Erosion	H/H
Water Erosion	L/L	Water Erosion	L/L	Water Erosion	M/L
Sediment Delivery	L/L	Sediment Delivery	L/L	Sediment Delivery	M/M
Tillage Practices	L/L	Tillage Practices	M/M	Tillage Practices	H/M-H
Septic Contamination	L	Septic Contamination	L	Septic Contamination	L
Urban Runoff	M/L	Urban Runoff	L/L	Urban Runoff	L/L
Construction Site Runoff	L/L	Construction Site Runoff	L/L	Construction Site Runoff	L/L
Transportation Runoff	L	Transportation Runoff	L/L	Transportation Runoff	L
EB AuGres R. (10102)		**Rifle R. (10105)**		**NB Kawkawlin R. (10203)**	
Livestock Access/Runoff	L/L	Livestock Access/Runoff	M/L	Livestock Access/Runoff	M/L
Streambank Erosion	M/M	Streambank Erosion	H/H	Streambank Erosion	M/M
Wind Erosion	L/L	Wind Erosion	L/L	Wind Erosion	L/M
Water Erosion	L/L	Water Erosion	M/M-H	Water Erosion	L/L
Sediment Delivery	M/H	Sediment Delivery	H/H	Sediment Delivery	M/M
Tillage Practices	L/L	Tillage Practices	L/L	Tillage Practices	L/M-H
Septic Contamination	M	Septic Contamination	L	Septic Contamination	M
Urban Runoff	L/L	Urban Runoff	L/L	Urban Runoff	L/L
Construction Site Runoff	L/L	Construction Site Runoff	L/L	Construction Site Runoff	M/L
Transportation Runoff	L	Transportation Runoff	L/M	Transportation Runoff	M
AuGres R. (10103)		**Pine R. (10201)**		**Kawkawlin R. (10204)**	
Livestock Access/Runoff	L/L	Livestock Access/Runoff	M/L	Livestock Access/Runoff	L/L
Streambank Erosion	M/M	Streambank Erosion	L/M	Streambank Erosion	M/H
Wind Erosion	L/L	Wind Erosion	L/H	Wind Erosion	M/H
Water Erosion	L/M	Water Erosion	M/L	Water Erosion	M/M
Sediment Delivery	M/M	Sediment Delivery	M/M	Sediment Delivery	M/H
Tillage Practices	M/L	Tillage Practices	M/L	Tillage Practices	M/H
Septic Contamination	L	Septic Contamination	L	Septic Contamination	L
Urban Runoff	L/L	Urban Runoff	L/L	Urban Runoff	L/L-M
Construction Site Runoff	L/L	Construction Site Runoff	L/L	Construction Site Runoff	L/L
Transportation Runoff	L/M	Transportation Runoff	L	Transportation Runoff	L

Table 5: Saginaw Bay Watershed Prioritization: Field Agency/Basin Committee Survey Ratings

Eastern Coastal Basin Criteria	Watershed Rating
Quanicassee R. (10301)	
Livestock Access/Runoff	L/L
Streambank Erosion	L/M
Wind Erosion	H/H
Water Erosion	L/M
Sediment Delivery	H/M
Tillage Practices	H/H
Septic Contamination	M
Urban Runoff	L/L
Construction Site Runoff	L/L
Transportation Runoff	M/M
NW Drain (10302)	
Livestock Access/Runoff	L/L
Streambank Erosion	L/M
Wind Erosion	M/H
Water Erosion	L/L
Sediment Delivery	M/M-H
Tillage Practices	M/M-H
Septic Contamination	L
Urban Runoff	L/L
Construction Site Runoff	L/L
Transportation Runoff	M/M-H
Wiscoggin Dr. (10303)	
Livestock Access/Runoff	L/L
Streambank Erosion	L/M
Wind Erosion	L/H
Water Erosion	L/M
Sediment Delivery	M/M-H
Tillage Practices	M/H
Septic Contamination	L
Urban Runoff	L/L
Construction Site Runoff	L/L
Transportation Runoff	L/M-H

Eastern Coastal Basin Criteria	Watershed Rating
Sebewaing R. (10304)	
Livestock Access/Runoff	L/L
Streambank Erosion	M/H
Wind Erosion	L/H
Water Erosion	M/M
Sediment Delivery	M/H
Tillage Practices	H/H
Septic Contamination	M
Urban Runoff	L/L
Construction Site Runoff	L/L
Transportation Runoff	L/H
Shebeon Cr. (10305)	
Livestock Access/Runoff	L/L
Streambank Erosion	M/H
Wind Erosion	L/H
Water Erosion	L/M
Sediment Delivery	M/H
Tillage Practices	H/H
Septic Contamination	M
Urban Runoff	L/L
Construction Site Runoff	L/L
Transportation Runoff	L/H
Pigeon R. (10306)	
Livestock Access/Runoff	M/L
Streambank Erosion	M/H
Wind Erosion	M/H
Water Erosion	M/M
Sediment Delivery	M/H
Tillage Practices	H/H
Septic Contamination	M
Urban Runoff	L/L
Construction Site Runoff	L/L
Transportation Runoff	L/H

Eastern Coastal Basin Criteria	Watershed Rating
Pinnebog R. (10307)	
Livestock Access/Runoff	M/L
Streambank Erosion	M/H
Wind Erosion	M/H
Water Erosion	M/M
Sediment Delivery	M/H
Tillage Practices	M/H
Septic Contamination	M
Urban Runoff	L/L
Construction Site Runoff	L/L
Transportation Runoff	L/H
Bird Cr. (10308)	
Livestock Access/Runoff	L/L
Streambank Erosion	L/M
Wind Erosion	M/H
Water Erosion	M/M
Sediment Delivery	M/H
Tillage Practices	M/H
Septic Contamination	L
Urban Runoff	L/L
Construction Site Runoff	L/L
Transportation Runoff	L/L

Table 5: Saginaw Bay Watershed Prioritization: Field Agency/Basin Committee Survey Ratings

Tittabawassee River Criteria	Watershed Rating	Tittabawassee River Criteria	Watershed Rating	Tittabawassee River Criteria	Watershed Rating	Tittabawassee River Criteria	Watershed Rating
Upper Tittabawassee R. (20101)		**Upper Cedar R. (20104)**		**S.B. Tobacco R. (20107)**		**Sturgeon Cr. (20110)**	
Livestock Access/Runoff	L/L	Livestock Access/Runoff	M/L	Livestock Access/Runoff	M/H	Livestock Access/Runoff	L/L
Streambank Erosion	M/M	Streambank Erosion	L/L	Streambank Erosion	M/H	Streambank Erosion	M/M
Wind Erosion	L/L	Wind Erosion	L/L	Wind Erosion	M/M	Wind Erosion	L/L
Water Erosion	M/L	Water Erosion	M/L	Water Erosion	M/M	Water Erosion	M/M
Sediment Delivery	M/L	Sediment Delivery	M/L	Sediment Delivery	M/M	Sediment Delivery	M/M-H
Tillage Practices	L/L	Tillage Practices	M/L	Tillage Practices	M/M	Tillage Practices	M/M
Septic Contamination	M	Septic Contamination	M	Septic Contamination	M	Septic Contamination	L
Urban Runoff	M/L	Urban Runoff	M/L	Urban Runoff	M/M	Urban Runoff	M/M
Construction Site Runoff	M/L	Construction Site Runoff	L/L	Construction Site Runoff	M/M	Construction Site Runoff	L/M
Transportation Runoff	M/M	Transportation Runoff	M/M	Transportation Runoff	M/M-H	Transportation Runoff	L/M
Molasses R. (20102)		**Lower Tobacco R. (20105)**		**Salt R. (20108)**		**Carroll Cr. (20111)**	
Livestock Access/Runoff	L/L	Livestock Access/Runoff	M/H	Livestock Access/Runoff	M/H	Livestock Access/Runoff	L/L
Streambank Erosion	L/L	Streambank Erosion	M/H	Streambank Erosion	M/H	Streambank Erosion	L/M
Wind Erosion	L/L	Wind Erosion	M/L	Wind Erosion	M/M	Wind Erosion	L/L
Water Erosion	H/L	Water Erosion	H/M	Water Erosion	M/H	Water Erosion	L/L
Sediment Delivery	L/L	Sediment Delivery	M/L	Sediment Delivery	H/H	Sediment Delivery	L/L
Tillage Practices	L/L	Tillage Practices	H/L	Tillage Practices	M/H	Tillage Practices	L/L
Septic Contamination	L	Septic Contamination	M	Septic Contamination	M	Septic Contamination	M
Urban Runoff	L/L	Urban Runoff	M/L	Urban Runoff	L/L	Urban Runoff	L
Construction Site Runoff	L/L	Construction Site Runoff	M/L	Construction Site Runoff	L/L	Construction Site Runoff	L
Transportation Runoff	L/L	Transportation Runoff	M/M-H	Transportation Runoff	L	Transportation Runoff	M/M
Sugar R. (20103)		**Upper Tobacco R. (20106)**		**Sanford Lake (20109)**		**Bullock Cr. (20112)**	
Livestock Access/Runoff	H/M	Livestock Access/Runoff	H/H	Livestock Access/Runoff	M/L	Livestock Access/Runoff	M/L
Streambank Erosion	H/M	Streambank Erosion	M/H	Streambank Erosion	H/H	Streambank Erosion	M/L-M
Wind Erosion	H/L	Wind Erosion	L/L	Wind Erosion	M/L	Wind Erosion	M/M
Water Erosion	H/M	Water Erosion	H/M	Water Erosion	M/L	Water Erosion	L/M
Sediment Delivery	H/L	Sediment Delivery	M/M	Sediment Delivery	M/M	Sediment Delivery	M/M
Tillage Practices	H/L	Tillage Practices	H/M	Tillage Practices	M/L	Tillage Practices	M/M
Septic Contamination	H	Septic Contamination	M	Septic Contamination	M/H	Septic Contamination	M
Urban Runoff	H/L	Urban Runoff	L/L	Urban Runoff	M/H	Urban Runoff	L/L
Construction Site Runoff	H/L	Construction Site Runoff	L/L	Construction Site Runoff	H/M	Construction Site Runoff	L/L
Transportation Runoff	H/L	Transportation Runoff	H/H	Transportation Runoff	M/M	Transportation Runoff	M

Table 5: Saginaw Bay Watershed Prioritization: Field Agency/Basin Committee Survey Ratings

Tittabawassee River Criteria	Watershed Rating	Tittabawassee River Criteria	Watershed Rating	Tittabawassee River Criteria	Watershed Rating
Lower Tittabawassee R. (20113)		N.B. Chippewa R. (20203)		Salt Cr. (20206)	
Livestock Access/Runoff	L/L	Livestock Access/Runoff	H/M	Livestock Access/Runoff	M/M
Streambank Erosion	H/H	Streambank Erosion	H/H	Streambank Erosion	M/M-H
Wind Erosion	L/M	Wind Erosion	L/M	Wind Erosion	L/M-H
Water Erosion	M/L	Water Erosion	H/H	Water Erosion	M/M
Sediment Delivery	M/M-H	Sediment Delivery	H/H	Sediment Delivery	M/M-H
Tillage Practices	M/M	Tillage Practices	H/L-M	Tillage Practices	M/M
Septic Contamination	L	Septic Contamination	M	Septic Contamination	M
Urban Runoff	M/M-H	Urban Runoff	L/L	Urban Runoff	M/M
Construction Site Runoff	M/M	Construction Site Runoff	L/L	Construction Site Runoff	M/M
Transportation Runoff	L/L	Transportation Runoff	L/M	Transportation Runoff	M/M
Upper Chippewa R. (20201)		Pine R. (20204)		Upper Pine R. (20207)	
Livestock Access/Runoff	M/M	Livestock Access/Runoff	L/L	Livestock Access/Runoff	H/M
Streambank Erosion	L/M	Streambank Erosion	L/M	Streambank Erosion	M/M
Wind Erosion	L/L	Wind Erosion	M/L	Wind Erosion	M/L
Water Erosion	L/M-H	Water Erosion	M/M	Water Erosion	M/M
Sediment Delivery	L/M	Sediment Delivery	M/L-M	Sediment Delivery	M/M
Tillage Practices	L/M	Tillage Practices	M/L-M	Tillage Practices	M/M
Septic Contamination	M	Septic Contamination	L	Septic Contamination	L
Urban Runoff	L/L	Urban Runoff	L/L	Urban Runoff	L/M
Construction Site Runoff	L/L	Construction Site Runoff	L/L	Construction Site Runoff	L/L
Transportation Runoff	M/M	Transportation Runoff	L/M	Transportation Runoff	L
Coldwater R. (20202)		Lower Chippewa R. (20205)		Lower Pine R. (20208)	
Livestock Access/Runoff	L	Livestock Access/Runoff	L/L	Livestock Access/Runoff	M/L
Streambank Erosion	L	Streambank Erosion	M/M	Streambank Erosion	M/M
Wind Erosion	M	Wind Erosion	L/L	Wind Erosion	M/M
Water Erosion	M	Water Erosion	M/M	Water Erosion	L/M
Sediment Delivery	M	Sediment Delivery	M/M	Sediment Delivery	M/M
Tillage Practices	M	Tillage Practices	L/L	Tillage Practices	M/M-H
Septic Contamination	L	Septic Contamination	L	Septic Contamination	L
Urban Runoff	L	Urban Runoff	M/M-H	Urban Runoff	L/M
Construction Site Runoff	L	Construction Site Runoff	M/M-H	Construction Site Runoff	L/L
Transportation Runoff	L	Transportation Runoff	M/M-H	Transportation Runoff	L

Table 5: Saginaw Bay Watershed Prioritization: Field Agency/Basin Committee Survey Ratings

Shiawassee River Criteria	Watershed Rating	Shiawassee River Criteria	Watershed Rating	Shiawassee River Criteria	Watershed Rating	Shiawassee River Criteria	Watershed Rating
Swan Cr. (20301)		**Bad R. (20304)**		**Lower Shiawassee R. (20307)**		**Upper Shiawassee R. (20310)**	
Livestock Access/Runoff	L/L	Livestock Access/Runoff	L/L-M	Livestock Access/Runoff	L/L	Livestock Access/Runoff	L/M
Streambank Erosion	M/M-H	Streambank Erosion	M/H	Streambank Erosion	H/H	Streambank Erosion	L/M
Wind Erosion	M/H	Wind Erosion	L/H	Wind Erosion	M/M	Wind Erosion	L/L
Water Erosion	M/M	Water Erosion	M/M	Water Erosion	L/H	Water Erosion	L/M
Sediment Delivery	M/H	Sediment Delivery	M/H	Sediment Delivery	M/H	Sediment Delivery	L/L
Tillage Practices	M/H	Tillage Practices	M/H	Tillage Practices	L/M	Tillage Practices	L/L
Septic Contamination	L	Septic Contamination	L	Septic Contamination	M	Septic Contamination	M
Urban Runoff	L/M-H	Urban Runoff	L/L	Urban Runoff	M/M	Urban Runoff	M/H
Construction Site Runoff	L/M-H	Construction Site Runoff	L/L	Construction Site Runoff	L/L	Construction Site Runoff	M/H
Transportation Runoff	L	Transportation Runoff	L/M	Transportation Runoff	M/L	Transportation Runoff	M/H
Marsh Cr. (20302)		**S. Fork Bad R. (20305)**		**Mid Shiawassee R. (20308)**			
Livestock Access/Runoff	L/L	Livestock Access/Runoff	L/M	Livestock Access/Runoff	M/L		
Streambank Erosion	L/M	Streambank Erosion	L/H	Streambank Erosion	L/M		
Wind Erosion	M/M	Wind Erosion	L/H	Wind Erosion	L/L		
Water Erosion	L/M	Water Erosion	L/M	Water Erosion	L/M		
Sediment Delivery	M/M	Sediment Delivery	M/H	Sediment Delivery	M/M		
Tillage Practices	M/M	Tillage Practices	L/H	Tillage Practices	L/L		
Septic Contamination	L	Septic Contamination	L	Septic Contamination	L		
Urban Runoff	L/L	Urban Runoff	L/L	Urban Runoff	L/M		
Construction Site Runoff	L/L	Construction Site Runoff	L/L	Construction Site Runoff	L/M		
Transportation Runoff	L/L	Transportation Runoff	L/M	Transportation Runoff	L/L		
Beaver Cr. (20303)		**Birch Run (20306)**		**S.B. Shiawassee R. (20309)**			
Livestock Access/Runoff	L/L	Livestock Access/Runoff	L/L	Livestock Access/Runoff	M/M		
Streambank Erosion	M/H	Streambank Erosion	M/H	Streambank Erosion	L/M		
Wind Erosion	L/H	Wind Erosion	M/M	Wind Erosion	L/L		
Water Erosion	M/M	Water Erosion	M/L	Water Erosion	M/M		
Sediment Delivery	L/M-H	Sediment Delivery	M/H	Sediment Delivery	L/L		
Tillage Practices	M/H	Tillage Practices	M/H	Tillage Practices	M/L		
Septic Contamination	L	Septic Contamination	L	Septic Contamination	M		
Urban Runoff	L/L	Urban Runoff	M/H	Urban Runoff	M/H		
Construction Site Runoff	L/L	Construction Site Runoff	M/H	Construction Site Runoff	M/H		
Transportation Runoff	L/M	Transportation Runoff	L/H	Transportation Runoff	M/H		

Table 5: Saginaw Bay Watershed Prioritization: Field Agency/Basin Committee Survey Ratings

Flint River Criteria	Watershed Rating
Misteguay Cr. (20401)	
Livestock Access/Runoff	L/L
Streambank Erosion	M/M-H
Wind Erosion	L/M
Water Erosion	L/L-M
Sediment Delivery	L/M
Tillage Practices	L/M
Septic Contamination	L
Urban Runoff	L/L
Construction Site Runoff	L/L
Transportation Runoff	L/L
Lower Flint R. (20402)	
Livestock Access/Runoff	L/L
Streambank Erosion	M/H
Wind Erosion	L/M
Water Erosion	M/M
Sediment Delivery	M/H
Tillage Practices	M/L
Septic Contamination	L
Urban Runoff	M/H
Construction Site Runoff	L/H
Transportation Runoff	L/H
Swartz Cr. (20403)	
Livestock Access/Runoff	M/L
Streambank Erosion	M/M
Wind Erosion	L/L
Water Erosion	L/M
Sediment Delivery	L/M
Tillage Practices	L/L
Septic Contamination	L
Urban Runoff	L/H
Construction Site Runoff	M/H
Transportation Runoff	M/H

Flint River Criteria	Watershed Rating
Thread Cr. (20404)	
Livestock Access/Runoff	L/L
Streambank Erosion	M/M
Wind Erosion	L/L
Water Erosion	L/L
Sediment Delivery	L/L-M
Tillage Practices	L/L
Septic Contamination	L
Urban Runoff	M/H
Construction Site Runoff	M/H
Transportation Runoff	L/H
Kearsley Cr. (20405)	
Livestock Access/Runoff	L/L
Streambank Erosion	L/H
Wind Erosion	L
Water Erosion	L/H
Sediment Delivery	L/H
Tillage Practices	L/L
Septic Contamination	M/H
Urban Runoff	M/H
Construction Site Runoff	M/M
Transportation Runoff	L/M-H
Mid Flint R. (20406)	
Livestock Access/Runoff	M/L
Streambank Erosion	M/M
Wind Erosion	M
Water Erosion	M/M
Sediment Delivery	M/M
Tillage Practices	L/L
Septic Contamination	M
Urban Runoff	M/H
Construction Site Runoff	M/H
Transportation Runoff	M/H

Flint River Criteria	Watershed Rating
Lower S.B. Flint R. (20407)	
Livestock Access/Runoff	M/M
Streambank Erosion	M/M
Wind Erosion	L/L
Water Erosion	M/M
Sediment Delivery	M/H
Tillage Practices	M/M
Septic Contamination	M
Urban Runoff	H/H
Construction Site Runoff	M/M
Transportation Runoff	M/M
Upper S.B. Flint R. (20408)	
Livestock Access/Runoff	L/L
Streambank Erosion	L/L-M
Wind Erosion	L/L
Water Erosion	M/L
Sediment Delivery	M/M
Tillage Practices	M/M
Septic Contamination	M
Urban Runoff	M/M
Construction Site Runoff	M/M
Transportation Runoff	M/M
N.B. Flint R. (20409)	
Livestock Access/Runoff	M/M
Streambank Erosion	M/M
Wind Erosion	L/M
Water Erosion	H/H
Sediment Delivery	M/M
Tillage Practices	M/H
Septic Contamination	M
Urban Runoff	L/L
Construction Site Runoff	L/L
Transportation Runoff	L/L

Flint River Criteria	Watershed Rating
Cedar Cr. (20410)	
Livestock Access/Runoff	M
Streambank Erosion	M
Wind Erosion	L
Water Erosion	H
Sediment Delivery	H
Tillage Practices	M
Septic Contamination	L
Urban Runoff	L
Construction Site Runoff	L
Transportation Runoff	M

Table 5: Saginaw Bay Watershed Prioritization: Field Agency/Basin Committee Survey Ratings

Cass River Criteria	Watershed Rating	Cass River Criteria	Watershed Rating	Cass River Criteria	Watershed Rating
Lower Cass R. (20501)		Upper Cass R. (20504)		N.B. Cass R. (20507)	
Livestock Access/Runoff	L/L	Livestock Access/Runoff	M/L-M	Livestock Access/Runoff	L/H
Streambank Erosion	M/H	Streambank Erosion	M/L-M	Streambank Erosion	L/H
Wind Erosion	L/M	Wind Erosion	L/L	Wind Erosion	L/M
Water Erosion	L/L	Water Erosion	M/H	Water Erosion	M/H
Sediment Delivery	M/M	Sediment Delivery	M/H	Sediment Delivery	M/H
Tillage Practices	M/H	Tillage Practices	M/H	Tillage Practices	M/H
Septic Contamination	M	Septic Contamination	M	Septic Contamination	L
Urban Runoff	L/M	Urban Runoff	L/L-M	Urban Runoff	L/L
Construction Site Runoff	L/L	Construction Site Runoff	L/M	Construction Site Runoff	L/L
Transportation Runoff	L/M	Transportation Runoff	L/L	Transportation Runoff	L/L-M
Perry Cr. (20502)		White Cr. (20505)		S.B. Cass R. (20508)	
Livestock Access/Runoff	M/M	Livestock Access/Runoff	M/M-H	Livestock Access/Runoff	M/H
Streambank Erosion	M/M	Streambank Erosion	M/M	Streambank Erosion	L/H
Wind Erosion	M/L	Wind Erosion	L/L	Wind Erosion	L/M
Water Erosion	M/M	Water Erosion	M/H	Water Erosion	M/H
Sediment Delivery	M/M	Sediment Delivery	M/M	Sediment Delivery	M/H
Tillage Practices	M/M	Tillage Practices	M/H	Tillage Practices	M/H
Septic Contamination	M	Septic Contamination	M	Septic Contamination	M
Urban Runoff	L/L	Urban Runoff	L/L	Urban Runoff	L/L
Construction Site Runoff	L/L	Construction Site Runoff	L/L	Construction Site Runoff	L/L
Transportation Runoff	L	Transportation Runoff	L	Transportation Runoff	M/L-M
Mid Cass R. (20503)		Mid Branch Cass R. (20506)		Columbus Dr. (20509)	
Livestock Access/Runoff	L/M	Livestock Access/Runoff	M/H	Livestock Access/Runoff	M
Streambank Erosion	M/M	Streambank Erosion	M/H	Streambank Erosion	M
Wind Erosion	L/L	Wind Erosion	L/M	Wind Erosion	L
Water Erosion	L/M-H	Water Erosion	M/H	Water Erosion	M
Sediment Delivery	L/M	Sediment Delivery	M/H	Sediment Delivery	M
Tillage Practices	M/M	Tillage Practices	M/H	Tillage Practices	M
Septic Contamination	L	Septic Contamination	L	Septic Contamination	M
Urban Runoff	L/L-M	Urban Runoff	L/L	Urban Runoff	L
Construction Site Runoff	L/L	Construction Site Runoff	L/L	Construction Site Runoff	L
Transportation Runoff	L	Transportation Runoff	L/L-M	Transportation Runoff	M

Table 5: Saginaw Bay Watershed Prioritization: Field Agency/Basin Committee Survey Ratings

Saginaw River Criteria	Watershed Rating
Lower Saginaw R. (20601)	
Livestock Access/Runoff	L/L
Streambank Erosion	M/M
Wind Erosion	M/M
Water Erosion	M/L
Sediment Delivery	M/M
Tillage Practices	M/M
Septic Contamination	L
Urban Runoff	L/H
Construction Site Runoff	L/H
Transportation Runoff	L/H
Upper Saginaw R. (20602)	
Livestock Access/Runoff	L/L
Streambank Erosion	M/M
Wind Erosion	M/M
Water Erosion	M/L
Sediment Delivery	M/M
Tillage Practices	M/M
Septic Contamination	L
Urban Runoff	L/H
Construction Site Runoff	L/H
Transportation Runoff	L/H

Table 6: Field Agency, Basin Committee and Combined Survey Ratings for Overall Nonpoint Source Pollution Potential by Basin

Western Coastal Basin

Field Agencies	Rating	Basin Committee	Rating	Combined	Rating
N.B. Kawkawlin R.	16	Kawkawlin R.	17.5	Kawkawlin R.	32.5
Pinconning R.	16	Rifle R.	15.5	Rifle R.	31.5
Rifle R.	16	N.B. Kawkawlin R.	14.5	N.B. Kawkawlin R.	30.5
Kawkawlin R.	15	Pinconning R.	13.5	Pinconning R.	29.5
Pine R.	14	AuGres R.	13	AuGres R.	26
AuGres R.	13	Pine R.	12	Pine R.	26
E.B. AuGres R.	13	Big Cr.	11	E.B. AuGres R.	24
Tawas R.	13	E.B. AuGres R.	11	Big Cr.	23
Big Cr.	12	Tawas R.	8.5	Tawas R.	21.5

Eastern Coastal Basin

Field Agencies	Rating	Basin Committee	Rating	Combined	Rating
Pigeon R.	18	Pigeon R.	20	Pigeon R.	38
Quanicassee R.	18	Pinnebog R.	20	Pinnebog R.	37
Pinnebog R.	17	Sebewaing R.	20	Sebewaing R.	36
Sebewaing R.	16	Shebeon Cr.	18	Quanicassee R.	35
Shebeon Cr.	15	Wiscoggin Dr.	18	Shebeon Cr.	33
Bird Cr.	14	Bird Cr.	17	Bird Cr.	31
N.W. Drain	14	Quanicassee R.	17	N.W. Drain	30.5
Wiscoggin Dr.	12	N.W. Drain	16.5	Wiscoggin Dr.	30

Tittabawassee R. Basin

Field Agencies	Rating	Basin Committee	Rating	Combined	Rating
Sugar R.	30	S.B. Tobacco R.	20.5	Sugar R.	42
Lower Tobacco R.	22	Salt Cr.	19.5	S.B. Tobacco R.	40.5
N.B. Chippewa R.	21	Salt R.	19	Sanford Lake	40
Sanford Lake	21	Sanford Lake	19	N.B. Chippewa R.	39.5
Upper Tobacco R.	21	N.B. Chippewa R.	18.5	Upper Tobacco R.	39
S.B. Tobacco R.	20	Upper Tobacco R.	18	Salt Cr.	38.5
Salt Cr.	19	Lower Tittabawassee R.	17	Lower Tobacco R.	37.5
Salt R.	18	Lower Chippewa R.	16.5	Salt R.	37
Bullock Cr.	17	Sturgeon Cr.	16.5	Lower Tittabawassee R.	34
Lower Tittabawassee R.	17	Lower Tobacco R.	15.5	Lower Chippewa R.	32.5
Upper Cedar R.	17	Upper Chippewa R.	15.5	Sturgeon Cr.	31.5
Upper Pine R.	17	Upper Pine R.	14	Upper Pine R.	31
Upper Tittabawassee R.	17	Pine R.	13	Bullock Cr.	29.5
Lower Chippewa R.	16	Bullock Cr.	12.5	Upper Chippewa R.	28.5
Lower Pine R.	15	Lower Pine R.	12.5	Upper Tittabawassee R.	28
Sturgeon Cr.	15	Sugar R.	12	Lower Pine R.	27.5
Coldwater	14	Upper Tittabawassee R.	11	Pine R.	27
Pine R.	14	Upper Cedar R.	10	Upper Cedar R.	27
Upper Chippewa R.	13	Carroll Cr.	9	Carroll Cr.	21
Carroll Cr.	12	Molases R.	9	Molases R.	21
Molases R.	12	Coldwater		Coldwater	14

Table 6: Field Agency, Basin Committee and Combined Survey Ratings for Overall Nonpoint Source Pollution Potential by Basin

Shiawassee R. Basin

Field Agencies	Rating	Basin Committee	Rating	Combined	Rating
Birch Run	17	Birch Run	20	Birch Run	37
Lower Shiawassee R.	17	S. Fork Bad R.	20	Lower Shiawassee R.	35
S.B. Shiawassee R.	17	Bad R.	19.5	S.B. Shiawassee R.	35
Swan Cr.	15	Swan Cr.	19.5	Swan Cr.	34.5
Bad R.	14	Beaver Cr.	18.5	Bad R.	33.5
Upper Shiawassee R.	14	Lower Shiawassee R.	18	Upper Shiawassee R.	32
Beaver Cr.	13	S.B. Shiawassee R.	18	Beaver Cr.	31.5
Marsh Cr.	13	Upper Shiawassee R.	18	S. Fork Bad R.	31
Mid Shiawassee R.	12	Marsh Cr.	14	Marsh Cr.	27
S. Fork Bad R.	11	Mid Shiawassee R.	14	Mid Shiawassee R.	26

Flint R. Basin

Field Agencies	Rating	Basin Committee	Rating	Combined	Rating
Lower S.B. Flint R.	20	Kearsley Cr.	21.5	Lower S.B. Flint R.	39
Mid Flint R.	19	Lower Flint R.	21	Lower Flint R.	36
Cedar Cr.	18	Lower S.B. Flint R.	19	Mid Flint R.	36
N.B. Flint R.	17	Swartz Cr.	18	Kearsley Cr.	34.5
Upper S.B. Flint R.	17	Mid Flint R.	17	N.B. Flint R.	34
Lower Flint R.	15	N.B. Flint R.	17	Swartz Cr.	32
Swartz Cr.	14	Thread Cr.	16.5	Upper S.B. Flint R.	31.5
Kearsley Cr.	13	Upper S.B. Flint R.	14.5	Thread Cr.	29.5
Thread Cr.	13	Misteguay Cr.	14	Misteguay Cr.	25
Misteguay Cr.	11	Cedar Cr.		Cedar Cr.	18

Cass R. Basin

Field Agencies	Rating	Basin Committee	Rating	Combined	Rating
Columbus Dr.	17	Mid Br. Cass R.	20.5	S.B. Cass R.	36.5
Perry Cr.	17	N.B. Cass R.	20.5	Mid Br. Cass R.	35.5
S.B. Cass R.	16	S.B. Cass R.	20.5	N.B. Cass R.	33.5
Upper Cass R.	16	Lower Cass R.	17	Upper Cass R.	31.5
White Cr.	16	Upper Cass R.	15.5	White Cr.	31.5
Mid Br. Cass R.	15	White Cr.	15.5	Lower Cass R.	31
Lower Cass R.	14	Mid Cass R.	14	Perry Cr.	30
N.B. Cass R.	13	Perry Cr.	13	Mid Cass R.	26
Mid Cass R.	12	Columbus Dr.		Columbus Dr.	17

Saginaw R.

Field Agencies	Rating	Basin Committee	Rating	Combined	Rating
Lower Saginaw R.	15	Lower Saginaw R.	19	Lower Saginaw R.	34
Upper Saginaw R.	15	Upper Saginaw R.	19	Upper Saginaw R.	34

CHAPTER VI: SOIL EROSION & SEDIMENTATION

A. INTRODUCTION

1. Background

The Soil Erosion & Sedimentation Technical Advisory Committee (TAC) of the Saginaw Bay National Watershed Initiative developed this chapter in order to report on the nature and extent of soil erosion and sedimentation within the Saginaw Bay watershed, and to provide recommendations for addressing these problems.

Erosion and sedimentation activities are natural processes that can be influenced by human intervention, but never stopped entirely. In 1984, the U.S. Environmental Protection Agency (EPA) identified sediments as the largest nonpoint source (by volume) water pollutant in the United States. In order to maintain and improve the quality and productivity of water and land ecosystems in the Saginaw Bay basin, erosion rates and sedimentation must be minimized. A soil maintenance program, demanding consistent attention through a continuous planning process, is required to obtain a desirable lasting effect.

High erosion rates are still a serious problem in the Great Lakes basin, even though they are not driving federal programs. In 1980, the estimated load of suspended solids to inner Saginaw Bay was 252,000 metric tons, of which agricultural nonpoint sources contributed roughly 88%. The inner portion of the bay had the greatest agricultural nonpoint source suspended solid load -- 124 metric tons -- while the northern portion of the outer bay received only 9.6 metric tons.

2. Types of Soil Erosion

Wind and water erosion of agricultural lands have been documented as the major source of sediment in the Saginaw River and Saginaw Bay. Erosion rates can be influenced by a variety of factors such as soil type, land use, management techniques, and climate.

According to the 1982 National Resources Inventory, more than 8,700,000 metric tons of agricultural soil are eroded annually in the Saginaw Bay watershed. More than 63% (5,400,000 metric tons) of eroded soil was the result of wind erosion. In Arenac, Gratiot, Huron, Isabella, Midland and Saginaw counties, wind erosion causes more than 70% of the total erosion. Water-induced sheet and rill erosion account for an estimated 3,200,000 metric tons (37%) of the annual erosion.

3. Sources of Soil Erosion

Land use strongly influences the total amount of soil erosion that occurs. Cropland has been reported to be the largest source of soil erosion nationally. In addition, stream banks, gullies, roads, and construction sites contribute a significant amount of erosion relative to their surface area. Forest lands usually have a small amount of soil erosion relative to their area. However, not all cropland is eroding at alarming rates, and not all forest land is adequately protected.

Agriculture

Technological improvements have brought about more intensive row crop farming, larger equipment, and larger fields. This resulted in more land being cleared and the loss of field border areas, which increased the potential for wind and water erosion and ultimate depletion of soil. This also negatively impacted wildlife habitat. Other soil degradation problems are also related to these practices including decreased use of rotations and legumes, less organic matter being returned to the soil, and larger equipment working in less than optimum conditions, all of which continue to compound soil compaction and productivity problems.

However, as mentioned earlier, not all cropland erodes at the same rate because soil erosion depends on a variety of factors. A disproportionate amount of cropland erosion can be attributed to areas eroding at greater than 2T (2 times T, where "T" -- the Tolerable Soil Loss Limit -- is the maximum rate at which soil can erode and still maintain productivity). This rate is calculated for each soil type and is usually in the range of 2-5 tons/acre/year. It is not based on off-site impacts.

Forestry (logging techniques and transportation)

The same trends can be seen in pasture and forest lands as in croplands. A small percentage of the land is contributing the majority of the soil erosion. With forest land, the bulk of erosion is occurring in areas with grazing or timber harvesting activities. In 1987, a Saginaw Bay Area USDA study concluded that only approximately 5% of the 1.2 million acres of commercial forest land is managed. The other 95% is unmanaged or mismanaged, decreasing the value of the existing resource. The on-going economic return was reported as approximately $7.00 per acre per year. Under multiple use forest management, this could increase to $33.00 an acre per year. By implementing forest management practices, soil erosion, runoff and flood potential can be reduced.

Urban/Transportation

Many water quality experts believe that urban area sediments have more serious, prolonged effects on local water quality in streams, reservoirs, lakes and harbors than sediments from rural areas. On a per unit area basis, urban erosion is extremely significant. Up to 90% of the soil erosion in urban areas is attributable to land under development, such as at construction sites and roads. It has been documented that although construction activities in urban settings affect relatively small areas of land, they can lose soil at rates 50-100 times that of crop land.

Erosion and transport of sediment in urban areas is caused primarily by construction activities and storm water runoff. Because of the flat topography and heavy soils found throughout the Saginaw Bay watershed, the transport of storm water runoff is a major problem. The replacement of relatively permeable land areas with large impervious surfaces and lined drainage channels or storm sewers, has led to increased water runoff and soil erosion as well as decreased infiltration and groundwater recharge. The large volumes of water from urban runoff have caused flooding, soil erosion, and siltation problems. Pollutant loads delivered to the receiving stream through urban storm water runoff have created severe water quality problems in localized areas.

Numerous studies have related degraded water quality to land use type. Densely populated urban areas have often been found to contribute runoff water high in suspended solids concentrations. One study that compared rain-related discharge from urban, wetland and agricultural areas, concluded that urban areas contributed the highest inputs of phosphorus, while agricultural sources contributed the greatest nitrogen load per surface area of land. Another report analyzed two sub-basins in Washington, one urbanized and one agricultural, and determined that the urbanized sub-basin contributed the greatest pollution loads from the watershed, even though the agricultural area was 1.85 times larger. In the Saginaw Bay watershed, approximately 45 cities account for roughly 5% of the land area. These areas can contribute a substantial amount of harmful substances to the Saginaw River and Saginaw Bay.

Watercourses (hydrologic modifications)

Dredging, channelization and impoundments are the primary categories of in-stream, hydrologic modifications that occur in the Saginaw Bay watershed. These practices can aggravate sedimentation and turbidity problems. Sediment yields have been estimated to vary between 50 and 200 tons annually per square mile, with an estimated 600,000 cubic yards of sediment accumulating in the lower Saginaw River each year. Dredging this river is an annual maintenance operation. In 1982, it cost the ACOE more than $1.5 million to remove sediment from the Saginaw River.

4. Effects of Soil Erosion

In 1988, the MDNR conducted a mail survey of natural resource, environmental, and agricultural agency staff, to determine their perceptions on nonpoint sources of pollution and the effect on Michigan watersheds. Responses were received from over 200 individual offices. The major rural sources most frequently identified were septic systems (81% of the 297 watersheds in Michigan delineated for the survey), streambank erosion (80%), and agricultural erosion (75%). The major urban sources most frequently identified were construction site erosion (74%) and urban runoff (70%). The top two effects were sedimentation (95%) and turbidity (87).

There are two types of soil erosion impacts, on-site and off-site. On-site impacts of soil erosion are damage caused at the site by the wearing away of soil. Soil erosion damages have long been recognized, particularly in the area of agriculture, but corresponding cost figures are difficult to obtain. However, some cost estimates are available for agriculture including: the loss of nutrients with the soil, reduced productivity, and the potential loss of arable land. The monetary value of nitrogen, phosphorus and potassium that is lost with soil erosion has been estimated to be $3 to $6 per ton of soil. Reduced productivity can range from 10-20% in yield, with severe erosion, dependent on the soil properties. The loss of arable land is a result of nutrient loss and reduced productivity, which is also difficult to measure in economic terms.

Off-site impacts of erosion and sedimentation are difficult to quantify. Sediment is only one of many factors affecting water quality. Impacts such as reductions in fish populations, or loss of recreational uses of a waterbody, may be caused by a combination of factors. Below is a list of both on- and off-site effects from soil erosion and sedimentation:

* water temperature changes through reduction of heat exchange at the water surface;

* structural changes to the waterbody by aggradation of streambeds and elimination pools and riffles;

* alteration of flow rates;

* reduction in sunlight transmission, which can alter photosynthesis rates and plant growth;

* aesthetic impairment of recreational water sports;

* increased hazards for swimming and boating (visibility is reduced, and sandbars and suspended sediments can also damage boat machinery);

* visual feeding behaviors of fish are altered and angling becomes more difficult;

* decreased fishing and hunting opportunities;

* adsorbed pollutants are transported by eroded soil;

* increased fish mortality through suffocation of fish eggs, benthos and other necessary food organisms;

* increased habitat degradation, including loss of fish spawning areas;

* reduced feeding opportunities for waterfowl;

* increased biological oxygen demand of the water, from algal growth stimulated by nutrients carried with sediments, which adversely affects fish and other aquatic organisms;

* ingestion of toxic pesticides by fish, which may increase fish mortality and may also cause human health concerns;

* increased water treatment costs from the addition of chemicals that accelerate the settling of sediments, additional filtering time and capacity, and sludge disposal for municipal and industrial uses;

* increased costs for dredging to maintain navigational waterways and roadside ditches, and flood prevention;

* resuspension of toxic chemicals and/or contaminated sediments when dredging occurs, and the presence of sediments increases total volume of water;

* increased damage to property because a water and soil mixture is more damaging than less turbid water flows;

* damage to prime agricultural lands from alluvial soils that reduce productivity;

* decreased efficiency of water transportation; and

* reduced quality of irrigation water.

B. PROBLEM EVALUATION

1. Saginaw Bay Watershed

Erosion and runoff problems are most severe when the soil surface is exposed, and where poorly drained soils having a high soil erodibility rating occur on a rolling to hilly topography. A USDA study summarized erosion, sedimentation and flooding problems in a 14-county, Saginaw Bay area by location. This study estimated average annual erosion on 3 million acres of crop land in 1982 to be 5.8 million tons from wind erosion and 3.5 million tons from sheet and rill erosion. This equates to an average of 3.1 tons per acre per year. Twenty percent of the cropland in this study area was eroding above the tolerable soil loss limit. The USDA study selected two watersheds as high priority areas needing accelerated assistance: (1) Swan Creek in Saginaw County, and (2) the Lake Huron Eastern Shore Drainage in Huron County. Watershed Preauthorization Planning reports were currently being prepared for these watersheds. The study also mapped Potential Watershed Protection Projects.

Section 208 of Public Law 92-500 required the development of water quality management plans to control nonpoint sources of pollution through Michigan's 14 regional planning agencies. Agricultural lands were recognized to be potentially significant sources of water pollution. Of the four regional planning commissions that occur within the boundaries of the Saginaw Bay watershed, the 14-county East Central Michigan Planning and Development Region (ECMPDR) is the largest. ECMPDR's water quality management plan, completed in 1978, identified agriculture related problems that had either a direct or indirect effect on water quality.

ECMPDR's 208 Plan for reducing agricultural sedimentation listed 12 high priority areas within a 45-mile radius of Saginaw Bay or other Lake Huron waters. These areas, identified as susceptible to erosion, were based on the percentage of the basin covered by cropland on high clay, low infiltration rate soils.
The basins were listed according to their need for special projects to control agricultural pollutants as follows:

1) Quanicassee River
2) Kawkawlin River
3) Allen-Wiscoggin Drains
4) Sebewaing River
5) Cheboyganing Creek
6) Mud Creek-Shebeon Creek
7) Pigeon River
8) Swan Creek
9) Au Gres River
10) Dutch Creek
11) Pinnebog River
12) Western Saginaw Bay Tributaries

2. Subwatersheds

The MDNR has been working with federal, state and local agencies to develop a process to prioritize Saginaw Bay subwatershed management units as discussed in Chapter IV. Though the major watersheds have been delineated based on hydrology, the subwatershed management units that make up a watershed may deviate somewhat from hydrologic boundaries in an effort to define a more manageable land mass. But in no case, however, does a management unit cross significant hydrologic boundaries.

The dominant MIRIS land use (1978) for each Saginaw Bay management unit is shown in Map 6-1 and Table 7, column 3. Table 7 also includes the annual soil loss for wind (column 5) and water (column 4), potential streambank erosion (column 6), and sediment estimates (column 8) completed by SCS; and known or potential problem areas (column 7) identified by ECMPDR in 1987 extrapolated from the 208 Areawide Water Quality Plans of 1978.

Land Use

Agriculture was by far the most prevalent land use, dominating in 51 of the 69 management units (Table 7). Agriculture was most dominant in the thumb region and extending southward into the Saginaw Valley and south central portion of the basin (Map 6-1).

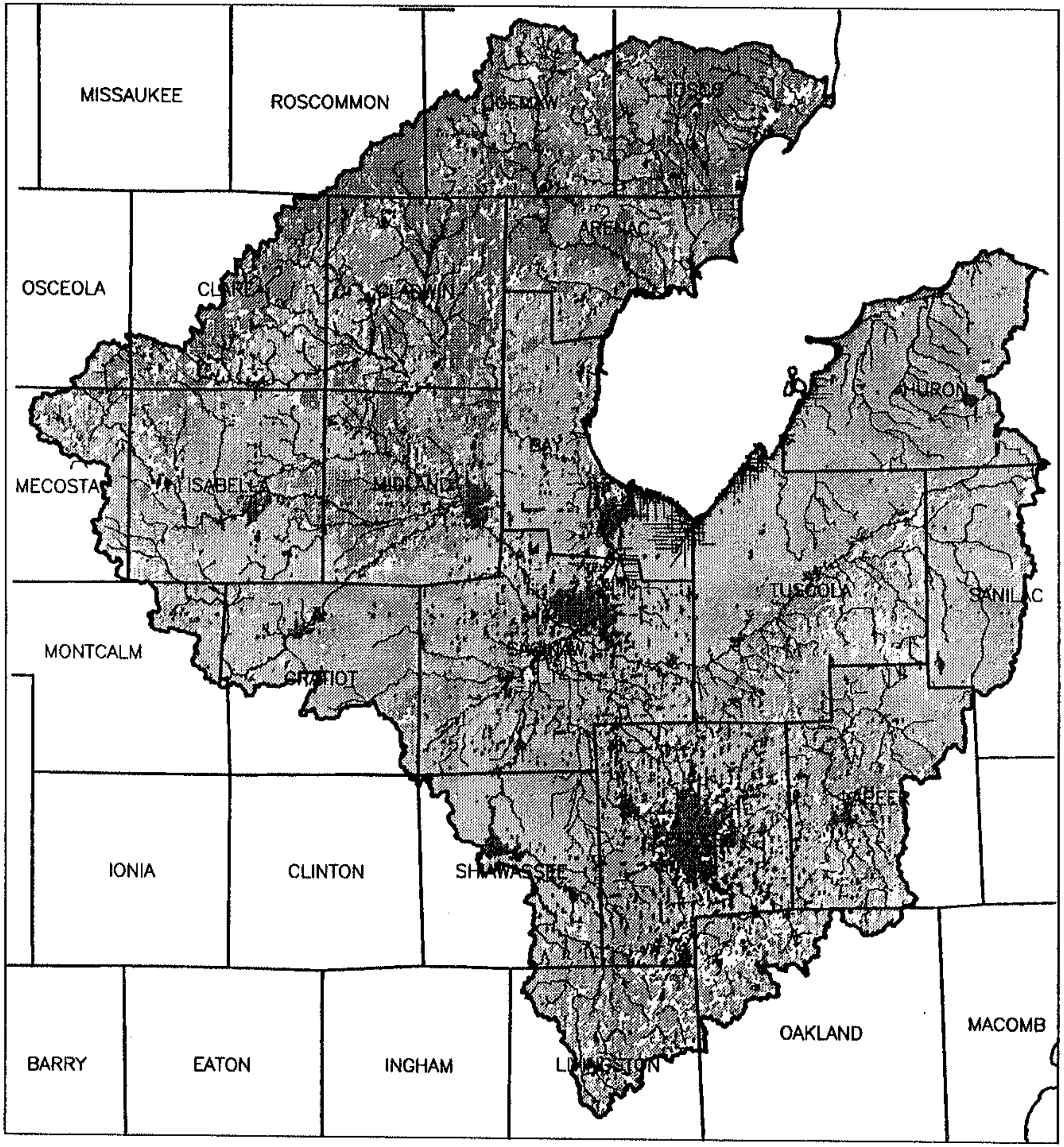
Urban areas were also considered an important land use and were listed in column 3 if this category was greater than 10%. Fourteen of the management units were identified as having urban land use as a dominant characteristic. Only one management unit was identified as having urban as a majority of the land use (Thread Creek of the Flint River). Though urban areas are concentrated near the transportation corridor running through Oakland, Genesee, Saginaw, Bay and Midland counties, they are found throughout the watershed.

Forestry was the dominant land use in 17 management units. Geographically, forestry was predominant in the northern portion of the watershed.

Water Erosion

The SCS calculated soil loss from water erosion for each management unit utilizing the Universal Soil Loss Equation (USLE). Map layers representing rainfall, erodibility, land slope, and land cover were evaluated to produce a "Tons of Annual Erosion" map layer. The acreage of each soil loss amount was totaled by management unit, then, this amount was divided by the number of acres in each unit to determine the annual erosion per acre by management unit (Map 10-3; Table 7, column 4). The low erosion areas (<1 ton/acre) tend to stretch from the northern portion of the watershed down into the Saginaw Valley. High water erosion areas

Land Use
Saginaw Bay Watershed



Major Land Uses

- Urban
- Agriculture
- Forest
- Other

N

20 0 20 MILES

20 0 20 KILOMETERS

LOCATION MAP

Map produced by SCS State Office GIS Staff
DATA SOURCE: MIRIS Base and Land Use Data

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Table 7 SOIL EROSION PRIORITIZATION

(1) Number	(2) Watershed	(3) Dominant Land Use		Erosion							Sediment		
				(4) Water Erosion		(5) Wind Erosion		(6) Streambank			(7) Regional 208 Plans	(8) SCS Sediment Yield	
		%	Priority	t/a	Priority	%	Priority	%	Priority	Flow Stab	Problem	t/a	Priority
10101	Tawas R	65	F	.3	L	12	L	68	H	2		.06	L
10102	EB,AuGrsR	65	F	.34	L	12	L	54	M	2	Potential	.07	L
10103	AuGres R	41/39	F/A	.72	L	34	M	35	M	3	Potential	.15	M
10104	Big Creek	55	F	.39	L	25	L	56	M	3		.09	L
10105	Rifle R	55	F	.78	L	22	L	67	H	2		.17	M
10201	Pine R	51	A	.57	L	50	M	41	M	3	Potential	.12	M
10202	Pinconn R	62	A	.75	L	61	H	39	M	3		.15	M
10203	N.Kakawl R	43/40	A/F	.47	L	35	M	60	M	3		.1	M
10204	Kakawl R	73/13	A/U	.9	L	70	H	39	M	3	Potential	.19	M
10301	Quanic R	90	A	.89	L	89	H	32	M	3	Potential	.19	M
10302	NW Drain	94	A	1.3	M	93	H	28	L	3		.29	M
10303	Wiscog D	91	A	1.2	M	89	H	39	M	3		.26	M
10304	Sebewaing R	93	A	1.7	H	77	H	13	L	3		.36	H
10305	Shebeon C	76	A	1.3	M	24	L	24	L	3		.29	M
10306	Pigeon R	88	A	1.9	H	31	M	32	M	3	Potential /Known	.38	H
10307	Pinebog R	82	A	1.8	H	25	L	40	M	3	Potential	.37	H
10308	Bird Cr	79	A	1.3	M	11	L	7	L	3		.27	M
20101	U.Tib R	67	F	.5	L	12	L	86	H	2		.12	M
20102	Molasses R	73	F	.04	L	1	L	88	H	3		.01	L
20103	Sugar R	40/33	A/F	1.2	M	37	M	31	M	2		.27	M
20104	U.Cedar R	75	F	.32	L	9	L	92	H	2		.09	L
20105	L.Tobac R	49	F	.7	L	22	L	61	H	2		.17	M
20106	U.Tobac R	57	F	.65	L	17	L	71	H	2		.17	M
20107	SB.Tobac R	43	F	1.0	M	25	L	86	H	2		.24	M
20108	Salt R	60	A	1.5	M	51	H	54	M	3		.3	H
20109	Sanford L	52	F	.33	L	15	L	70	H	2		.07	L
20110	Sturgen C	38/33/11	F/A/U	.32	L	27	M	49	M	3		.07	L
20111	Carroll C	58	F	.1	L	8	L	90	H	3		.02	L
20112	Bullock C	69	A	.73	L	59	H	38	M	3		.18	M
20113	L.Tib R	34/32	F/U	.4	L	32	M	50	M	2		.08	L
20201	U.Chipwa R	41/32	F/A	1.1	M	26	M	99	H	2	Potential	.25	M

Table 7

(1) Number	(2) Watershed	(3) Dominant Land Use		Erosion							Sediment		
				(4) Water Erosion		(5) Wind Erosion		(6) Streambank			(7) Regional 208 Plans	(8) SCS Sediment Yield	
		%	Priority	t/a	Priority	%	Priority	%	Priority	Flow Stab	Problem	t/a	Priority
20202	Coldwtr R	41	A	1.4	M	35	M	100	H	2		.43	H
20203	NB.Chipw R	68	A	2.7	H	65	H	99	H	2		.71	H
20204	Pine R	52	A	2.1	H	49	M	100	H	2		.5	H
20205	L.Chipwa R	48/25	A/U	1.8	H	45	M	73	H	2	Potential	.47	H
20206	Salt Cr	59	A	.94	L	49	M	83	H	2		.19	M
20207	U.Pine R	63	A	1.7	H	62	H	58	H	2	Potential	.38	H
20208	L.Pine R	69	A	1.0	M	63	H	38	M	3	Potential	.21	M
20301	Swan Cr	76	A	.84	L	75	H	37	M	3		.18	M
20302	Marsh Cr	56	A	.6	L	56	H	53	M	3		.15	M
20303	Beaver Cr	79	A	.99	L	78	H	21	L	3		.23	M
20304	Bad River	80	A	1.1	M	80	H	33	M	3		.25	M
20305	S.FrkBad R	60	A	.68	L	60	H	64	H	3		.14	M
20306	Birch Run	64	A	.74	L	64	H	94	M	3		.16	M
20307	L.Shiaw R	75/11	A/U	1.6	H	75	H	83	H	3	Potential	.38	H
20308	M.Shiaw R	69	A	1.9	H	57	H	90	H	2	Known	.4	H
20309	SB.Shia R	41	A	1.4	M	41	M	99	H	2	Potential	.33	H
20310	U.Shiaw R	33/13	A/U	1.4	M	31	M	100	H	2		.34	H
20401	Mstguay C	82	A	1.7	H	82	H	67	H	3	Potential	.38	H
20402	L.Flint R	42/27	A/U	.75	L	42	M	84	H	3	Potential	.16	M
20403	Swartz Cr	43/18	A/U	1.2	M	30	M	81	H	3		.27	M
20404	Thread Cr	36	U	.96	L	22	L	86	H	3		.23	M
20405	Kearsly C	33/19	A/U	1.4	M	30	M	95	H	3		.36	H
20406	M.Flint R	39/22	A/U	1.3	M	38	M	72	H	2	Potential	.28	M
20407	LSB.Flint R	42/11	A/U	1.4	M	40	M	67	H	2	Potential /Known Plum Cr stream bank	.39	H
20408	USB Flint R	40	A	2	H	37	M	66	H	2	Potential	.48	H
20409	NB.Flnt R	68	A	1.9	H	66	H	65	H	2	Potential	.43	H
20410	Cedar Cr	58	A	1.7	H	55	H	100	H	2		.46	H
20501	L.Cass R	59/13	A/U	.88	L	59	H	71	H	3	Potential	.19	M
20502	Perry Cr	54	A	1.5	M	54	H	89	H	3		.33	H
20503	M.Cass R	46	F	.97	L	29	M	88	H	3	Potential	.21	M

Table 7

(1) Number	(2) Watershed	(3) Dominant Land Use		Erosion: (4) Water Erosion		Erosion: (5) Wind Erosion		Erosion: (6) Streambank			Sediment: (7) Regional 208 Plans	Sediment: (8) SCS Sediment Yield	
		%	Priority	t/a	Priority	%	Priority	%	Priority	Flow Stab	Problem	t/a	Priority
20504	U.Cass R	45	A	1.6	H	44	M	91	H	3		.39	H
20505	White Cr	59	A	1.5	H	58	H	100	H	3	Potential	.34	H
20506	MB.Cass R	58	A	1.7	H	58	H	76	H	3	Potential	.41	H
20507	NB.Cass R	64	A	2.5	H	63	H	100	H	3	Potential	.58	H
20508	SB.Cass R	82	A	1.1	M	82	H	99	H	3	Potential	.21	M
20509	Columbus Dr	84	A	1	M	80	H	100	H	3	Potential	.25	M
20601	U.Sagin R	76/14	A/U	.93	L	76	H	27	L	3	Potential	.22	M
20602	L.Sagin R	64/26	A/U	.75	L	65	H	32	M	3	Potential	.15	M

KEY:

Dominant Land Use
A = Agriculture
F = Forest
U = Urban greater than 10%

Water Erosion (Values based on Universal Soil Loss Equation)
H = greater than 1 1/2 tons per acre
M = 1-1 1/2 tons per acre
L = less than 1 tons per acre

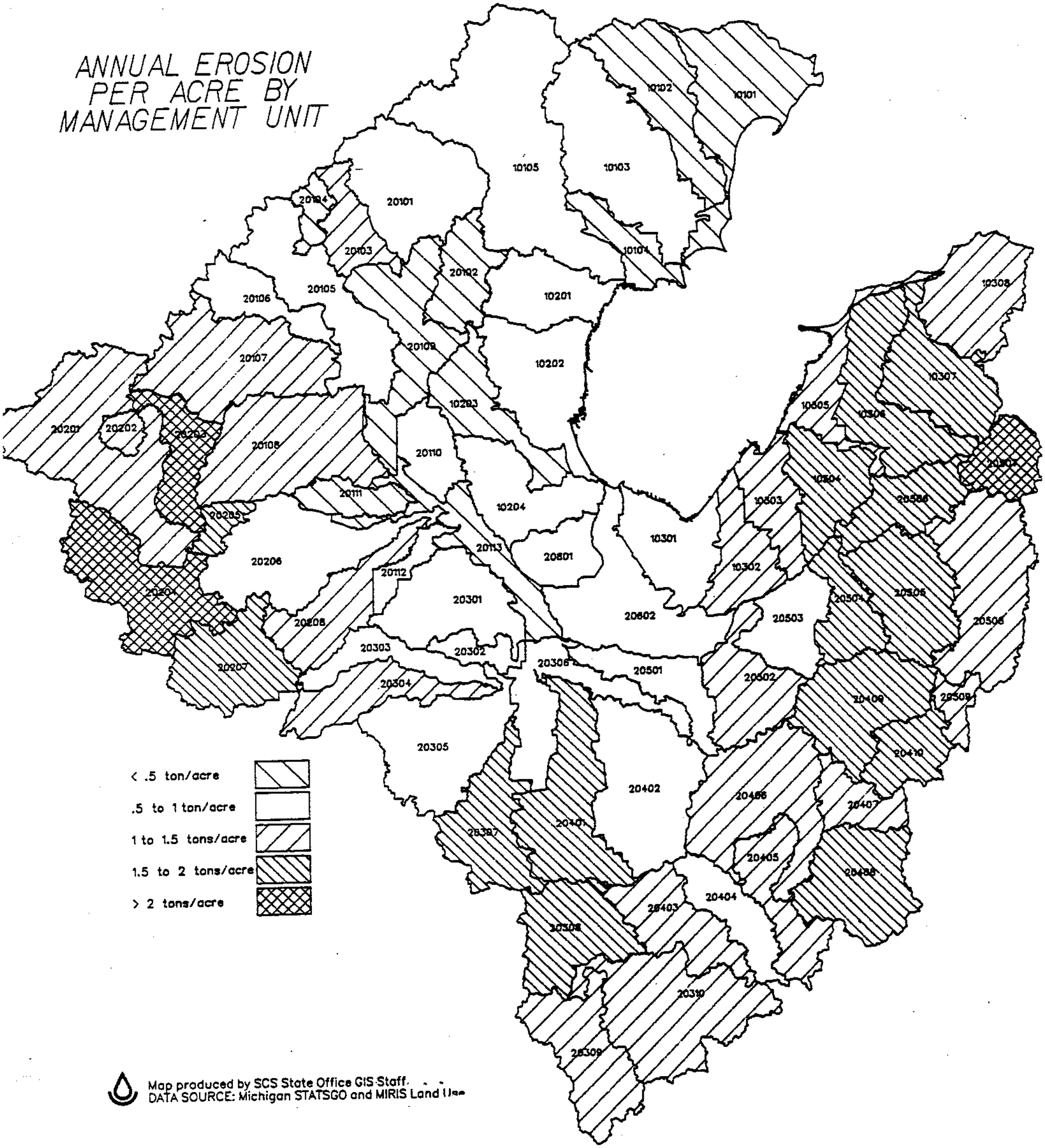
Flow Stability
1 = Stable, x less than 2
2 = Variable, 2 less than x less than 7
3 = Flashy, 7 less than x

Sediment
H = greater than .3 tons per acre
M = .1 - .3 tons per acre
L = less than .1 tons per acre

Wind Erosion (Percent of land highly susceptible)
H = greater than 51% total Wind Erodability Group in Watershed
M = 26 - 50%
L = less than 25%

Stream Bank Erosion Potential
H = 61 - 100%
M = 31 - 60%
L = 0 - 30%

ANNUAL EROSION PER ACRE BY MANAGEMENT UNIT



Map produced by SCS State Office GIS Staff.
DATA SOURCE: Michigan STATSGO and MIRIS Land Use

(>1.5 tons/acre) were located in portions of Huron, Tuscola, Lapeer, Gratiot, Isabella Shiawassee and Montcalm counties.

Wind Erosion

The susceptibility of land to wind erosion varies throughout the Saginaw Bay watershed (Map 10-2). The data were generated from the general soils maps for Michigan. By using this general soils information, each soil type could have up to 21 different components. The wind erosion map was created by calculating the percentage of each soil type that is susceptible to wind erosion if lacking cover. These percentages were then grouped into high, medium and low categories, where greater than 50% was high, 26-50% ranked medium, and 0-25% was low.

Thirty-one management units were identified as being highly susceptible to wind erosion and 22 management units were listed as medium (Table 7, column 5). Management units falling in these two categories were predominantly located in the coastal basins, the headwaters of the Tittabawassee River, and sporadically throughout Gladwin, Midland and southern Tuscola counties.

Streambank Erosion

The potential for streambank erosion is generally greatest in areas where water velocities and stream flow volumes fluctuate. The SCS used surficial geology data, provided by Michigan State University's Center for Remote Sensing and Institute of Water Research, to rate the potential for streambank erosion throughout the Saginaw Bay watershed (Map 11-1).

Many management units in the watershed were identified as having flashy streams (Table 7, column 6). The more flashy a stream, the more strongly it is influenced by runoff events, and the more likely it is to have streambank erosion problems. Such streams tend to have large seasonal flow variations and lower base flows. Streams in the northwestern portion of the watershed are generally more stable than elsewhere.

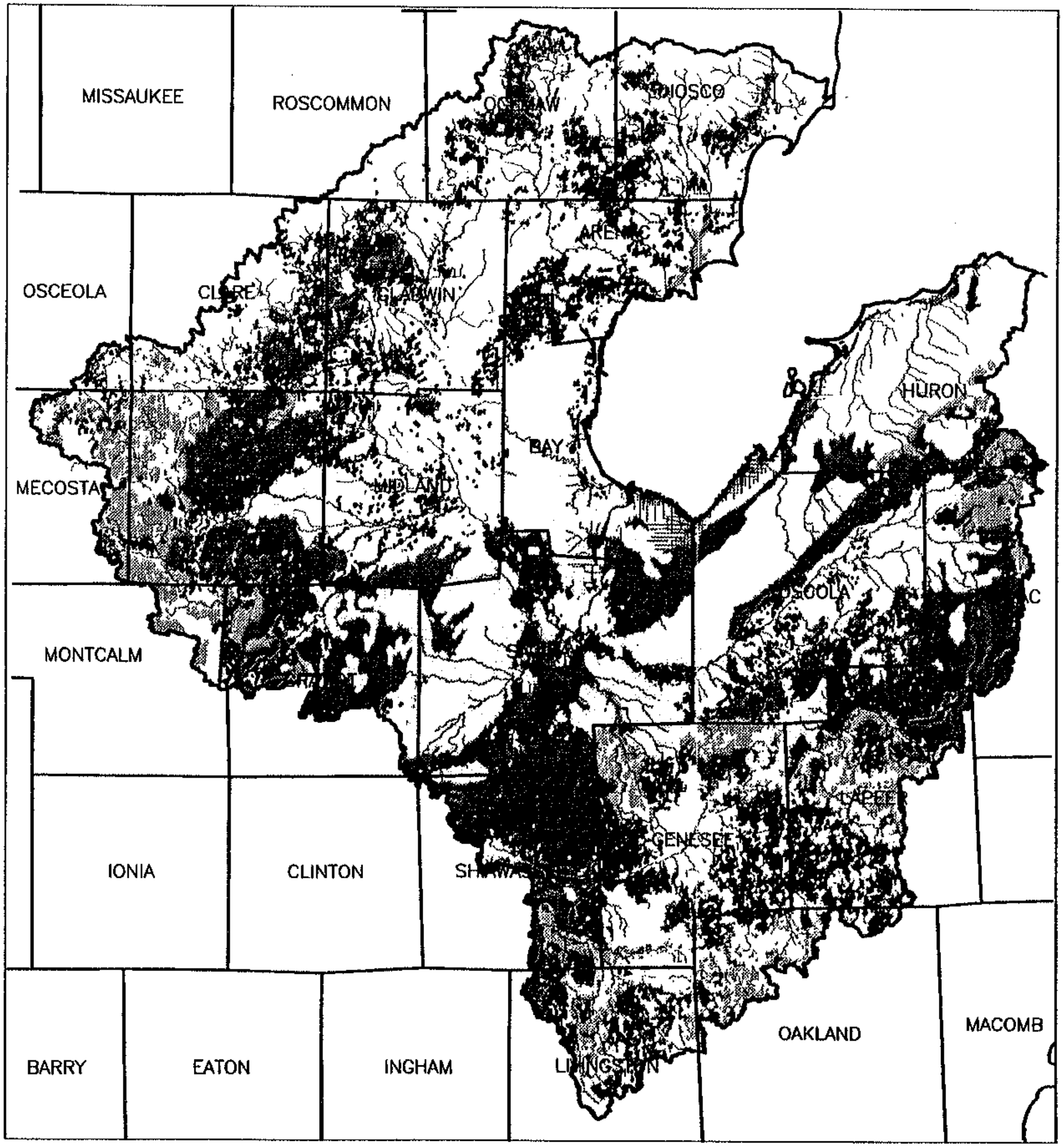
Sedimentation

Annual sediment delivery per acre was calculated by the SCS for each management unit in the Saginaw Bay watershed. The SCS adjusted the number of square miles in each management unit according to topography, multiplied by the total estimated soil loss, then divided by the number of acres in each unit. The high sediment yields were generally found in the same counties as water erosion, with the addition of Livingston and portions of Oakland counties (Map 11-2). The highest sediment yield was 0.71 tons/acre in the North Branch Chippewa River management unit, followed by 0.58 tons/acre in the North Branch Cass River and 0.48 tons/acre in the Upper South Branch Flint River (Table 7, column 8).

UNITED STATES DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

Land Subject To Wind Erosion
Saginaw Bay Watershed



Percent of land which is highly susceptible to wind erosion

- Not Highly Susceptible
- 1% to 25% Highly Susceptible
- 26% to 50% Highly Susceptible
- 51% to 75% Highly Susceptible
- 76% to 100% Highly Susceptible

N

20 0 20 MILES

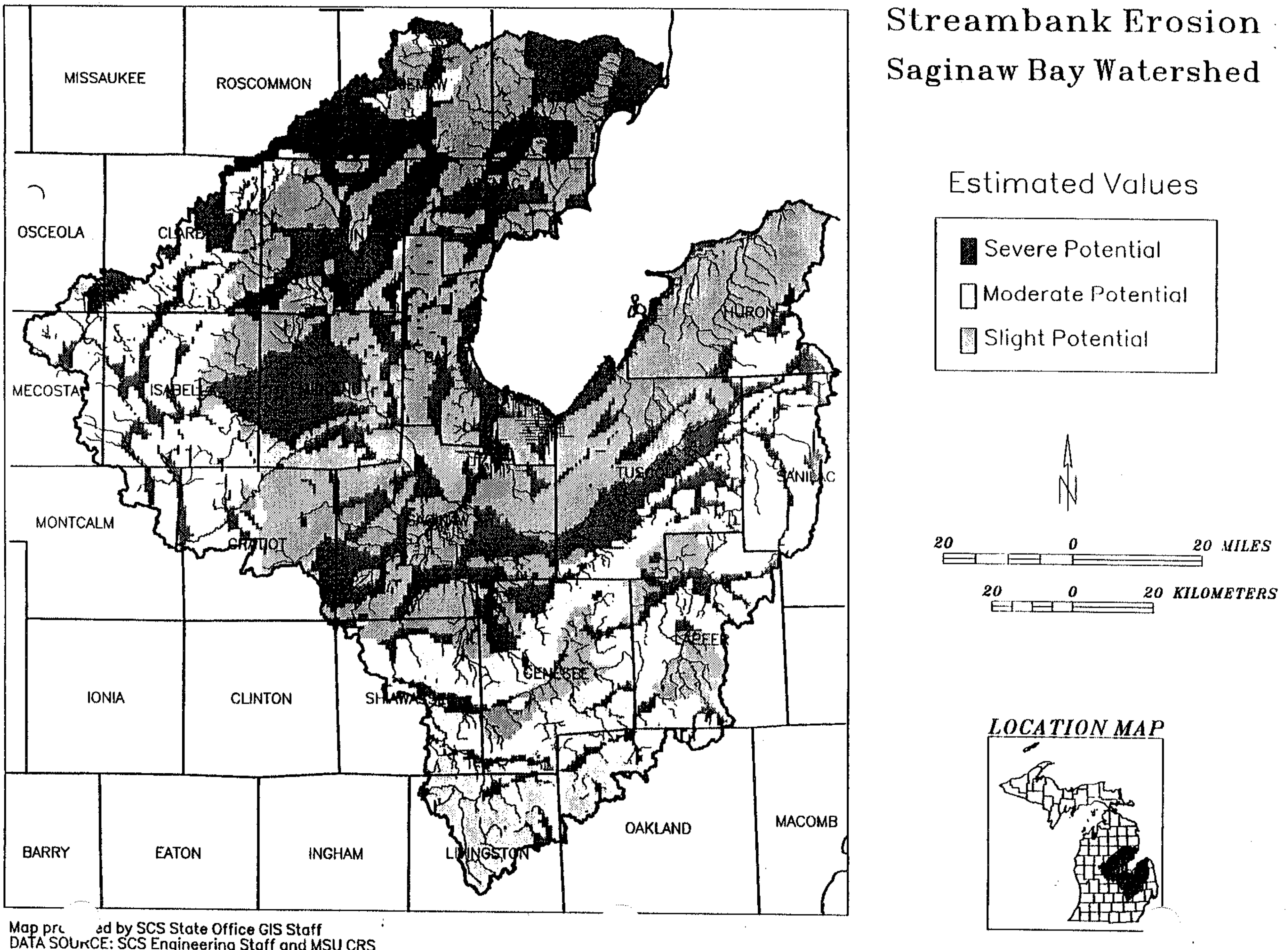
20 0 20 KILOMETERS

LOCATION MAP

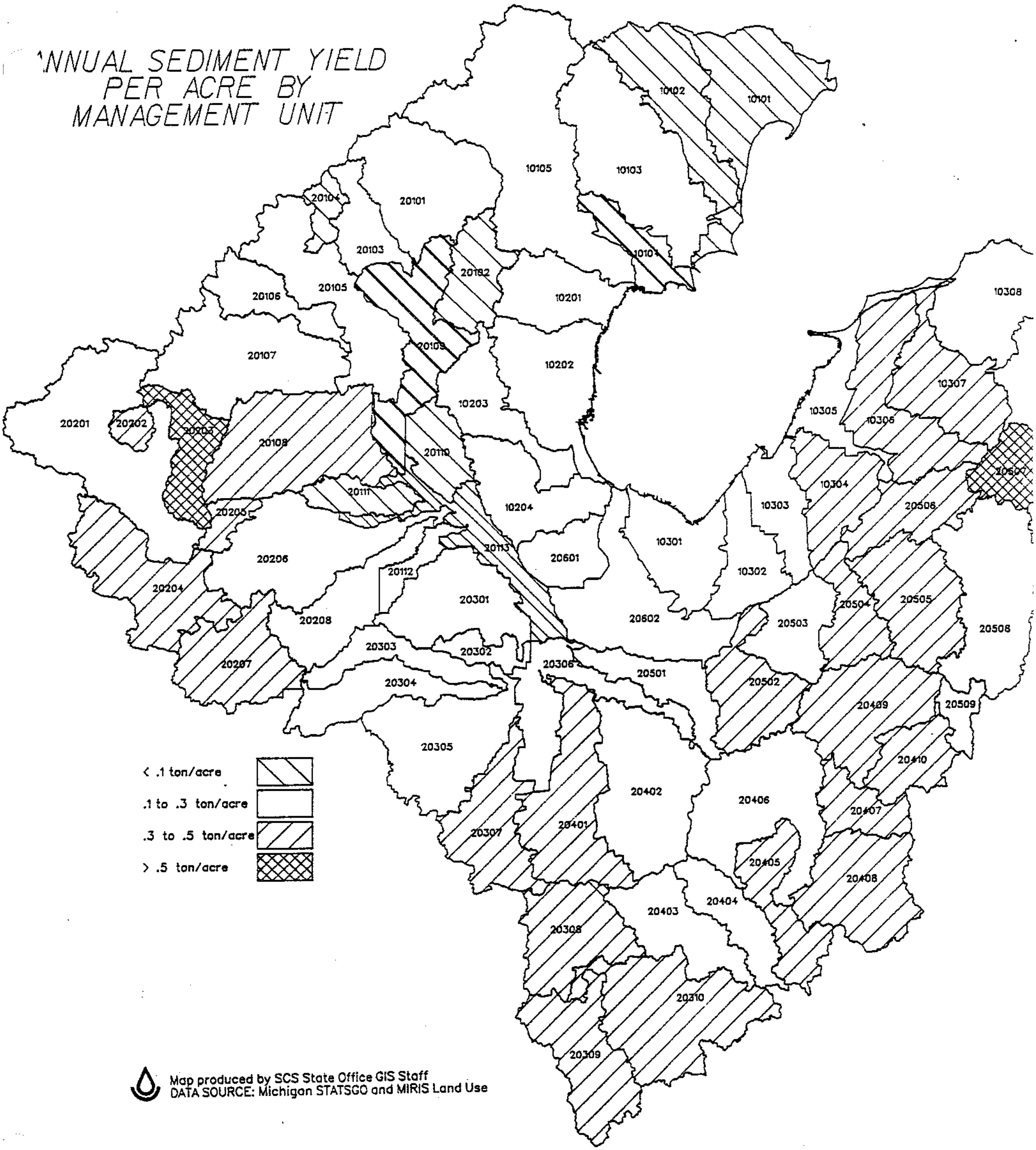
Map produced by SCS State Office GIS Staff
DATA SOURCE: Michigan STATSGO and MIRIS Land Use

JULY 1994

Streambank Erosion
Saginaw Bay Watershed



ANNUAL SEDIMENT YIELD PER ACRE BY MANAGEMENT UNIT



Known or potential sediment problem areas were identified in the 208 Areawide Water Quality Management Plans of the four regional planning agencies located within the Saginaw Bay watershed. A "known" problem indicated water quality data and/or site specific information was available to determine the source or extent of the sediment problem. A "potential" water quality problem indicated sediments were suspected of causing impacts. Twenty-eight of the 69 management units were noted as having "potential" sediment problems in 1978 (Table 7, Column 7). These areas were scattered throughout the watershed, with the major concentrations in the Cass, Flint and Saginaw subwatersheds. The three "known" sediment problem areas were identified as the Pigeon River, Middle Branch Shiawassee River, and Plum Creek management units.

C. RECOMMENDATIONS

Several recommendations of the Soil Erosion and Sedimentation TAC follow, and key actions among them are summarized in Chapter IX.

1. The TAC developed the following Priority Area Identification Process to aid interested local management unit parties in implementing needed improvement projects.

Magnitude

Determining the magnitude of the problem is the first step in identifying a possible priority watershed. If a complete inventory has not already been made, categories and potential factors of erosion within the specific management unit should be researched and listed. Additional information, if needed, should be gathered to measure the total extent of the problem. Some examples of categories and potential factors for identifying problem areas of soil erosion are provided in an example survey form (Figure 12-1).

Benefits and Impacts

Benefits and/or impacts are usually described in broad, general terms, for example, sedimentation will decrease walleye spawning; or specific, as in a road and/or drain cleanout costs incurred every 10 years versus every 25 years. These benefits may be very site-specific and may or may not be determined before the inventory is completed.

Ready, Willing and Able

The target audience needs to be ready, willing and able to adopt and/or implement the identified recommendations. In order to obtain this information, surveys can sometimes be utilized. Not only can a survey indicate program success, it may also point out that more education is necessary, such as when an identified problem is not perceived by the target audience to be a problem.

SURVEY DATA SHEET

WATERSHED:
SUBWATERSHED:
SUB2WATERSHED:
SUB3WATERSHED:
SUB4WATERSHED:

DATE:
SURVEY LOCATION:
WEATHER CONDITIONS: Event/Nonevent

I. Major Land Use (Add to 100%)

____ Agricultural
____ Rural
____ Urban (pop. density_______)
____ Open
____ Forested

II. Topography

____ A slopes (0-2%)
____ B slopes (2-6%)
____ C slopes (6-12%)
____ D slopes (12-18%)

III. Soil Type

____

IV. Land Use Practices

____ Impervious Area (%)
____ Conventional Tillage (% of Area)
____ Conservation Tillage (% of Area)
____ Wind Breaks/Forested (% of Area)
____ Cover Crops (% of Area)
____ Other Practices (%)______

VI. Potential Sources

____ Gully Erosion
____ Streambank Erosion
____ Construction Site Erosion
____ Livestock Access/Runoff
____ Other Sources: ______

VI. Drains/Ditches

1) Steepness of Banks
____ Good Slopes (3:1,4:1)
____ Marginal Slopes (2:1)
____ Steep Slopes (1:1, Vertical)

2) Erosion
____ None
____ Slight (0-20%)
____ Medium (20-50%)
____ Severe (>50%)

3) Bank Vegetation
____ None
____ Slight (<30%)
____ Medium (30-60%)
____ Severe (>60%)

4) Land Use Along Drain
____ Farming to Edge (% of Drain)
____ Filter Strips (% of Drain)
____ Bermed/Diked (% of Drain)
____ Other Practices(%)__________

5) Type of Bank Vegetation
____ Grass
____ Weeds
____ Brush
____ Overgrown w/ Trees & Shrubs
____ Other:__________________

6) Type of Aquatic Vegetation
____ Cattails/Aquatic Plants
____ Algal Growth
____ Other:__________________

7) Deposition
____ None
____ Slight
____ Medium

8) Bottom of Drain
____ Rocky/Gravel (Circle)
____ Slightly Embedded
____ Severely Embedded
____ Clay/Sandy
____ Vegetated
____ Other: __________________

9) Size of Channel (Width-Top)
____ Small (<10 ft.)
____ Medium (10-30 ft.)
____ Large (>30 ft.)

VII. Water

1) Color
____ Brown ____ Clear
____ Black ____ Other: _____

2) Turbidity
____ Low (Can see bottom)
____ Medium (Can see into water but can not see bottom)
____ High (Muddy in appearance can not see into water)

3) Flow
____ None
____ Stagnant
____ Low
____ Medium
____ High
____ Tile Outlets (number)

Remedial Action(s) Recommended:

Figure 12-1

2. The Soil Erosion & Sedimentation TAC reiterated the 208 Plan recommendations listed below on technical management solutions for controlling sediment loads.

   Minimize the amount of water that is drained from or over bare soil.

   Stabilize all drainage ditch banks and prevent plowing through or into surface drainage ditches.

   Provide non-erosive systems and structures for all agricultural drains.

   Develop substantial permanent protection for soils with medium and high potential for wind erosion.

   Implement BMPs as needed on a site-specific basis for the general control of agricultural nonpoint sources.

   In areas of high risk erosion, local communities should enact special zoning regulations or other types of land use controls, and restrict development on these areas.

3. The USDA Agricultural Stabilization & Conservation Service should consider incorporating water quality practices in their Agricultural Conservation Program (ACP).

4. Improve the current Soil Erosion and Sedimentation Control Act (Act 347 of 1972), by providing the necessary staff personnel to provide adequate program management.

5. There are currently several agencies and programs that aid in the control of sedimentation in the Saginaw Bay watershed and, therefore, it is important to plan and coordinate efforts to ensure that funds are used within the areas contributing the highest amount of sediment.

6. A continuous planning process should be adopted to effectively and efficiently review and update the progress and status of these changes.

7. Support a basin-wide effort to implement filter strips to protect stream corridors.

8. In order to accurately rate streambank erosion, other data that was not available for the present analysis should be considered, such as the actual presence of streams within each geographic class, the type of land cover that exists on the stream bank, etc.

9. The TAC recommends the following on BMPs for the Saginaw Bay watershed to achieve the most economical, practical, and effective combination of controls to reduce or prevent pollutants from source activities entering either surface water or groundwater.

   Soil erosion can be reduced by utilization of sound management planning combined with vegetative and/or structural practices.

   Often, a combination of practices is needed to reduce erosion to an acceptable level.

   Soils, geology, topography, economics, climate, and receiving water quality are the major parameters that should be investigated prior to selecting specific BMPs for each site.

   Sediment control can be achieved through three primary lines of defense:

   (1) prevent erosion from taking place by protecting exposed surfaces;

   (2) reduce the quantity and velocity of surface runoff to prevent rill and gully erosion and to decrease the transport of sediment; and

   (3) trap the sediments that are transported by ponding, filtering or treating.

   The MDNR, Surface Water Quality Division produced several BMP manuals for Michigan's Nonpoint Source Pollution Program. These manuals should be utilized when selecting corrective measures for the areas of agriculture, forest land, and urban storm water management.

10. The TAC identified the following additional data needs that should be filled.

    - Using "T" (the Tolerable Soil Loss Limit) to judge attainment of water quality goals is not a good approach because it does not consider off-site impacts such as damage to water quality or other aspects of the environment. Erosion on the land may leave some areas with deficient soil depth, but not cause off-site damage. Some other areas may be meeting "T", but still be causing significant off-site damages. Furthermore, "T" does not address the type of soil material being eroded and reaching off-site locations. For example, coarse soil carries little adsorbed material, while clay-sized particles can adsorb large amounts of agricultural chemicals that can be transported greater distances. The majority of the Saginaw Bay watershed is eroding at rates of T or less, yet many areas are experiencing severe water quality problems from excessive sedimentation. Therefore, the relationships between soil erosion and water quality goals need to be incorporated into the USDA SCS Universal Soil Loss Equation and into the USDA Agricultural Stabilization & Conservation Service (ASCS) ACP.

- Quantitative information on the off-site costs and impacts of soil erosion and sedimentation. No reliable figures are available detailing the extent of damages attributable to sedimentation and the public costs incurred for clean up.

- Linkages need to be developed between erosion and sediment control and dredging.

- Implement a hydrology study to determine the stability of streambanks in Saginaw Bay watershed tributaries.

- Study the soil types susceptible to streambank erosion and compare with high and low flow rates to reveal those with potential for streambank erosion.

- Field surveys should be conducted to provide site-specific verification information.

- Research sediment delivery from wind erosion to determine the extent of the problem in relation to water quality problems.

D. CONCLUSIONS

As noted in the previous section, areas that are not highly erodible, or below "T", may still cause water quality problems as a result of their close proximity to rivers, streams, drains or Saginaw Bay. This focus on erosion rates is a deficiency in current erosion control programs, which focus just on erosion rather than on sedimentation and the effects on water quality. It is possible to have high erosion rates and a very low sediment delivery rate, or a low erosion rate but a very high proportion of that erosion actually entering the streams. If soil conservation practices emphasize only erosion rates and do not target areas with high sediment delivery, then water quality problems will remain unsolved.

The USDA 1987 study (which covered 14 out of the 22 Saginaw Bay counties) concluded erosion control is needed on 749,000 acres (13%) of the 5.8 million acre study area. To accomplish this erosion control, the strategy identified the need for promotion and adoption of conservation tillage, wind barriers, and conservation cropping systems. The study estimated that to implement these changes on the 617,400 acres needing treatment would require approximately 413 SCS staff-years. If staff and funds were made available, it was expected that this goal could be reached by the year 2000.

LITERATURE REVIEW FOR SOIL EROSION AND SEDIMENTATION

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CHAPTER VII: CONTAMINATED SEDIMENTS

A. CHARGE

The Program Advisory Committee of the Saginaw Bay National Watershed Initiative established the Contaminated Sediment Technical Advisory Committee (TAC) to address the specific problems in the Saginaw Bay Watershed associated with contaminated sediments. Contaminated sediments were defined for this report as sediments with elevated levels of toxic substances -- conventional parameters and nutrients were discussed previously in Chapter V.

In addition to the base TAC charges described earlier in Chapter I, the Program Advisory Committee requested that the Contaminated Sediment TAC be responsible for reviewing the results of the U.S. Environmental Protection Agency's Assessment and Remediation of Contaminated Sediments (ARCS) 1988-1994 study of the lower Saginaw River. The Saginaw River/Bay was one of five Great Lakes Areas of Concern (AOCs) selected (the only one in Michigan) under this national demonstration program to assess the nature, extent and impact of bottom sediment contamination; evaluate and demonstrate remedial options; and provide guidance or tools for the assessment of contaminated sediment problems and the implementation of necessary remedial actions in other AOCs.

Specific activities in the Saginaw River (lower 10 miles) included sediment sampling and acoustic profiling; sediment bioassays (acute toxicity, chronic toxicity, mutagenicity, bioaccumulation); benthic community structure evaluation; Toxicity Identification Evaluation (TIE) tests to identify the contaminant, or class of contaminants, causing acute toxicity in the sediment; evaluation of remedial technologies; sediment hazard assessments focusing on human health, aquatic life, and wildlife endpoints; fish tumor survey; mini mass balance modeling (exposure, foodchain, sediment resuspension/transport); fish tissue analysis; water column sampling; and development of a remediation concept plan describing logistical and engineering considerations that would be part of a full scale clean-up of contaminated sediments under a variety of scenarios.

Unfortunately, many of the ARCs reports on these results have not yet been completed. As of July 1994, only three reports associated with the Saginaw River/Bay component of the ARCS Study had been finished. Of these three reports -- "Baseline Human Health Risk Assessment: Saginaw River, Michigan, Area of Concern"; "Biological and Chemical Assessment of Contaminated Great Lakes Sediment"; and, "Risk Assessment and Modeling Overview" -- only the first one is discussed here. The data specific to the Saginaw River/Bay AOC presented in the other two reports will be analyzed in much greater detail in forthcoming ARCS reports. The tentative titles for the reports expected to be completed in the near future under the ARCS program that are relevant to the Saginaw River and Saginaw Bay include the following.

-- Movement and loadings of contaminants through the lower Saginaw River.

-- Concentrations of dissolved and particulate PCBs in water from the Saginaw River, Michigan.

-- PCB concentrations in selected fish species from the Saginaw River Area of Concern.

-- Wildlife Hazard Assessment: Saginaw River Area of Concern.

-- Modeling results for the Saginaw River.

-- Summary of sediment chemistry data for the lower Saginaw River.

-- Saginaw River Area of Concern Case Study.

-- Pilot scale demonstration of sediment washing for the treatment of Saginaw River sediments.

Because so many of the ARCS reports have not been completed yet, the Contaminated Sediment TAC was unable to review the ARCS project results for inclusion in this biennial RAP report. It is envisioned that the Contaminated Sediment TAC will be able to provide an in depth review of the ARCS reports during 1995, and that the significant findings from this review will be presented in the next biennial Saginaw River/Bay RAP document.

Furthermore, additional sediment assessment work is expected to take place over the next several years in conjunction with the Saginaw River and Saginaw Bay natural resource damage suit filed by the State of Michigan, under Act 307 in June 1994, against several potentially responsible parties. This information may also be available for review by the TAC.

B. ARCS REPORT SUMMARY

The following is a summary of the information presented in the U.S. EPA Assessment and Remediation of Contaminated Sediments (ARCS) report entitled "Baseline Human Health Risk Assessment: Saginaw River, Michigan, Area of Concern". The document summarizes the risks to human health due to contaminated sediments in the Saginaw River. As described below, MDNR toxicologists have reviewed this report and identified some serious methodological and reporting problems with the study, which impact the conclusions presented.

Study Area

The ARCS risk assessment covers an area adjacent to the lower 8 km of the Saginaw River as it passes through Bay City, Essexville, and parts of Hampton and Bangor townships before entering Saginaw Bay. The area has a history of water quality problems due to point (i.e., industrial and municipal discharges) and nonpoint (e.g. upstream agricultural and urban runoff) sources of nutrients and contaminants. High levels of nutrients, heavy metals, polychlorinated biphenyls (PCBs), and in some areas, dioxins, have been measured in the Saginaw River. Concentrations of PCBs in excess of 1 mg/kg have been measured in surficial sediments. In addition, fish consumption advisories have been issued warning people to not eat carp and channel catfish from the Saginaw River because of excessive levels of PCBs and dioxins in the tissue of these species. The Michigan Department of Natural Resources (MDNR) has implemented a Remedial Action Plan (RAP) process to identify and implement pollution abatement measures.

Exposure Assessment

Exposure and risk assessment guidelines were applied to determine the baseline human health risks associated with direct and indirect exposures to contaminated sediments. These risks were estimated for noncarcinogenic (e.g., reproductive toxicity, teratogenicity, liver toxicity) and carcinogenic (e.g., probability of an individual developing cancer over a lifetime) effects.

The ARCS assessment focused on two pathways by which residents of the lower Saginaw River could be exposed to sediment-derived contaminants: 1) consumption of contaminated fish (i.e., walleye or carp), and 2) consumption of contaminated waterfowl (i.e., mallards and gadwalls). Other exposure pathways were determined to be either incomplete or insignificant in terms of risk.

Walleye were chosen because they are the preferred sport fish in the Saginaw River and represent the pelagic food chain. Carp were selected because they are generally the most contaminated fish in waterbodies and represent the benthic food chain. By examining the estimated risk from consuming either carp or walleye, a range of risk estimates could be determined for a variety of exposure scenarios. Limited data were available for waterfowl consumption, the only data set containing contaminant levels in wild waterfowl was for two mallards and six gadwalls collected in 1985 from the Saginaw River area.

Noncarcinogenic and carcinogenic risks were estimated for typical (low consumption), reasonable maximum (medium consumption), and subsistence exposures (high consumption). Typical exposures were assumed to occur over a period of 9 years; reasonable maximum and subsistence exposures were assumed to occur over a period of 30 years. These exposure durations were extrapolated over a period of 70 years for estimating carcinogenic risks. MDNR toxicologists that reviewed this report stated that one reason the results of this study are questionable is because many of the exposure factors used to calculate the estimated chemical doses were ambiguous or "study assumptions" without supporting information (e.g., the fraction of fish meals ingested from the contaminated sources).

Several heavy metals and organic compounds were included in the exposure assessment: arsenic, cadmium, copper, mercury, zinc, chlordane, dieldrin, heptachlor epoxide, hexachlorobenzene, PCB, p,p' dichlorodiphenyl dichloroethane (DDD), p,p' dichlorodiphenyl dichloroethylene (DDE), p,p' dichloridiphenyl trichloroethane (DDT), and styrene. This list was selected for those chemicals detected in fish and waterfowl for which noncarcinogenic and/or carcinogenic toxicity values were available.

Determination of Risk

Carcinogenic risks were estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposures to potential carcinogens. The report states that "The EPA believes it is prudent public health policy to consider actions to mitigate or minimize exposures to contaminants when estimated, upper-bound excess lifetime cancer risks exceed the 10^{-5} to 10^{-6} range", and when noncarcinogenic health risks are estimated to be significant.

However, MDNR toxicologists point out that the cited risk range of 10^{-5} to 10^{-6} is not generally recognized as a "concern level". Although the ARCS study cites an EPA document in support of this range, the document cited was a risk management report specific to dioxin contamination at one particular site, not a statement of EPA policy to be broadly applied. Under the EPA's Superfund program, the acceptable risk range is 10^{-4} to 10^{-6}. According to the EPA contact for the ARCS study, EPA personnel and the study's author agreed to deviate from the Superfund program guidance, but the rationale for this approach was not provided.

Noncarcinogenic Risks

The ARCS report states that noncarcinogenic risks were insignificant for all exposure levels and pathways except for the subsistence consumption of walleye and carp (Table 1). For the high consumption of walleye, the noncarcinogenic risk was at a borderline level of concern and was due mostly to the additive risk of methyl mercury and copper.

The report concludes that, based on the results of the study, it would be premature to state that no noncarcinogenic risk exists from consuming fish or waterfowl from the lower Saginaw River area under typical and reasonable maximum exposures. The noncarcinogenic risk reported was an estimated risk based on limited, currently available data and toxicity information and should not be construed as an absolute risk.

Furthermore, the noncarcinogenic risk assessment excludes PCBs. The author stated that this was because a toxicity benchmark (EPA Reference Dose, RfD) was not available at the time the document was developed. Because of the widespread PCB contamination in Saginaw River sediments, this exclusion of PCBs results in a great underestimation of the risks and Hazard Quotients (HQ) and Hazard Index (HI) values. MDNR toxicologists believe it is far more appropriate to assess the health significance of PCBs by comparing to Aroclor 1016 as a surrogate for potential noncarcinogenic effects. This is facilitated by the availability (since January 1993) of an EPA RfD for Aroclor 1016. This approach results in noncarcinogenic risk characterizations that are substantially higher than presented in this study. For example, using the RdD for Aroclor 1016 in the study's exposure scenarios with carp ingestion results in exceedances of the RfD by factors of 2, 14 and 93 for typical, reasonable maximum, and subsistence exposure scenarios, respectively. In comparison, the study reports Hazard Indices (magnitude of exceedance of acceptable doses) of 0.08, 0.5 and 4 for these three scenarios, respectively, with PCBs excluded from consideration.

On the other hand, MDNR toxicologists also reported that the study method used to derive the Hazard Index (HI) was the simplest (assume that all chemicals behave additively in mixtures) and resulted in an error in the opposite direction (though not nearly as great) than the PCB exclusion described above. EPA (1989) Risk Assessment Guidance for Superfund states that this additive technique should only be used to serve as a screening level. Any HI of ≤ 1 can be assumed to indicate an insignificant noncancer risk. Any HI of ≥ 1 should be subjected to further analysis to determine the appropriateness of summing the Hazard Quotients (i.e., additivity should be assumed only when chemicals share a common site or type of effect). This study did not go beyond the screening step, resulting in HI values that may be overly conservative (higher than appropriate).

TABLE 1. ESTIMATED NONCARCINOGENIC AND CARCINOGENIC RISKS TO PEOPLE RESIDING IN THE LOWER SAGINAW RIVER AREA

Type of Risk and Exposure	Individual Risks			Additive Risks	
	Walleye	Carp	Waterfowl	Walleye + Waterfowl	Carp + Waterfowl
Noncarcinogenic (Hazard Index)**					
Typical (Low Consumption)	0.02	0.08	0.001	0.02	0.08
Reasonable Maximum (Medium Consumption)	0.2	0.5	0.02	0.2	0.5
Subsistence (High Consumption)	1*	4*	0.08		
Carcinogenic (Upper-bound, incremental risk)					
Typical (Low Consumption)	0.00001*	0.0001*	0.000006*	0.00002*	0.0001*
Reasonable Maximum (Medium Consumption)	0.002*	0.003*	0.0002*	0.0004*	0.003*
Subsistence (High Consumption)	0.003*	0.02*	0.001*		

* Risk is at or above level of concern

** A hazard index of less than 1 indicates that the noncarcinogenic risk is significant. When the hazard index is greater than 1, there may be concern for potential noncancer health effects.

Carcinogenic Risks

The ARCS report concluded that the estimated, upper-bound carcinogenic risk levels for all pathways and exposure scenarios were at or above concern levels (i.e., 10^{-5} to 10^{-6} range). In all cases, PCBs accounted for nearly all of the carcinogenic risk (there is a possibility that people who ingest, inhale, or have dermal contact with certain PCB mixtures may have a greater chance of incurring liver cancer; though this statement is based on suggestive evidence rather than on verified data).

However, as was described above, MDNR toxicologists stated that the cited risk range of 10^{-5} to 10^{-6} is not generally recognized as a "concern level". The ARCS study approach results in the perception that the contamination poses cancer risks that are much higher than the EPA's Superfund guidance of 10^{-4} to 10^{-6} would indicate. Furthermore, the ARCS study characterizes the significance of all the exposure scenarios as "at or above concern levels", when it would be more appropriate to state which exposure scenarios **exceeded** and **fell within** the range of acceptable risks.

Uncertainties

The report discusses several factors that create some uncertainty in the risk assessment calculation. Several assumptions and estimated values were used in this baseline risk assessment that contributed to the overall level of uncertainty associated with the noncarcinogenic and carcinogenic risk estimates. As with most environmental risk assessments, the uncertainty of the risk estimates probably varied by at least an order of magnitude or greater. Uncertainties were addressed in a qualitative way for those parameters and assumptions that appeared to contribute the greatest degree of uncertainty.

Also, as stated previously, MDNR toxicologists that reviewed the report identified some serious methodological and reporting problems. The most serious concerns were that the characterization of noncarcinogenic risk was seriously underestimated due to the exclusion of PCBs, and the characterization of carcinogenic risks is accompanied by a rationale and justification that are questionable.

CHAPTER VIII: HABITAT

A. HABITAT CHANGES

1. Use Impairment

Loss of fish and wildlife habitat was one of the identified beneficial use impairments that resulted in designation of Saginaw River/Bay as an Area of Concern (AOC). Habitat degradation results in the reduction of economic, recreational and aesthetic resources as well as a potential loss of biodiversity.

2. Historical Habitat

In September 1993, the Michigan Natural Features Inventory (MNFI), Natural Heritage Program, prepared a report for the Saginaw Bay National Watershed Initiative entitled, "Historical Wetlands of the Saginaw Bay Watershed". The report presents a comparison of presettlement versus current wetland acreage within the eight counties entirely included within the Saginaw Bay Watershed.

Comparisons of presettlement and current cover types for eight Michigan counties located entirely within the Saginaw Bay watershed revealed the extent of impacts past and current land uses have had on the natural landscape. The pattern of land exploited for timber and agriculture is clearly indicated by comparing acreage of various land cover types. In most counties of the watershed, upland forests located on rich soils were cleared to the extent that, in some counties, as little as 2% of the acreage once supporting upland forests remain forested. In addition, major forest type conversions occurred, greatly modifying the habitat for many plants and animals.

Of the eight counties where direct comparisons were made, between 44% (Genesee) and 77% (Gladwin) of the wetland acreage present in the 1830s remain today (Table 1A). A clear pattern of past exploitation of conifer-dominated swamps and the drainage of wet prairies has nearly eliminated these types from several counties. Many of these historical conifer swamps and prairies have converted to swamps dominated by hardwoods and shrubs, causing acreage calculations of these two wetland categories to show increases in many counties.

Table 1A, Wetland Change from Presettlement to the Present Day

County	Wetland Acreage Presettlement	Wetland Acreage Present	Percentage Change
Arenac	118,811	73,637	38% loss
Gladwin	114,484	88,085	23% loss
Isabella	49,957	29,654	41% loss
Midland	68,607[a]	—[a]	—[a]
Bay	78,592	40,075	49% loss
Saginaw	118,017	60,374	49% loss
Tuscola	148,603	75,407	49% loss
Genesee	42,127	18,871	55% loss
Total	670,591[a]	386,103[a]	42% loss[a]

SOURCE: Resource Management Group, Inc., with data from NFI (1993).

a According to Comer and others 1993, page 30: "Current statistics for total wetland acreage are distorted (for Midland County) by the amount of acreage of aspen forests incorrectly designated as swamp." Therefore, figures for Midland County have not been included here.

B. HABITAT INVENTORY

1. Habitat TAC Approach

In order to set goals for density and composition of desired fish and wildlife species in the area, the Habitat Technical Advisory Committee (TAC) of the Saginaw Bay National Watershed Initiative started with the premise that some type of habitat inventory was necessary. Since the majority of the watershed is private land, the best land use data available is from Michigan Resource Information System (MIRIS). Current MIRIS cover type maps were developed using aerial photographs from 1978.

The Habitat TAC identified four major categories related to habitat in the watershed as important: land use, coastal shoreline, habitat fragmentation, and threatened and endangered species. The land use, length of coastal shoreline and fragmentation measurements were all from MIRIS data. Information on threatened and endangered species and communities is from the Michigan Natural Features Inventory (MNFI) database.

The inventories were completed on a management unit basis, except for the threatened and endangered species data. Management units are subwatersheds roughly delineated by topographic contour, and range in size from 13,448 acres to 242,534 acres (Map 1).

2. Land Use

Land use was broken into six general categories: urban, agriculture, forested, nonforested, water, and wetland. Descriptions for these categories and percentages of land use for each management unit are shown in Table 1.

Agriculture is an important land use throughout the watershed. Fifty-two of the 69 management units have 30 percent or more of their land in agriculture, four have more than 90 percent agriculture, and only eight have less than 20 percent agriculture (Table 1).

In contrast, wetland makes up more than 10 percent of only three management units, and makes up 5-10 percent of 17 management units. The remaining 49 management units have less than five percent of their area in wetland.

Urban land use ranges from less than one percent to 36 percent. Fifteen of the management units have greater than 10 percent of their area classified as urban.

Map 1. Saginaw Bay Watershed management units

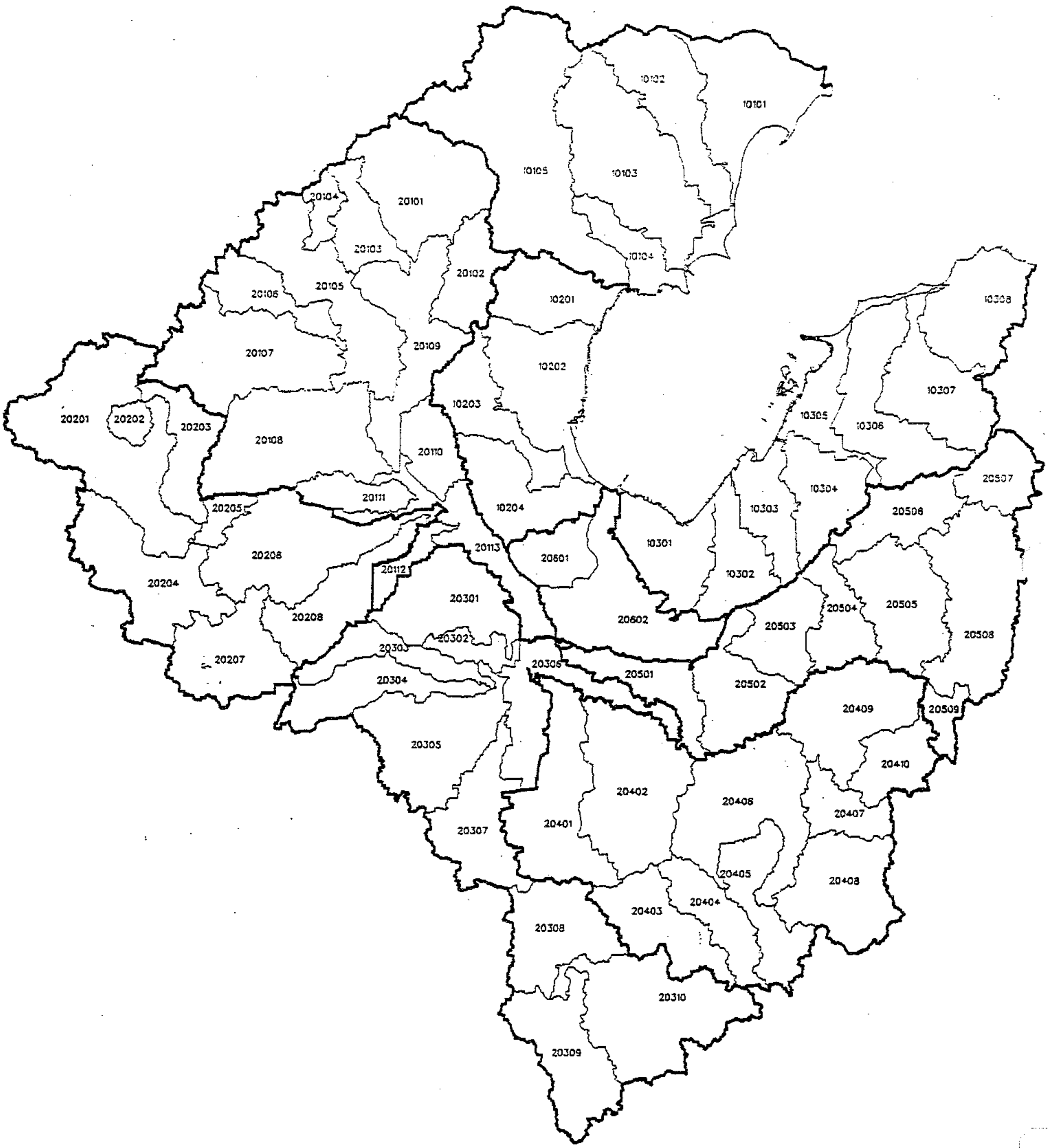


Table 1. Land use by management unit, percentages

Management Unit	Urban	Ag	Forested	Water	Nonformal	Wetland
10101	5.1	13.1	65.1	1.8	6.1	8.8
10102	4.3	18.8	65.1	2.2	5.7	4.0
10103	2.2	38.8	40.8	1.6	11.8	4.8
10104	1.5	24.7	54.5	0.3	10.3	8.7
10105	3.9	23.1	55.4	1.4	12.8	3.3
10201	4.0	50.7	28.2	0.2	14.2	2.8
10202	5.2	61.5	21.3	0.5	8.6	2.8
10203	2.6	43.1	40.2	0.1	6.1	7.9
10204	12.6	73.3	7.5	0.3	4.7	1.6
10301	4.7	90.1	1.9	0.4	1.0	2.0
10302	1.2	93.8	4.1	0.0	0.8	0.1
10303	2.1	90.9	4.1	0.0	1.5	1.4
10304	0.8	93.4	3.7	0.0	1.8	0.2
10305	5.7	75.9	12.7	0.2	3.0	2.5
10306	1.1	87.8	7.5	0.1	0.7	2.7
10307	2.8	81.6	10.5	0.1	3.0	2.0
10308	3.2	79.2	13.8	0.0	2.4	1.4
20101	2.4	12.3	67.4	1.9	9.6	6.4
20102	0.2	0.9	73.4	0.0	3.7	21.8
20103	1.7	40.2	33.3	2.7	16.3	5.7
20104	2.0	9.3	74.7	1.7	7.8	4.5
20105	4.0	24.1	48.5	1.5	17.8	4.0
20106	6.7	17.2	56.5	1.7	15.2	2.6
20107	3.8	28.3	43.0	0.9	20.3	3.1
20108	3.7	60.1	23.7	0.0	9.7	2.8
20109	4.8	18.0	51.7	3.5	12.6	9.4
20110	10.7	33.1	37.8	0.0	12.6	5.7
20111	6.8	14.4	58.2	0.0	13.9	6.6
20112	6.8	68.9	15.0	0.0	6.4	2.9
20113	31.6	33.6	21.3	1.5	10.8	1.2
20201	3.2	31.8	41.2	3.1	14.3	6.4
20202	1.4	40.7	24.5	0.5	17.1	15.8
20203	1.4	67.9	22.3	0.4	5.2	2.8
20204	1.8	51.7	28.5	0.5	12.8	4.9
20205	25.1	48.4	12.4	1.8	10.9	1.3

Management Unit	Urban	Ag	Forested	Water	Nonformal	Wetland
20206	5.2	58.7	23.4	0.4	10.8	1.5
20207	3.6	62.6	18.5	0.5	11.3	3.4
20208	6.9	69.0	12.7	0.4	9.3	1.6
20301	7.9	76.0	12.5	0.1	2.8	0.7
20302	8.8	56.4	30.2	0.1	2.7	1.8
20303	3.9	78.9	14.4	0.0	2.5	0.3
20304	3.7	79.9	13.7	0.1	2.4	0.2
20305	4.1	59.7	30.1	0.2	3.5	2.4
20306	6.2	64.2	20.3	2.0	4.1	3.3
20307	11.2	74.8	7.9	0.7	4.8	0.6
20308	7.1	68.5	11.3	0.5	10.0	2.6
20309	8.5	41.0	20.6	1.6	23.0	5.3
20310	13.3	32.7	18.7	5.0	23.4	7.0
20401	4.4	82.1	10.6	0.1	2.7	0.1
20402	27.2	42.1	13.8	0.8	15.9	0.1
20403	18.4	42.6	14.7	2.0	18.1	4.1
20404	36.0	22.9	13.9	1.3	21.2	4.7
20405	18.7	32.7	19.3	2.3	21.5	5.3
20406	22.2	38.5	16.5	3.0	17.3	2.5
20407	11.1	41.5	26.2	1.1	15.1	5.0
20408	8.0	40.3	20.8	1.8	21.7	7.5
20409	2.9	68.2	15.8	0.5	8.9	3.7
20410	2.3	58.1	21.9	1.3	10.5	5.9
20501	12.5	58.5	21.8	0.9	6.1	0.2
20502	5.6	53.5	28.3	0.7	8.5	3.4
20503	6.7	30.2	45.7	0.9	12.6	3.9
20504	3.3	45.1	25.8	0.5	18.9	6.5
20505	0.9	58.5	18.7	0.1	15.0	6.9
20506	2.0	57.9	20.6	0.1	13.7	5.7
20507	1.4	63.6	11.6	0.0	8.8	14.6
20508	1.2	82.0	10.4	0.0	4.9	1.5
20509	1.6	83.8	5.5	0.0	7.6	1.5
20601	13.9	76.2	3.3	2.4	2.5	1.8
20602	25.9	64.0	2.7	2.3	3.7	1.3

3. Coastal Areas

Coastal areas are important as both fish and wildlife habitat. In addition, because of their unique nature, Great Lakes coastal areas have a relatively large number of threatened and endangered species and communities associated with them.

Twelve of the management units have coastal shoreline. Within these management units, the length of shoreline ranges from 153 feet to 148,018 feet (Table 2). In many cases, the coastal influence extends inland substantially beyond the shoreline. In the presettlement vegetation maps prepared by Michigan Natural Features Inventory, Great Lakes marsh, lakeplain prairie, and lowland hardwoods were dominant cover types up to five miles from the coastline.

4. Fragmentation

Fragmentation is a conservation issue because increasing fragmentation can have a negative effect on the diversity of species and communities in an area. Fragmentation can also affect a species ability to persist in an area as a population. A species ability to migrate in response to habitat changes, such as conversion from a forested land type to agriculture, or a forest fire, is reduced in a highly fragmented ecosystem.

Fragmentation was measured as the mean patch size per management unit. A patch is defined for this report as a continuous land use cover type. Agriculture and urban land use types were removed from the analysis, so the data represents the average patch size of forested, nonforested and wetland cover types within the management unit.

Because of the broad land use categories used in this analysis, the description of patch may not be a good indicator that a habitat patch has a homogeneous biological function and structure. For instance, a conifer forested area adjacent to a hardwood forested area was measured as one patch of forest. These areas will likely be different structurally, have different understories, and different successional paths. On the other hand, this analysis did indicate that there is a difference in patch size between management units. The patch sizes picked as categories are not referenced to any species or communities, but were chosen so there would be a somewhat even distribution of the categories.

Average patch size for each management unit is given in Table 2 and shown in Map 2. Average patch size ranged from eight to 41 acres and the average is 21 acres. In general, the areas with low and medium fragmentation are in the north and western part of the watershed, and the areas of high fragmentation are in the eastern and southern part. This map reflects the expected results that areas of intensive agriculture have, in general, greater fragmentation of the landscape.

Table 2. Fragmentation, threatened and endangered species and community rankings and distance of coastal shoreline by management unit in the Saginaw Bay Watershed.

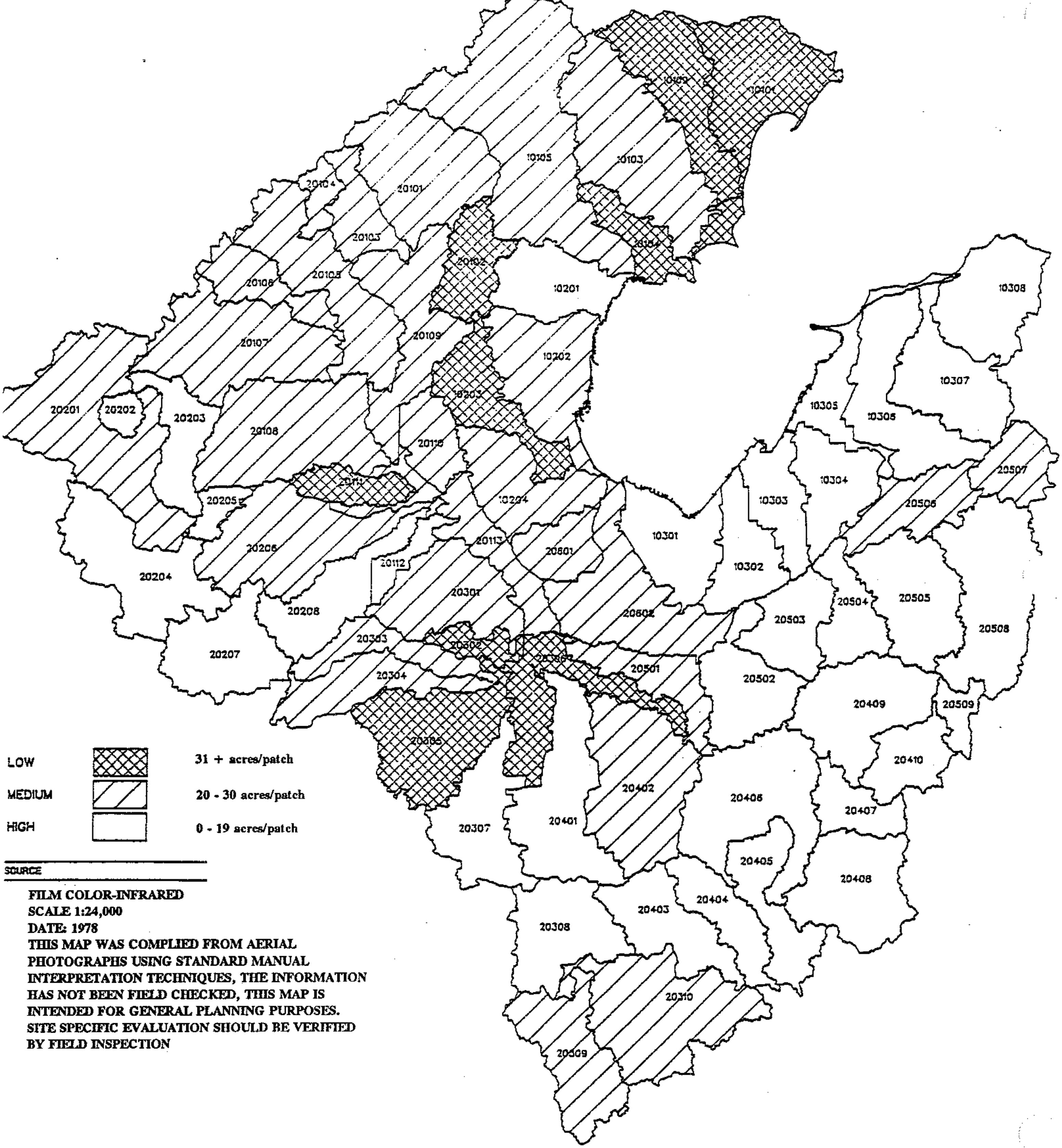
Management Unit Number	Watershed	Fragmentation		Threatened and Endangered Rankings	Distance of Coastal Shoreline (ft)
		Patch Size	Rank *		
10101	Tawas R	41	L		148,818
10102	EB,AuGrsR	38	L		N/A
10103	AuGres R	22	M		N/A
10104	Big Creek	37	L		38,436
10105	Rifle R	22	M	G1-G3 = 13	N/A
10201	Pine R	18	H	S1-S3 = 26	33,973
10202	Pinconn R	23	M		100,502
10203	N.Kakawl R	39	L		N/A
10204	Kakawl R	21	M		N/A
10301	Quanic R	12	H		N/A
10302	NW Drain	8	H		63,918
10303	Wiscog D	10	H		17,127
10304	Sebewaing R	10	H	G1-G3 = 14	34,091
10305	Shebeon C	16	H	S1-S3 = 35	1,523
10306	Pigeon R	17	H		90,136
10307	Pinebog R	17	H		153
10308	Bird Cr	17	H		N/A
20101	U.Tib R	29	M		122,017
20102	Molases R	39	L		N/A
20103	Sugar R	20	M		N/A
20104	U.Cedar R	28	M		N/A
20105	L.Tobac R	22	M		N/A
20106	U.Tobac R	25	M	G1-G3 = 5	N/A
20107	SB.Tobac R	23	M	S1-S3 = 13	N/A
20108	Salt R	24	M		N/A
20109	Sanford L	28	M		N/A
20110	Sturgen C	26	M		N/A
20111	Carroll C	37	L		N/A
20112	Bullock C	18	H		N/A
20113	L.Tib R	23	M		N/A
20201	U.Chipwa R	25	M		N/A
20202	Coldwtr R	12	H		N/A
20203	NB.Chipw R	19	H		N/A
20204	Pine R	16	H		N/A
20205	L.Chipwa R	13	H	G1-G3 = 9	N/A
20206	Salt Cr	28	M	S1-S3 = 25	N/A
20207	U.Pine R	15	H		N/A
20208	L.Pine R	16	H		N/A

Management Unit Number	Watershed	Fragmentation		Threatened and Endangered Rankings	Distance of Coastal Shoreline (ft)
		Patch Size	Rank *		
20301	Swan Cr	21	M	G1-G3 = 6 S1-S3 = 23	N/A
20302	Marsh Cr	39	L		N/A
20303	Beaver Cr	21	M		N/A
20304	Bad River	22	M		N/A
20305	S.FrkBad R	33	L		N/A
20306	Birch Run	40	L		N/A
20307	L.Shiaw R	15	H		N/A
20308	M.Shiaw R	17	H		N/A
20309	SB.Shia R	22	M		N/A
20310	U.Shiaw R	21	M		N/A
20401	Mstguay C	18	H	G1-G3 = 8 S1-S3 = 25	N/A
20402	L.Flint R	23	M		N/A
20403	Swartz Cr	16	H		N/A
20404	Thread Cr	17	H		N/A
20405	Kearsly C	18	H		N/A
20406	M.Flint R	18	H		N/A
20407	LSB.Flint R	17	H		N/A
20408	USB Flint R	16	H		N/A
20409	NB.Flnt R	15	H		N/A
20410	Cedar Cr	16	H		N/A
20501	L.Cass R	20	M	G1-G3 = 3 S1-S3 = 11	N/A
20502	Perry Cr	16	H		N/A
20503	M.Cass R	18	H		N/A
20504	U.Cass R	15	H		N/A
20505	White Cr	18	H		N/A
20506	MB.Cass R	20	M		N/A
20507	NB.Cass R	20	M		N/A
20508	SB.Cass R	13	H		N/A
20509	Columbus Dr	15	H		N/A
20601	U.Sagin R	20	M	Unknown	N/A
20602	L.Sagin R	22	M		1,422

* High = 0 - 19 acres/patch
Medium = 20 - 30 acres/patch
Low = 31 + acres/patch

Biodiversity Rank Definitions: Ranking definitions are given in Appendix 1. For purposes of assigning biodiversity ranks to sites, elements with range ranks are to be treated as follows: treat range ranks spanning two levels (e.g. G2G3) as if they had the higher (e.g. G2) of the two ranks; treat three level range ranks (e.g. G3G5) at the middle rank (G4); treat ranks such as G3? as if there were no question mark; treat GU as if it were G4. Elements with Q's attached to their global rank (i.e. questionable taxa) and subspecific taxa (i.e. T ranked taxa) should be treated at the next lower G rank (e.g. treat G3Q as if it were G4; treat G4T1 as if it were a G2). Element occurrences with range ranks (e.g. AB) should be treated as if they were ranked at the lower of the two levels(e.g. B). Treat unranked occurrences as if they were C-ranked.

Map 2. habitat fragmentation



SOURCE

FILM COLOR-INFRARED
SCALE 1:24,000
DATE: 1978
THIS MAP WAS COMPLIED FROM AERIAL PHOTOGRAPHS USING STANDARD MANUAL INTERPRETATION TECHNIQUES, THE INFORMATION HAS NOT BEEN FIELD CHECKED, THIS MAP IS INTENDED FOR GENERAL PLANNING PURPOSES. SITE SPECIFIC EVALUATION SHOULD BE VERIFIED BY FIELD INSPECTION

Areas of note from this analysis are management unit 20602, which had a medium rating, probably due to the inclusion of the Shiawassee National Wildlife Refuge within the unit. Units 20305, 20302, and 20306 are all rated as low fragmentation areas and all include parts of the Shiawassee National Wildlife Refuge or the Shiawassee River State Game area which probably increased the average patch size for each of these management units.

5. Threatened and Endangered Species

The number of threatened and endangered species and communities came from the Natural Heritage Biological and Conservation Datasystem, which was developed by the Michigan Natural Features Inventory (MNFI). The MNFI database is an ongoing, continuously updated information base. It is the only comprehensive single source of existing data on Michigan's endangered, threatened, or otherwise significant plant and animal species, natural plant communities, and other natural features.

However, the MNFI database cannot provide a definitive statement on the presence, absence or condition of the natural features in any given locality, since most sites have not been specifically or thoroughly surveyed for their occurrence. Therefore, the information provided should not be regarded as a complete statement on the occurrence of special natural features in the area in question. MNFI supplied the data as is with all errors it may contain. MNFI makes no warranty whatsoever as to the fitness of the data for any purpose, nor that the data are necessarily accurate.

Species and communities were ranked by MNFI based on relative rarity and degree of threat. Both global (G) and state (S) ranks were assigned. The number of high ranking elements (G1-G3, S1-S3) in each subwatershed are summarized in Table 2. Ranking definitions, the scientific name, and the number of occurrences are presented in Appendix Three: Area Description. The presence of these species, or communities, serve as indicators of the remnants of relatively intact native ecosystems and can be important for assessing ecosystem health.

C. HABITAT CONCERNS AND RECOMMENDATIONS

The historical and current cover type data, combined with current information on existing sensitive habitats, populations of rare species, and existing data on other important wetland values, provides concrete direction for the development of priorities and strategies for the management and restoration of the Saginaw Bay Watershed. Many of these goals were identified earlier in Chapter I, and related recommendations are listed in Chapter IX. A general discussion of the major issues follows.

Table 3 lists habitat concerns for the Saginaw Bay watershed and gives recommendations to address these concerns within each of the four major land use categories. Although criteria for ranking management units for habitat values were not developed, Table 3 can be used to assess the suitability of projects in different areas of the watershed. For example, in areas dominated by agriculture, projects should be among those listed in the agriculture column.

The Habitat TAC was not able to set goals for density and composition of desired fish and wildlife species. However, it was agreed that coastal areas are important, and that we should work to protect and improve areas with threatened and endangered species and communities.

Fisheries habitat concerns were not addressed in depth by the TAC. Fisheries concerns that were identified as important are dams and land use. Dams have a negative effect on the fishery resource by limiting fish movement and changing the flow rates at critical times. Land use is a concern because of water quality and sedimentation problems. Also, the rivers and streams in predominantly agriculture or urban areas are very flashy.

In order to improve the habitat assessment, a current map of land use is needed. Having current land use in a Geographic Information System (GIS) format would allow comparison with the 1978 information. Land use changes and trends could be evaluated and a measure of threat to habitat could be designed. A measure of threat would be an important criteria in determining which habitat types should be targeted for protection or restoration. Data in a GIS format would allow analysis of the habitat on a landscape scale. It would make it more practical to measure the potential effects of habitat loss or restoration.

Table 3. Habitat concerns and recommendations for the Saginaw Bay Watershed

	Agriculture	Urban	Forest	Coastal
Headwaters	Protect, buffer	——	maintain, road crossings	——
Soil Stabilization	increase, protect areas near rivers, drains	——	increase, road crossings	——
Presettlement Vegetation	——	——	maintain, increase	maintain, increase
Flow Regime	increase, wetland/floodplain	stormwater runoff control	maintain	——
Water Quality	increase soil stabilization, prevent pesticide and fertilizer runoff	stormwater runoff control	logging BMPs, road crossings	
Linkages	increase	river corridors, park planning	——	increase
Maintain Existing Biota	——	——	implement ecosystem forest management	maintain land in wetland state and increase
Floodplains	increase by moving dikes back from rivers	stormwater runoff control	maintain	——
Wetlands	increase acreage - especially adjacent to streams/drains	increase	increase	increase
Threatened and Endangered Species	——	——	protect and inventory	protect and inventory
Stormwater	——	improve	——	——

D. WETLAND RESTORATION STRATEGY

1. Strategy

In July 1994, Saginaw Valley State University, with assistance from Public Sector Consultants, Inc. and Resource Management Group, Inc., prepared a study entitled, "Saginaw Bay Watershed: A Strategy for Wetland Restoration". The two primary goals of this project were to:

- consolidate and evaluate Saginaw Bay watershed information that could be incorporated into the statewide wetland strategy; and,

- provide planning tools for local, state, and federal interests to use in developing local wetland protection and restoration projects.

The Saginaw Bay watershed strategy describes components of a nonregulatory approach that has emerged from national and state initiatives to develop comprehensive wetland conservation strategies. The strategy identified the following components necessary for implementing a wetland restoration plan for Saginaw Bay.

- Determine the extent of wetland loss.
- Set wetland restoration goals.
- Identify the benefits gained from wetland restoration as perceived by local community members.
- Analyze the critical aspects of a successful wetland restoration plan as perceived by local community members.
- Describe the agencies and organizations involved in wetland restoration and identify potential funding sources.
- Develop a methodology for identifying potential restoration sites.
- Develop conceptual restoration plans for specific types of demonstration sites for restoration.

As part of the study, three local focus group participants were asked to identify important benefits each believed could be achieved through the restoration of wetlands. Collectively, the focus groups arrived at the following list:

- wildlife protection through habitat restoration;
- flood control through storm water retention;
- enhancement of water quality through sediment control and nutrient capture;
- recreational use and potential revenue generation;
- educational value; and,
- enhancement of community character and aesthetic values.

2. Goals

The Saginaw Bay watershed encompasses approximately 8,700 square miles, or approximately 15 percent of Michigan's 58,100 square miles of land area. Based on the short-term wetland restoration goal of 50,000 acres statewide by 2010, the proportionate share based on land area for the Saginaw Bay watershed is 7,500 acres of new wetlands, that is, creation of 500 wetland acres annually for the next fifteen years.

Viewed another way, estimates of presettlement and present-day wetlands in Michigan indicate that about 5 million acres may have been lost statewide. Wetland losses in the Saginaw Bay watershed amount to between 250,000 and 300,000 acres that have been converted to other land uses since the mid-1800s in seven of the eight counties wholly within the watershed (Midland County excluded). Since the short-term goal for Michigan represents an attempt to restore one percent of the historical wetlands lost statewide, creating 7,500 new acres of wetlands in the Saginaw Bay watershed by 2010 represents a restoration of 2.5-3.0 percent of the wetlands lost in seven of the eight counties within the watershed.

In other words, the goal of 50,000 acres of restored wetlands statewide, if distributed proportionate to land surface, would likely involve a larger percentage of restored wetlands in the Saginaw Bay watershed than the statewide goal of one percent.

3. Recent Restorations

Since 1987, wetland enhancement and restoration projects have been conducted on approximately 1,206 acres of public land in the Saginaw Bay watershed (Table 5). During the same time period, wetland restorations were completed on over 214 acres of private land in the watershed (Table 6). These estimates are conservative since data on the number of sites and total acreage restored are not available for all organizations. Many local chapters within larger organizations frequently participate in projects with multiple partners, making it difficult to estimate the total acreage restored.

4. Future Restorations

In order to ensure the success of a large-scale wetland restoration effort, considerable technical expertise is needed as well as funding to support restoration projects. Currently, small-scale conversion of some marginal private agricultural land to wetlands is occurring by plugging drains and removing tiles. In addition, wetlands in larger state-owned areas are being enhanced or restored. Many of the projects are funded through partnerships involving private landowners, federal and state agencies, and local and statewide conservation organizations. These partnerships allow larger projects to be undertaken as well as provide technical assistance and a variety of funding for smaller projects.

Table 5. Recent Wetland Restorations/Enhancements Conducted by the Wildlife Division, MDNR, on Public Lands in the Saginaw Bay Watershed

Year	Location	Size	Partners with MDNR
87, 1990	Tuttle Marsh	A channel 3.5 miles long by 36' wide, 380 acres	DU, USFS
1989	Nayanquing Point	330 acres	DU
1989	Shiawassee River State Game Area	200 acres	MWHF, SFCHA, MDHA, DU,
1991	Crow Island	240 acres with additional 570 acres possible	DU, NHF, WU, MDHA
In progress	Lapeer State Game Area	56 acres	DU, MWHF, MDHA, Seymour & George Addison

SOURCE: Public Sector Consultants, Inc., with data from Wildlife Division, MDNR.

KEY: DU = Ducks Unlimited; MDHA = Michigan Duck Hunters Association; MWHF = Michigan Wildlife Habitat Foundation; NHF = New Haven Foundry; SFCHA = Shiawassee Flats Citizens and Hunters Association; USFS = United States Forest Service; USFWS = United States Fish and Wildlife Service; WU = Waterfowl USA.

Table 6. Recent Wetland Restorations Conducted on Privately Owned Land in the Saginaw Bay Watershed

ꞁars	Location	Number or Size	Participants
.987–93	Saginaw Bay Watershed	149 sites	USFWS (administered by SNWR)
1991–93	Gladwin County	11 sites totalling 23 acres	Gladwin SCD (USFWS funding)
1988–94	Sanilac County	65 sites totalling 55-65 acres	Sanilac SCD (USFWS funding)
1987–94	Lapeer County	39 sites totaling 63 acres	Lapeer SWCD (USFWS, ASCS, MDNR funding)
1991–94	Saginaw Bay Watershed	approx. 20 sites	MWHF
1993	Saginaw Bay Watershed	7 sites totalling 15 to 20 acres	SBRCD (50% USFWS funding)
1993	Saginaw Bay Watershed	41 sites totalling 81.5 acres	DU (50% USFWS funding)
	Saginaw Bay Watershed	Unknown	MDHA, PF, ASCS

SOURCE: Public Sector Consultants, Inc.

KEY: ASCS = Agricultural Stabilization Conservation Service; DU = Ducks Unlimited; MDHA = Michigan Duck Hunters Association; MWHF = Michigan Wildlife Habitat Foundation; PF = Pheasants Forever; SBRCD = Saginaw Bay Resource Conservation and Development Area; SCD = Soil Conservation District; SNWR = Shiawassee National Wildlife Refuge; SWCD = Soil and Water Conservation District; USFWS = United States Fish and Wildlife Service

The strategy presents a methodology for identifying natural candidate sites for wetland restoration. Natural candidates are historical wetland sites that still contain remnants of wetlands, or may have been put to other uses but retain some of the hydric soils, vegetation, and hydrological conditions that could make them fully functional wetlands. Data are available for most of Michigan that identify soil types, hydrological conditions, evidence of remnant wetland vegetation, and other information critical to identifying potential restoration sites. Using Geographic Information System (GIS) technology, these data sources can be screened for large geographical areas to identify natural candidate sites.

Based on the types of sites specified by the MDNR, the information assembled, and the focus group discussions, ten potential wetland restoration areas were selected from the original list (Table 7). In addition, a Flint River restoration site was added as a result of the focus group discussions. This site initially had not been identified because it was not labeled as a historical wetland on the presettlement vegetation maps, even though it was adjacent to a large river. Further analysis revealed that it had excellent potential based on the evaluation criteria.

After an analysis was conducted on the short list of 11 potential restoration sites, three locations were chosen as sites for the development of conceptual wetland restoration plans and each is described below. As required by the MDNR, each site offered diverse benefits and was located in a different setting: one site is coastal, another urban/urban fringe, and the third is agricultural. To reiterate what was explained earlier, these sites were chosen based on the manual screening of information, the GIS co-occurrence analysis, input from the regional focus groups, and discussions with area interests such as drain commissioners, and the Saginaw Bay National Watershed Initiative Work Group.

Quanicassee Site

The proposed coastal wetland restoration site is located in Sections 14, 23, and 24 of Hampton Township, Bay County, Michigan. This site was identified as a target area in the manual analysis and in the GIS analysis. The site encompasses approximately 170 acres, approximately 60 acres are owned by Consumers Power Company and the remainder are under mixed private ownership.

The wetland restoration plan proposes that the 110 acres of privately owned land be exchanged for an equivalent or greater amount of Consumer's Power property. Up to 150 acres of contiguous Consumers Power property is located immediately south of the project area and may be available for exchange. Presettlement vegetative cover at the site consisted almost entirely of Great Lakes marsh. The Great Lakes marsh has been manipulated to affect the hydrology of the wetland and the historical lakeplain prairie has been eliminated.

Table 7

~~Figure 3:~~ **Short List of Potential Wetland Restoration Areas in the Saginaw Bay Watershed**

Location (County)	FG[a]	Site Number	Land Use[b]	Soils Hydricity[c]	Wetland Type[d]	Size (acres)	Public Land	Pop. Density[e]	House Value[f]	Prime Farmland[g]	% Pop. Increase[h]
Saginaw /Gratiot	1/2	7	AG	3/4	Emergent Marsh E	1050	No	1	1	1	0
Arenac	1	23	C	4	Great Lakes Marsh M	650	No	2	1	2	0
Saginaw	2	Flint River	AG	2	Emergent Marsh/ Other M	5700	No	2	2	1	0
Midland	2	2	R/UF	3	Emergent Marsh E	250	No	2	2/3	2	0
Bay	2	4	C	3	Lakeplain Prairie M	1100	No	2	2	1	0
Saginaw	2	6	UF	2	Lakeplain Prairie E	850	No	2	2/3	4	0
Genesee	2	20	UF	3	Lakeplain Prairie E	800	No	3/4	4	2	1
Bay	3	3	AG	1	Emergent/ G.L Marsh E	3250	No	1/3	2/4	4	0
Huron	3	9B	C/AG	3	Great Lakes Marsh E	1100	No	2	1	1	0
Huron	3	9C	C	1	G.L. Marsh/ L.P. Prairie E	650	No	2	1	4	0
Tuscola/ Bay	3	28	C	1	G.L. Marsh/ L.P. Prairie E	27000	Some	1	1/2	2	0

SOURCE: Resource Management Group, Inc.

[a] Focus group.
[b] Ag = Agricultural, R = Recreational, C = Coastal, UF = Urban Fringe.
[c] Ranging from 1 = 75–100% Hydric to 4 = 0–25% Hydric.
[d] E = Eliminated, M = Hydrology manipulated.
[e] Ranging from 1 = Low to 4 = High.
[f] Ranging from 1 = Low to 4 = High.
[g] If drained, the land's potential as prime farmland ranges from 1 = Low to 4 = High.
[h] 0 = Lost population, 1 = Gained up to 3.5%, 2 = Gained 3.5 to 6.7%, 3 = Gained 6.7 to 12.2%, and 4 = Gained 12.2 to 56%.

The specific wetland functions expected to be restored by the Quanicassee restoration include:

- improved water quality,
- reduced sedimentation,
- expanded wildlife habitat, and
- greater vegetative diversity.

Flushing Site

This 46 acre site, characterized as urban fringe, is classified as eliminated lakeplain prairie. It is located on the north edge of the city of Flushing, Michigan, in the south part of sections 23 and 24. Presettlement vegetative cover at the project site consisted of lakeplain prairie that has been eliminated as a result of agricultural practices.

The goal of the Flushing site restoration is to create a saturated soil condition, which will promote growth of a diversity of native wetland plant species. The present land use of the Flushing site is fallow agricultural field, and it possibly has been enrolled in the Conservation Reserve Program through the U.S. Department of Agriculture (USDA). Due to the presence of the Boman Drain, only certain presettlement wetland functions could be restored.

The specific wetland functions expected to be restored by the Flushing wetland restoration project are:

- improved water quality,
- floodwater retention, and
- expanded wildlife habitat.

Flint River Site

The Flint River site includes 19 acres located in Section 36 of Spaulding Township and Section 1 of Albee Township, Saginaw County and is part of the Flint River Dike Project, administered by the Flint River Dike and Erosion Control Board.

The Saginaw Bay Resource Conservation and Development Area Council, Inc., describes the Flint River Dike Project as "Setback and reconstruction of seriously eroded dikes along the Flint River for the prevention of flooding, to control erosion of fields during flood periods, to protect home owners, and to retain emergency services, all of which are lost during a flood period."

The specific wetland functions expected to be restored by the Flint River project are:

- improved water quality,
- floodwater retention/detention,
- expanded wildlife habitat,
- sediment reduction, and
- vegetative diversity.

CHAPTER IX: ACTIONS NEEDED

A. OVERVIEW

This chapter of the Saginaw River/Bay Remedial Action Plan (RAP) is the main reason this document has been compiled. It primarily identifies actions needed to further address the environmental degradation problems in Saginaw Bay and its watershed, focusing on land use, water resources, habitat and related topics. The ultimate goal is to achieve the "vision" established for the bay and the watershed, which states, in part, the following.

> "Saginaw Bay and its watershed will provide a safe, enjoyable, balanced environment with clean water for all forms of life. The bay will support the wide range of multiple uses and benefits typical of a Great Lakes embayment. Basin rivers, streams, lakes, drains and other waters within the watershed will also support multiple uses, while at the same time protecting the water quality of Saginaw Bay. Both the bay and the watershed will provide for biodiversity, naturally self-sustaining indigenous populations, good public health, recreational opportunities, and economic viability....
>
> "....Saginaw Bay and its watershed shall be protected against further degradation of water quality or functional loss of habitat. Furthermore, existing environmental conditions will be improved to (1) restore all currently impaired beneficial uses (as defined by the Great Lakes Water Quality Agreement) in the Saginaw River and Saginaw Bay; and (2) enhance other water-related uses in the bay and the watershed as appropriate...."

The Michigan Department of Natural Resources (MDNR) has been designated as the state agency responsible for preparing the RAP, but this RAP document actually represents the work of multiple agencies, local governments, numerous corporations, and various public organizations. Though this document is not legally binding on any agency, government, corporation or individual, it does outline the approach the participants intend to take in applying expanded efforts, beyond existing programs and activities, to further address environmental issues in Saginaw Bay and its watershed.

It is intended that this RAP be used by all agencies (federal, state, local), local governments, organizations and individuals concerned with, affected by, or impacting water quality in the Saginaw Bay basin. Extensive efforts have been made, and continue to be made, to include all interested and/or affected partes in the development, review and implementation of this plan so that it fully addresses the issues from a variety of perspectives and is broadly supported. As the RAP project progresses, more groups are expressing interest in being involved in the process and mechanisms are generally implemented or modified to accommodate this interest. The Remedial Action Plan is an iterative, long-term effort. The RAP will be periodically updated and revised (currently on a biennial schedule with each report focusing on recent developments and priority issues) as more data are acquired, remedial measures are implemented, and environmental conditions improve.

A wide range of activities need to be undertaken to further address the environmental and natural resource problems affecting the Saginaw River/Bay AOC. The estimated cost of the actions identified in this document is more than $107 million over the next ten years (a period of time used for cost projection purposes only). This represents only a **small** portion of the overall cost since (1) estimates cannot be made on many actions, and (2) actions to address toxic substances are not included because toxic material issues were not addressed by the Technical Advisory Committees for this biennial report (it is expected that the TACs will address toxic substances in the next biennial report).

The activities outlined in this Remedial Action Plan are presented as current perceptions of the needed actions. They will be used to plan and guide remedial efforts at this stage of the Remedial Action Plan process. Since the RAP process is iterative, these actions are subject to further evaluation and modification consistent with changing environmental conditions in the Area of Concern or the acquisition of data supporting adjustments in scope or approach. Additional discussion of the remedial actions is encouraged and comments are welcome at any time from any interested party.

This list of actions was compiled by the various committees of the Saginaw Bay National Watershed Initiative. Some of the actions identified were also listed in the 1988 Saginaw River/Bay RAP. They are included here again if they are (1) still relevant, and (2) need additional implementation, were only partially implemented, or were never implemented.

The remedial activities discussed on the following pages focus primarily on eight topic areas: public participation and education, data management/integration, land use planning, identifying impacted areas and the contaminants involved, assessing the magnitude of environmental degradation, identifying specific sources and source areas of pollutants, reducing pollutant loads at the source, and protecting/enhancing habitat. The activities are presented under six major subject headings:

(1) Public Information/Education

(2) Data Management and Integration

(3) Land Use Planning

(4) Pollutant Sources
- Point Sources
- Atmospheric Inputs
- Terrestrial Nonpoint Sources
- Aquatic Sediments

(5) Pollutant Effects
- Water
- Biota

(6) Habitat

Within each category is a general introduction to the topic followed by a discussion of specific remedial actions.

Additional discussions on general recommendations on their respective topic areas can be found in Chapter III, Land Use Planning; Chapter VI, Soil Erosion & Sedimentation; and, Chapter VIII, Habitat.

B. PUBLIC INFORMATION/EDUCATION

A public that is informed about, and active in, the Remedial Action Plan process is an important component that will affect the degree of success achieved by the RAP. Public support for remedial actions is necessary in order to achieve the political will to provide the funding, staff and time commitment levels required to carry out the proposed activities. This support would be fostered by greater public knowledge and understanding of the Saginaw basin's natural resources, environmental processes, water quality problems, resource uses, and Remedial Action Plan goals. Additionally, a diverse group of resource users exists in the basin and mutual understanding of each others needs and perspectives will enhance the process of achieving better environmental quality for all.

There are several difficulties to overcome in increasing both the general knowledge of local citizens on environmental and natural resource issues affecting the Saginaw Bay system, and the degree of public participation in the RAP process. One is access to information. Even among those of the general public who are versed in environmental principles, there is a feeling that information is not readily accessible to them on area water quality problems or the range of possible solutions to those problems. No single authority exists that the public can turn to for information about either the magnitude of the problems facing the Saginaw Bay system, or about how to participate in the development and implementation of remedial actions. Often, the information that is available is too technical to be readily understood by the layperson. Also, many people are uncertain about the impact of environmental contamination within the basin and feel ill prepared to assess the levels of acceptable risk. Developing public understanding about the levels of acceptable risk, and about subsequent actions to reduce that risk, is important to the success of the RAP.

A second impediment is the length of time involved in developing and implementing remedial actions. Because of the complex nature of the remaining environmental problems, and the financial costs of correcting them, a multifaceted and informed approach is needed. Consequently, a substantial amount of time often passes before observable remedial actions are implemented. This time is often perceived by the public as a time of inaction since no results are apparent. Efforts need to be undertaken to explain this process to the public and provide appropriate progress updates.

A corollary factor is that individual remedial actions often do not result in substantial environmental improvements. As a result, their merit is sometimes questioned, even though the action may be a key factor in a series of remedial actions that ultimately provide significant improvements in the ecosystem. Accordingly, individual remedial actions should be presented to the public in context with a stepwise approach and the overall remedial process.

During the past three years, significant progress has been made on public information/education through the efforts of the Saginaw Bay National Watershed Initiative

(SBNWI) program. The SBNWI has developed and implemented many public participation and education programs described earlier in Part II: Actions Implemented Since 1988. Among the most significant were:

- providing financial support to the Saginaw Bay Watershed Council to coordinate local government activities directed at water quality issues including the Saginaw Bay Watershed Adopt-A-Stream Program and the High School River Water Quality Monitoring Program;

- providing financial support to the Saginaw Basin Alliance to coordinate citizen activities and develop the Saginaw Bay Water Watchers Program;

- developing a variety of educational materials on the Saginaw Bay watershed and providing public school teacher training; and

- awarding numerous small grants to local nonprofit and educational groups to undertake implementation projects throughout the watershed.

Despite the dramatic progress made through the SBNWI, a variety of activities are still needed to (1) further educate the public on environmental and resource issues relevant to the Saginaw Bay watershed; (2) promote greater public involvement in the Saginaw River/Bay RAP process, and (3) facilitate coordination and communication among public organizations.

1. The SBNWI should continue its efforts to facilitate the coordination of education, public involvement, RAP implementation, economic development, and other resource restoration/protection activities in the Saginaw Bay watershed.

   Status- ongoing
   Schedule - continuous
   Cost - $150,000/year
   Funding - federal/state

2. The RAP process, through the ongoing efforts of the SBNWI, should continue to seek active public participation in (1) determining goals and objectives, (2) prioritizing activities and decision making, (3) implementing and tracking of actions, and (4) educating and involving local communities.

   Status- ongoing
   Schedule - continuous throughout project
   Cost - $50,000/year
   Funding - state and local

3. The Saginaw Basin Alliance (SBA) nonprofit corporation should continue its diverse efforts to address natural resource and environmental issues in the Saginaw Bay watershed by:

- soliciting and distributing funds for RAP activities that are consistent with corporation goals;
- implementing appropriate RAP actions as able;
- creating a broader public interest in, and understanding of, natural resource and environmental issues in the basin;
- promoting a positive public movement encouraging environmental consciousness and support for clean air, land and water;
- fostering a spirit of cooperation among the diverse interest groups present in the basin; and,
- establishing and maintaining lines of communication between itself and similar organizations in the U.S. and Canada.

Status - ongoing but the funding level fluctuates and is less than needed.
Schedule - continuous throughout process
Cost - $250,000/year
Funding - local

4. The SBA should continue its successful and popular water watchers program.

Status- ongoing
Schedule - continuous throughout project
Cost - $20,000/year
Funding - local

5. The Saginaw Bay Watershed Council (SBWC) of local governments should continue its diverse efforts to address natural resource and environmental issues in the Saginaw Bay watershed.

Status - ongoing but the funding level is less than needed.
Schedule - continuous throughout process
Cost - $250,000/year
Funding - local

6. The SBWC should continue its successful and popular Adopt-a-Stream and school water monitoring programs.

    Status - ongoing
    Schedule - continuous throughout project
    Cost - $40,000/year
    Funding - local

7. The MDNR should continue to work with the SBA on RAP document updates, RAP implementation activities, and receiving general public input on the RAP and implemented actions.

    Status- ongoing
    Schedule - continuous throughout project
    Cost - $10,000/year for SBA activities
    Funding - local

8. The SBA should be the lead organization in sponsoring RAP related public meetings and promoting public involvement in the RAP process. Any other organization can also conduct public meetings on RAP activities as necessary, but the meetings should be coordinated with the SBA to facilitate transfer of the most up-to-date information.

    Status - ongoing
    Schedule - continuous throughout project
    Cost - $10,000/year
    Funding - local

9. The MDNR should encourage local participation by supporting locally funded and implemented RAP related projects.

    Status - ongoing
    Schedule - continuous throughout project
    Cost - incidental

10. The SBA should continue to publish its informational newsletter "Basinotes", including RAP activities, SBA actions, and related topics of interest.

Status - ongoing
Schedule - quarterly
Cost - $10,000/year
Funding - local

11. The SBWC should continue to publish its informational newsletter "Watershed News & Views", including RAP activities, SBWC actions, and related topics of interest, with distribution to all local governmental agencies.

Status - ongoing
Schedule - quarterly
Cost - $10,000/year
Funding - local

12. Regularly scheduled meetings of the SBA and SBWC should be used as a public forum for participation in natural resource and environmental issues throughout the watershed.

Status - ongoing
Schedule - quarterly
Cost - $20,000/year ($10,000 each organization)
Funding - local

13. The MDNR should promote pollution prevention efforts throughout the Saginaw Bay watershed.

Status - new
Schedule - continuous
Cost - 60,000/year
Funding - federal/state

14. Positive developments or programs in the basin that are currently underway should be identified and widely publicized, including information on which groups, individuals or businesses are working to improve environmental quality in the basin, what their efforts are, and how successful they have been. Any organization could do this itself, or forward the information to SBA, SBWC, or the MDNR/SBNWI.

Status - ongoing
Schedule - periodically as appropriate
Cost - incidental

15. Environmental education efforts dealing specifically with the Saginaw Bay ecosystem should be greatly expanded, both within the formal K-12 education system and among the general public.

a. The SBNWI should continue its diverse educational efforts to reach all segments of the local communities including students, teachers, local government officials, and the general public.

Status - ongoing
Schedule - as appropriate
Cost - varies with scale of projects $10,000-$1,000,000/year
Funding - state and local

b. The 22 Michigan State University County Extension offices located throughout the watershed should be utilized as a major educational resource that can reach all areas of the watershed on a local scale.

Status - proposed
Schedule - as appropriate
Cost - varies with scale of projects $10,000-$1,000,000/year
Funding - state and local

16. The Michigan State University County Extension offices should develop educational materials, videos, fact sheets, etc. that could be used by other groups for informing and teaching people about the environment, clean water, and the importance of the Saginaw Bay ecosystem.

Status - proposed
Schedule - as appropriate
Cost - varies with scale of projects $5,000-$10,000/year
Funding - state and local

17. Michigan State University County Extension should facilitate an annual one to three day conference/workshop bringing together the various agencies, organizations, local governments, businesses and local public involved with ecosystem issues in the Saginaw Bay watershed. The objective of the meeting should be to update participants on past and future environmental research or restoration activities taking place in the watershed, and discuss the environmental issues that need to be addressed.

Status - proposed
Schedule - as appropriate
Cost - $10,000/year
Funding - state and local

18. The SBA should sponsor a public education forum that meets periodically to present information on, and discuss, environmental and natural resource issues of importance to area citizens. This could be part of, or separate from, SBA business meetings, but in either case should include an educational presentation.

Status - proposed
Schedule - quarterly
Cost - $5,000/year
Funding - local

19. The MDNR should pursue designation of the Saginaw Bay watershed under the proposed Watershed Management sections of the federal Clean Water Act (CWA) amendments.

Status - new
Schedule - concurrent with CWA revisions
Cost - incidental to MDNR operations
Funding - federal/state

C. DATA MANAGEMENT/INTEGRATION

The following recommendations evolved out of the Saginaw Bay small watershed prioritization process discussed in Chapter IV, and deal with updating and managing the database, and conveying the results to users at the local, state and federal level.

1. Criteria development, data collection, and data summarization procedures relevant to the small watershed prioritization process should be incorporated into appropriate agency Standard Operating Procedures (SOPs) in order to standardize the process and facilitate comparison of data from different agency/organization sources. Included in these SOPs should be data standards that provide for quality assurance/quality control.

2. An integrated, computerized system should be developed that presents the prioritized information in the most effective way for watershed planning.

3. A review process should be implemented to maintain high quality information, and assure that new technologies/procedures are included as appropriate. Further, the review process should gauge the success of the prioritization process relative to established benchmarks.

4. An information/education strategy should be implemented that effectively conveys the prioritized information, and involves all levels of government (federal/state/local) and the public in developing strategic watershed action plans (SWAPs) that address the issues in the various watersheds. These SWAPs should include an implementation schedule with specific tasks outlined, projected completion dates, and the agency and/or organization that is responsible for their implementation.

D. LAND USE PLANNING

The MUCC Land Use and Zoning study made specific recommendations in two areas. First are legislative actions; proposed changes in state and federal programs and legislative modifications of the authorities granted to local governments. Second, local actions are suggested to improve land use management and regulation by local governments. Some of these suggestions simply involve improving the use of existing local authority to better incorporate environmental concerns into the land use decision process. Some would involve fairly substantial changes in existing laws and programs. All of them share a common goal; to cause our concern for, and understanding of, natural resources protection issues to be better reflected in the day to day land use decisions made right in our own communities. A general discussion on land use planning recommendations can be found in Chapter III, specific recommendations are summarized below.

LEGISLATIVE ACTIONS

1. Provide adequate funding for MDNR permitting programs dealing with the land/water interface (wetlands, inland lakes and streams, etc.).

2. Increase state and federal funding commitments to Clean Water Act permitting programs.

3. Increase funding to the State Revolving Fund that finances community wastewater treatment projects.

4. Revise contaminated site cleanup standards to facilitate redevelopment of abandoned urban areas while still protecting the environment and public health.

5. Amend the Subdivision Control Act to provide for public review of land divisions, apportion increased infrastructure costs to developments responsible for them, bring so-called site condominiums under the same regulations, and strengthen enforcement provisions.

6. Incorporate the various planning enabling acts into a single statute with consistent authorities, procedures and responsibilities.

7. Incorporate, in a similar fashion, the three zoning enabling acts and make the connection between planning and zoning clearer.

8. Through comprehensive growth management legislation, empower local governments with such new land use control tools as the authority to purchase or transfer development rights, the ability to phase new development in only as infrastructure is capable of supporting it, the responsibility to coordinate development with regional impacts with neighboring communities, and the ability to define growth boundaries to more efficiently provide public services.

LOCAL ACTIONS

1. Education should be provided to local decision-makers and citizens to empower them to more effectively use authority already available to them.

2. Revisit local plans to incorporate a better understanding of such issues as natural resource protection and farmland preservation explicitly into the community's vision of its future.

3. Amend local zoning ordinances to reflect changes in emphasis in their supporting master plans.

4. Adopt local land division regulations to enable communities to more carefully guide future development.

5. Adopt and annually update a Capital Improvement program to proactively plan for infrastructure improvements as guided development occurs.

6. Cooperate and collaborate with adjacent communities to capitalize on joint opportunities and avoid problems caused by independent land use decisions.

E. POLLUTANT SOURCES

Point Sources

Wastewater discharges from municipal and industrial facilities continue to contribute pollutants to the Saginaw Bay system, though the amounts are substantially less than in the past. Efforts need to be continued to further reduce discharges of nutrients and conventional parameters

The meeting of NPDES permit limits should not be construed as an endpoint. Dischargers should strive to further reduce discharges as feasible pursuant to the federal Clean Water Act goal of zero discharge. This is particularly true for phosphorus, which continues to impair designated uses in the AOC. Facilities currently discharging materials at levels that are less than permit limits should attempt to maintain these lower levels and work toward further reduction where possible.

1. The MDNR needs to substantially expand the NPDES permit compliance monitoring efforts in the Saginaw Bay basin to verify if the discharge values reported by the facilities are accurate. This program has been seriously understaffed in recent years due to state budget constraints.

   Status - proposed
   Schedule - ongoing once implemented
   Cost - $140,000/year (one additional staff person for both Saginaw Bay and Shiawassee district offices)
   Funding - state or federal

2. The MDNR needs to expand efforts to enter information on minor dischargers into the PCS permit database system. This would enhance compliance tracking efforts and data analysis of discharges from minor facilities.

   Status - proposed
   Schedule - ongoing once implemented
   Cost - dependent on level of detail
   Funding - federal/state

3. The MDNR should review operating records of small WWTPs and lagoon systems to determine if the results of previous studies, which indicated that the contribution of these sources to tributary and bay loads were relatively insignificant, are still valid given recent increases in phosphorus loads to the bay from these sources.

   Status - proposed
   Schedule - to be determined
   Cost - dependent on complexity of review process
   Funding - federal/state

4. The MDNR should initiate procedures for reviewing quality assurance/quality control of discharge monitoring results submitted by minor facilities in order to ensure accuracy of reporting.

   Status - proposed
   Schedule - to be determined
   Cost - dependent on complexity of review process
   Funding - federal/state

5. Parties responsible for seasonal sewage lagoon discharges should make sure they contact MDNR district staff prior to discharge, as required in their NPDES permit, to ascertain that flow rates of receiving waters are adequate to receive the discharge flow.

   Status - implemented
   Schedule - based on permit
   Cost - incidental to lagoon operation

6. Notwithstanding other reasonable options to reduce pollutant discharges, several local municipal wastewater treatment facilities need to be upgraded to meet effluent discharge requirements.

   Status - proposed
   Schedule - facility dependent
   Cost - undetermined
   Funding - local

7. The MDNR should verify that municipal Industrial Pretreatment Programs adequately address phosphorus reduction.

   Status - proposed
   Schedule - facility dependent
   Cost - undetermined
   Funding - local

8. Municipal and industrial dischargers with existing treatment facilities capable of discharging effluent with less than the 1.0 mg/l limit, should, where feasible, continue to be required to provide this improved level of treatment in order to maintain lower phosphorus discharge concentrations.

   Status - required under the Michigan phosphorus reduction strategy.
   Schedule - facility dependent
   Cost - undetermined
   Funding - local

9. The MDNR will require municipalities to develop and implement plans for the control of CSOs and urban storm water runoff, including the construction of retention structures to reduce combined sewer overflows during periods of heavy runoff.

   Status - partially implemented
   Schedule - facility dependent based on NPDES permit
   Cost - City of Saginaw

Construct Weiss Street retention basin	$20.4 million
Construct 14th Street retention basin	$10.4 million
Construct Emerson Street retention basin	$17.9 million
Construct Webber Street retention basin	$ 8.2 million
Construct Salt-Frazer Street retention basin	$12.7 million
Construct Fitzhugh Street retention basin	$ 5.9 million

   - City of Essexville

Increase retention basin capacity	$ 7.0 million

   Funding - local

10. The MDNR should continue to make all efforts possible to reissue expired NPDES permits for minor facilities in the basin.

Status - implemented
Schedule - ongoing
Cost - undetermined
Funding - state and federal

11. Minor basin codes in the U.S. EPA Permit Compliance System should be revised to reflect hydrological basin boundaries. Combine minor basins 2102 and 2103 to form the Eastern Coastal Basin of the Saginaw Bay watershed. Minor basin 2102 has several watersheds that should be moved to 2101 because they drain to Lake Huron directly and not to Saginaw Bay. Minor basin 2101 would be better named Huron-Sanilac Coastal minor basin, because it is the drainage basin for tributaries to Lake Huron from Huron and Sanilac counties. Minor basins 2105, 2106, and 2107 should be combined to form the Western Coastal Basin of the Saginaw Bay watershed.

Status - proposed
Schedule - to be determined
Cost - should be covered by PCS general operation funds
Funding - federal/state

12. Minor basin 2104030 - Saginaw River, in the U.S. EPA Permit Compliance System should be further divided into its four main tributaries the Cass River, Flint River, Shiawassee River, and Tittabawassee River. Facilities in the Saginaw River basin should be encoded down to this level. The FHBC code is an 8 digit code which might be used to divide the Saginaw River basin into its four tributaries.

Status - proposed
Schedule - to be determined
Cost - should be covered by PCS general operation funds
Funding - federal/state

13. The six digit basin codes for all facilities in minor basins 2102, 2103, 2104, 2105, 2106, and 2107 should be revised if the receiving waters are not hydrologically connected to the designated basin. This may mean the creation of additional six digit basin codes. For example, Akron-Fairgrove WWSL drains to Allen Drain a direct tributary to the Saginaw Bay, however, its six digit basin code places it in the Wiscoggin Creek drainage basin which is hydrologically incorrect. This is one instance where the creation of a six digit basin code designating the Allen Drain drainage basin would be appropriate based on hydrology.

Status - proposed
Schedule - to be determined
Cost - should be covered by PCS general operation funds
Funding - federal/state

14. All facilities should be georeferenced using latitude/longitude coordinates and encoded into PCS. This is very important in order to make the transition toward a Geographic Information System more feasible.

Status - proposed
Schedule - to be determined
Cost - undetermined
Funding - federal/state

Atmospheric Inputs

Atmospheric deposition is a documented source of large quantities of some pollutants to the Great Lakes. Little is known of actual deposition rates of contaminants to the Saginaw Bay watershed or how rates vary annually, seasonally or with wet weather events versus dry weather settling. This lack of data also hampers efforts to relate the magnitude of atmospheric inputs of contaminants to Saginaw Bay with inputs from point sources and terrestrial nonpoint sources.

1. The MDNR should monitor atmospheric deposition of nutrients to Saginaw Bay. Use of previously operated monitoring stations such as Tawas Point and Bayport, should be considered. The monitoring objective should be to identify, quantify and determine the deposition rates of each contaminant on an annual basis to determine loads and trends.

   Status - proposed
   Schedule - sufficient to determine annual loads and trends on a long-term basis.
   Cost - $100,000/year
   Funding - state and federal

2. The MDNR should make a concerted effort to reduce conventional pollutant emissions to the air through adherence to, and enforcement of, regulatory laws and policies.

   Status - Reauthorization of the federal Clean Air Act enabled Michigan to enact rule changes that allow for existing permits for stack air emissions to be reviewed and reissued on a regular basis.
   Schedule - ongoing
   Cost - unknown
   Funding- state and federal

3. The MDNR should assess the magnitude of potential non-stack sources of nutrients to the atmosphere, such as volatilization from wastewater treatment plants and wind erosion of cropland, as well as existing sources. These sources should be assessed in terms of their relative contributions to total pollutant loads to the atmosphere and subsequent deposition levels in order to determine if emission reductions are needed from these sources.

   Status - proposed
   Schedule -undetermined
   Cost - $100,000/year
   Funding - state and federal

4. The SCS, ASCS, Cooperative extension Service and MDNR should encourage the continued and expanded implementation of agricultural and construction site BMPs to reduce the amount of wind erosion from exposed soils in the Saginaw Bay basin. Additional efforts to reduce fugitive dust should be implemented.

   Status - ongoing, proposed for expansion.
   Schedule - continuous throughout project.
   Cost - additional BMP implementation costs discussed in the following terrestrial non-point sources section.

Terrestrial Nonpoint Sources

Recent data indicate that nonpoint sources contribute 85% of the phosphorus load to Saginaw Bay. Agriculture is the predominant land use activity in the Saginaw Bay drainage basin, and it is the largest single source of nutrient loads to the bay. But other nonpoint sources, including construction sites, lawns, highway surfaces, and urban runoff, are also contributors. The following actions need to be taken to determine the magnitude of current pollutant inputs from these sources, define the geographic areas with the largest loads, and implement best management practices. Additional discussion on recommendations relevant to soil erosion and sedimentation control can be found in Chapter VI.

1. The SBNWI should continue the Saginaw Bay National Watershed Initiative Program Advisory Committee (PAC). The PAC should help focus programs from different agencies on common goals and foster interagency cooperation.

   Status - ongoing
   Schedule - meetings as needed
   Cost - Incidental to agency operations
   Funding - federal/state

2. The SBNWI, through the PAC, should develop a nonpoint source management plan specific to the Saginaw Bay watershed that draws from existing nonpoint source management plans, such as the MDNR state strategy and the phosphorus reduction plan for Saginaw Bay. The plan should include the assessment and ranking of individual tributary watersheds from both monitoring data and modelling results in order to determine geographical areas with high loads and thereby prioritize areas for the allocation of limited funds.

   Status - proposed
   Schedule - ongoing once implemented
   Cost - dependent on detail of plan
   Funding - various through participating organizations

3. The SBNWI, through the PAC, should evaluate the hydrologic system of the basin to determine the potential benefits of returning some areas to the approximation of their natural state, or increasing regional retention in some areas, in order to reduce nonpoint source contaminant inputs to Saginaw Bay, including the following.

-- Areas with potential for reclaimed or artificial wetlands in river flood plains and along the bay shoreline.

-- Diked rivers and streams for potential broadening of existing floodways.

-- Tributary channels and floodways for enhancement of characteristics that moderate flood peaks and reduce sediment transport from source areas.

-- Agricultural drains that have been established along natural creek bottoms to determine the potential for reestablishing natural contours.

-- Areas with the potential for buffer strip development in riparian corridors along the bay or its tributaries. This would include the development, and adoption by local government units, of zoning ordinances designed to protect these areas from disturbance.

Furthermore, additional measurements on those watersheds where very few or no miscellaneous measurements have been made would increase the accuracy of flow stability estimates and enhance the above assessment.

Status - proposed
Schedule - ongoing once implemented
Cost - dependent on assessment effort
Funding - various through participating organizations

4. The SBNWI and organizations in the PAC should encourage the continued and expanded use of Best Management Practices (BMPs), such as conservation tillage of agricultural land, planting of windbreaks, use of cover crops, and streambank stabilization, to reduce sediment erosion.

Status - proposed
Schedule - ongoing
Cost - Undetermined amount of funds needed for nonpoint source information/education activities throughout the watershed.

5. Additional programs for the adoption of BMPs should be pursued at both the state and federal level in order to reduce nonpoint source contaminant inputs to Saginaw Bay. As one example, the SBNWI should pursue the development of a filter strip/greenbelt program to provide for streambank stabilization, riparian soil erosion control, and habitat corridors. As another, the ASCS should consider incorporating water quality practices in the Agricultural Conservation Program (ACP).

   Status - proposed
   Schedule - ongoing once implemented
   Cost - unknown
   Funding - federal/state

6. The SBNWI, through the PAC, should work with member organizations to develop and implement a comprehensive plan to educate agricultural producers on how to employ and confirm participation in currently available state and federal programs to reduce agricultural pollutant loads to Saginaw Bay, including the following:

   -- Section 319 Clean Water Act grants program
   -- Conservation Reserve Program
   -- Other conservation provisions of the Food Security Act of 1985
   -- Agricultural Conservation Program
   -- Wetland Reserve Program

   Status - proposed
   Schedule - ongoing once implemented
   Cost - dependent on degree of education effort
   Funding - various through participating organizations

7. The agencies that oversee the implementation of BMPs should conduct additional studies in the Saginaw Bay watershed to quantify the economic and environmental effectiveness of various BMPs in reducing nonpoint source pollutant loads to Saginaw Bay and its tributaries. This should include research on the potential of new BMPs such as sub-irrigation and artificial wetland creation.

   Status - proposed
   Schedule - as needed
   Cost - $500,000/year
   Funding - federal

8. Quantitative information on the off-site costs and impacts of soil erosion and sedimentation needs to be gathered. This should include development of linkages between erosion and the public costs incurred for clean up, sediment control, and dredging.

Status - proposed
Schedule - 2 years
Cost - undetermined
Funding - federal, state, local

9. The SBNWI, through the PAC, should oversee the implementation of subwatershed water and sediment monitoring to obtain data on the following:

-- impacts of episodic events to the load from a given tributary at different stages of crop development under different storm events and snowmelt conditions;

-- pollutant contribution from land uses other than agriculture present in predominantly agricultural watershed;

-- edge-of-field and tile flow nutrient and sediment loads for different crop and soil types under various storm event conditions; and

-- characterization of base flow conditions.

Status - proposed
Schedule - intermittent once implemented
Cost - $100,000/year
Funding - federal and state

10. The SBNWI, through the PAC, should oversee the development and implementation of cost-effective agricultural storm water management to slow storm water flows from agricultural lands, consistent with guidelines and procedures of the U.S. SCS Farm Conservation Plan and other similar documents, as appropriate. Storm water management should be conducted in such a way as to avoid impairing normal field drainage or crop development.

Status - proposed
Schedule - ongoing once implemented
Cost - $500,000/year
Funding - federal/state/local

11. Basin agricultural producers should follow Michigan State University fertilizer level recommendations.

Status - proposed
Schedule - ongoing once implemented
Cost - net savings to producers

12. Agricultural producers should follow the right-to-farm guidelines in the Right-to-Farm act.

Status - proposed
Schedule - ongoing once implemented
Cost - net savings to producers

13. Basin drain commissioners should expand their traditional roles dealing with water quantity to include water quality issues. Drainage projects should consider hydrologic impacts on instream and Saginaw Bay water quality, and utilize sound nonpoint source pollution abatement practices to reduce pollutant inputs to Saginaw Bay.

Status - proposed
Schedule - ongoing once implemented
Cost - dependent on water quality management practices used
Funding - local

14. A report should be prepared on drain maintenance best management practices used in the Saginaw Bay watershed, and their cost effectiveness and environmental soundness.

Status - proposed
Schedule - 1 year
Cost - $70,000
Funding - local

15. Drain maintenance histories should be summarized to determine the extent and type of drain maintenance performed on Saginaw Bay watershed drains.

Status - proposed
Schedule - 1 year
Cost - $40,000
Funding - local

16. The SBNWI, through the PAC, should undertake a study to determine the location of all designated county drains in the Saginaw Bay watershed and undertake an evaluation of which drains are of significant concern to the ecology of the watershed and should be provided greater protection than that presently provided under the state drain code.

Status - proposed
Schedule - 2 years
Cost - $200,000
Funding - federal/state/local

17. The MDNR should periodically determine the present load of phosphorus and suspended solids to Saginaw Bay by tributary in order to facilitate the watershed prioritization process.

Status - currently being done by Limno-Tech under contract to EPA as part of the NOAA Saginaw Bay zebra mussel project.
Schedule - To be completed by early 1995.
Cost - Subset of $185,000 project.
Funding - federal

18. All agencies dealing with land use or terrestrial environments adjacent to basin watercourses should take steps to identify and stabilize areas with streambank erosion.

Status - proposed
Schedule - ongoing once implemented
Cost - site specific
Funding - federal, state and local

19. A hydrology study is needed to determine the stability of stream banks in Saginaw Bay watershed tributaries. The study should examine the soil types susceptible to streambank erosion and compare with high and low flow rates to reveal those with potential for streambank erosion. It should also assess other relevant information such as the actual presence of streams within each geographic class, and the type of land cover that exists on the stream bank.

Status - proposed
Schedule - 2 years
Cost - specific to project scope and detail
Funding - federal, state and local

20. Additional information is needed on quantifying sediment delivery from wind erosion to determine the extent of the problem relative to water erosion and water quality problems.

Status - proposed
Schedule - unspecified
Cost - undetermined
Funding - federal, state and local

21. A USDA 1987 study identified the need for promotion and adoption of conservation tillage, wind barriers, and conservation cropping systems on 617,400 acres (only 14 of the 22 Saginaw Bay counties were included in the study).

Status - proposed
Schedule - 6 years
Cost - approximately $21 million (413 SCS staff-years)
Funding - federal

22. The relationships between soil erosion and water quality goals need to be incorporated into the USDA SCS Universal Soil Loss Equation and into the USDA Agricultural Stabilization & Conservation Service (ASCS) ACP.

Status - proposed
Schedule - ongoing once implemented
Cost - undetermined
Funding - federal

23. In areas of high risk erosion, local communities should enact special zoning regulations or other types of land use controls, and restrict development on these areas.

Status - proposed
Schedule - ongoing once implemented
Cost - community specific
Funding - local

24. Improve the current Soil Erosion and Sedimentation Control Act (Act 347 of 1972), by providing the necessary staff personnel to provide adequate program management.

Status - proposed
Schedule - ongoing once implemented
Cost - undetermined
Funding - federal/state/local

25. NOAA, MDNR and CIESINS should and implement a process for summarizing precipitation and other weather related data from throughout the Saginaw Bay watershed.

Status - proposed
Schedule - yearly
Cost - undetermined
Funding - federal/state

26. The Saginaw Bay small watershed prioritization information should be taken out to local field agency offices and discussed in order to arrive at some consensus on what nonpoint source pollutant sources are most critical to address in the various watersheds.

Status - proposed
Schedule - 1 year
Cost - undetermined
Funding - federal/state/local

27. The field agency survey conducted as part of the small watershed prioritization process indicated that additional training of local agency staff on how to assess nonpoint source impacts is essential to improving future survey efforts. Once this has been done, a follow up survey should be conducted, which is statistically valid and provides adequate field verified support for ratings in conjunction with best professional judgment.

Status - proposed
Schedule - 3 years
Cost - undetermined
Funding - federal/state/local

28. Criteria and layout for the Saginaw Bay watershed Nonpoint Source Field Investigation Form should be finalized and a database developed to input data and generate results in an informative, user friendly report. Additionally, training should be instituted for volunteers in order to expand watershed survey efforts.

Status - proposed
Schedule - 1 year
Cost - undetermined
Funding - federal/state/local

29. A method for roughly determining the percent contribution from various nonpoint sources of pollution in individual small watersheds should be developed.

Status - proposed
Schedule - 1 year
Cost - undetermined
Funding - federal/state/local

Aquatic Sediments

Nutrients

Bottom sediments in portions of rivers throughout the watershed, and in Saginaw Bay, have elevated levels of nutrients. These sediments can act as a source of nutrients contributing to excessive biological productivity in aquatic ecosystems. In rivers, the major concern is the downstream transport of nutrients to areas, including Saginaw Bay, where nutrient enrichment problems are manifested. In Saginaw Bay, the major issue has been the contribution of resuspended nutrients to eutrophication problems in the bay. However, colonization of the bay by zebra mussels may make elevated nutrient concentrations in stationary bottom sediments an issue because of the increasing biomass in the benthic component of the food web, particularly the growth of rooted aquatic macrophytes.

Particulates

Sediment particles themselves can also be detrimental to aquatic ecosystems by silting over fish spawning areas, limiting light penetration, interfering with fish respiration, creating unstable bottom substrates, destroying habitat, decreasing water depth, increasing water temperatures, increasing flow velocities, and requiring maintenance dredging of navigation areas.

Toxics

During 1988-1994, extensive sediment sampling and analysis for toxic contaminants was done in the Saginaw River by the MDNR and EPA, and Saginaw Bay by the MDNR. These studies were described earlier in Part III: Actions Implemented Since 1988. The results of these studies (MDNR Act 307 Site Assessment; U.S. EPA Assessment and Remediation of Contaminated Sediments (ARCS)) were not available for review by the Contaminated Sediments Technical Advisory Committee (TAC) for inclusion in this report. However, it is anticipated that during the next year the information will become available for review and the Contaminated Sediments TAC will report on the significant findings and will make recommendations regarding contaminated sediments in the Saginaw River and Saginaw Bay for the next biennial RAP report.

Furthermore, substantial additional sediment assessment work is expected to take place over the next several years in conjunction with the Saginaw River and Saginaw Bay natural resource damage suit filed by the State of Michigan under Act 307 in June 1994, against several potentially responsible parties.

For these reasons, the specific sediment recommendations that follow deal only with nutrient and particulate issues.

1. The U.S. EPA or NOAA should study the frequency of occurrence, seasonal distribution, duration, geographic distribution and magnitude of sediment resuspension events in Saginaw Bay and the bioavailability of resuspended nutrients.

   Status - proposed
   Schedule - undetermined
   Cost - $250,000
   Funding - federal

2. When it is necessary to conduct maintenance dredging of navigation channels or drains, dredging should be conducted using methods to reduce to the maximum extent practical the resuspension of sediment material. When upland disposal of dredged spoils is used, the material should be placed, stabilized, or confined in a manner that reduces the potential for erosion of the dredged material.

   Status - proposed
   Schedule - ongoing once implemented
   Cost - site specific
   Funding - federal and local

3. Drain commissioners should expand, to the maximum extent practical, the use of environmentally sound techniques in the maintenance of drains. This would include giving consideration to typical stream hydrology such as maintaining or establishing a riffle-pool flow pattern and stream meanders. Better efforts need to be made to minimize the disturbance of vegetated stream banks.

   Status - proposed
   Schedule - ongoing once implemented
   Cost - site specific
   Funding - federal and local

F. POLLUTANT EFFECTS

Water

Conventional and nutrient parameters in Saginaw Bay and the watershed are at levels below those that would cause concern for public drinking water supplies or body contact recreation. However, nutrient levels are high enough to promote excessive biological productivity, which creates or contributes to numerous environmental impairments.

Water is a major transportation medium for the movement of contaminant materials in the Saginaw Bay system as well as an exposure route of contaminants to aquatic biota. It is often the medium where pollutant problems are first detected and can be used to locate the source of contaminant materials. Accordingly, several water monitoring actions are described to track water quality trends in Saginaw Bay and its tributaries, determine present concentration levels, and identify source areas.

1. The MDNR should periodically monitor nutrients and conventional parameters in all 28 tributaries to Saginaw Bay and six stations in the Saginaw River system (to include one station at the mouth of each tributary to the Saginaw -- Cass, Flint, Shiawassee and Tittabawassee -- and an upstream and downstream station on the Saginaw) to track water quality trends and determine relative assessments of water quality and pollutant loads among tributaries. This monitoring should be implemented for a 3-year period beginning in 2001, followed by approximately seven years of no monitoring, and then another three years of monitoring beginning in 2011. Monitoring should be done periodically throughout the year and cover high flow, low flow, and event conditions with flow measured throughout the year.

   Status - was conducted in 1991 and 1992, and partially implemented in 1993. Proposed for 2001-2003 and 2011-2013.
   Schedule - as described above.
   Cost - $750,000/3-year period
   Funding - state or federal

2. The MDNR, MDA, and SCS should develop a comprehensive nonpoint source water monitoring program for the Saginaw Bay watershed to: supplement the long-term trend monitoring program described above, provide site-specific data on selected watersheds as needed, and fill identified data gaps.

Status - proposed
Schedule - as needed.
Cost - $200,000/yr
Funding - federal/state

3. The U.S. EPA or NOAA should collect monthly water samples during the open water season at a minimum of 28 open water Saginaw Bay stations (those used during 1991-1992 in the NOAA Saginaw Bay zebra mussel project) to track bay water quality and parameter trends. As with the tributary monitoring, this bay monitoring should be implemented for a 3-year period beginning in 2001, followed by approximately seven years of no monitoring, and then another three years of monitoring beginning in 2011.

Status - was implemented in 1991-1992, and partially implemented (12 stations) in 1993-1994. Proposed for 2001-2003 and 2011-2013.
Schedule - as described above
Cost - $900,000/3-year period
Funding - federal

4. The EPA should periodically develop a current nutrient budget for Saginaw Bay to determine if phosphorus load reductions obtained under the Michigan phosphorus reduction strategy for Saginaw Bay have achieved the desired water quality results, or if further reductions are needed. This modeling should be conducted on a schedule to draw on the tributary and bay monitoring described above. Accordingly, modeling is proposed to be conducted in 2005-2006 for 2001-2003 data set, and in 2015-2016 for 2011-2013 data set.

Status - currently being done by Limno-Tech under contract to EPA for 1991 (and perhaps 1992) as part of the NOAA Saginaw Bay zebra mussel project. Proposed for 2005-2006 and 2011-2013.
Schedule - 1991 data to be completed by early 1995. Subsequent efforts as described above.
Cost - $250,000 per monitoring period.
Funding - federal

5. If further phosphorus load reductions to Saginaw Bay are needed, the EPA should determine the magnitude of reduction needed and the MDNR should determine what sources (type and watersheds) should be addressed.

Status - Currently being done by Limno-Tech under contract to EPA as part of the NOAA Saginaw Bay zebra mussel project. Proposed for future monitoring efforts.
Schedule - Current effort to be completed by early 1995. Subsequent efforts same schedule as modeling project.
Cost - Included in modeling effort.
Funding - federal

6. On the years in which tributary monitoring described in item one above is scheduled, the USGS should add a minimum of five flow gaging stations in the Saginaw Bay watershed and run the Saginaw River flow model annually, to track flow conditions and help quantify annual pollutant loads. Two stations should be established in each coastal basin and one at the mouth of the Saginaw River. The west coastal basin sites proposed are either new or reestablished stations on the Au Gres and Kawkawlin rivers. The Columbia Drain gaging station should be reestablished as one of the two east coastal basin sites.

Status - proposed
Schedule - 2001-2003 and 2011-2013
Cost - \$60,000/year (approx \$5,000/gage for establishment and \$11,000/year for operation)
Funding - federal/state/local

7. The MDNR, through the SBNWI, should pursue the development of a geographic mapping database of water quality values for Saginaw Bay and its tributaries that would be available for present and future reference to facilitate data analysis.

Status - had been begun as the GLIS component of MIRIS, but was discontinued.
Schedule - ongoing once implemented.
Cost - dependent on amount of data entered.
Funding - state or federal

8. Watersheds for which data does not now exist should be evaluated to determine if they are suspected of having water quality problems. If they are, the MDNR should made to conduct some monitoring on these watersheds and add the evaluation of results to the Saginaw Bay small watershed prioritization database.

Status - partially implemented
Schedule - based on MDNR 5-year basin survey schedule
Cost - dependent on level of effort
Funding - federal/state

9. Specific locations of interest in the Saginaw Bay watershed should be selected for continuous monitoring of certain parameters that can vary substantially over a 24-hr or several day period, such as dissolved oxygen, temperature, pH and conductivity, to determine the true range of measurement variation. This is often the only way to detect diurnal oxygen sags and temperature changes, as well as maximum and minimum levels during and following storm events.

Status - proposed
Schedule - site and parameter specific
Cost - dependent on level of effort
Funding - federal/state/local

Biota

The status of the biological community is the endpoint to which much of this RAP document is addressed. Monitoring of biological populations at various trophic levels is required to (1) track and identify geographic areas where problems exist, (2) define the magnitude of identified problems, (3) monitor the effectiveness of remedial actions, and (4) assess progress toward watershed goals.

1. The U.S. EPA or NOAA should collect monthly phytoplankton and zooplankton samples during the open water season at a minimum of 28 open water Saginaw Bay stations (those used during 1991-1992 in the NOAA Saginaw Bay zebra mussel project) to evaluate the bay community structure and track historical trends, which indicate improvement or degradation of bay water quality. This plankton monitoring should be conducted concurrently with the bay water monitoring described earlier. It is therefore proposed for a 3-year period beginning in 2001, followed by approximately seven years of no monitoring, and then another three years of monitoring beginning in 2011.

    Status - was implemented in 1991-1992, and partially implemented (12 stations) in 1993-1994. Proposed for 2001-2003 and 2011-2013.
    Schedule - as described above
    Cost - $600,000/3-year period assuming samples collected concurrently with water samples, otherwise $900,000/3-yr period.
    Funding - federal

2. The MDNR, U.S. EPA or NOAA should sample the Saginaw Bay benthic macroinvertebrate community seasonally approximately once every five years, to evaluate the benthic community structure and track historical trends.

    Status - implemented by NOAA for 1991-1994, proposed for future sampling.
    Schedule - proposed for 1996, 2001 and 2006
    Cost - $200,000/year
    Funding - federal or state

3. The MDNR should sample the benthic macroinvertebrate community at the mouths of tributaries to Saginaw Bay once every five years to determine which tributaries carry pollutant loads in sufficient quantity to impair the benthic community.

Status - implemented
Schedule - once every 5 years
Cost - $50,000/year
Funding - state

4. NOAA should monitor bay currents, macrophyte growth and plankton populations through the use of satellite photos or other remote sensing imagery to document the present distribution pattern and track trends.

Status - proposed
Schedule - as needed
Cost - dependent on methods used
Funding - federal

5. The MDNR should visually survey watershed rivers during summer months and identify areas where nutrient enrichment problems are manifested (e.g. profuse macrophyte growth, nuisance algae blooms).

Status - partially implemented as part of MDNR biological surveys. Increased effort proposed.
Schedule - as needed
Cost - $60,000
Funding - state

6. The MDNR should periodically monitor fish fry production in Saginaw Bay weekly including temporal distribution, food habits, and temporal/spatial availability of fry prey in order to assess the importance of various habitat areas, and to determine the impacts of eutrophication and zebra mussel colonization. It would be most appropriate to do this over the same 3-year periods (2001-2003, 2011-2013) described above during which phytoplankton and zooplankton are collected.

Status - some monthly samples collected in 1991-1993, but funding needed for sample analysis. Proposed weekly for 2001-2003 and 2011-2013.
Schedule - as described above
Cost - $250,000/3-year period
Funding - federal/state

7. The MDNR should periodically conduct intensive monthly trawl and gill net surveys in Saginaw Bay to supplement annual fall surveys of species abundance. The intensive studies would assess changes in the temporal distribution, food habits, growth, mortality, biomass and abundance of juvenile and adult fish populations in order to assess the importance of various habitat areas, and to determine the impacts of eutrophication and zebra mussel colonization. It would be most appropriate to do this over the same 3-year periods (2001-2003, 2011-2013) described above during which larval fish are collected.

Status - some samples collected in 1991-1993, but funding needed for sample analysis. Proposed for 2001-2003 and 2011-2013.
Schedule - as described above
Cost - $90,000/3-year period assuming samples collected concurrently with water samples, otherwise $250,000/3-yr period.
Funding - federal/state

8. The MDNR should assess natural recruitment rates for walleye by conducting alternate year stocking of walleye with other suitable sport fish.

Status - ongoing
Schedule - 1993-1998 (no walleye stocking in 93, 95 or 97)
Cost - Incidental to stocking operations
Funding - federal/state

9. The MDNR should conduct biological surveys on the 17 watershed management units for which no information was available for the Saginaw Bay small watershed prioritization process. Furthermore, the variability within each watershed assessed for the watershed prioritization process should be evaluated more fully to be certain the overall assessment is representative of the conditions in each watershed.

Status - partially implemented as part of ongoing MDNR biological survey efforts.
Schedule - complete within one 5-year basin survey period
Cost - undetermined
Funding - state

G. HABITAT

The loss, fragmentation and degradation of habitat throughout the Saginaw Bay watershed and in Saginaw Bay, negatively impacts the quality of life for basin residents as well as aquatic life and wildlife. As described in Chapter VIII, habitat loss and degradation results in the reduction of economic, recreational and aesthetic resources as well as a potential loss of biodiversity. Furthermore, many habitats not only provide important breeding, nesting, nursery, feeding and shelter areas, but protect the environmental quality of aquatic and terrestrial ecosystems as well.

Chapter VIII described the extensive loss and degradation of habitat that has occurred in the Saginaw Bay watershed. Most of the actions needed are related to the protection, enhancement and restoration of habitat. This includes control of pollutant inputs and soil erosion as well as physical disturbance. A general discussion on several of these recommendations can be found in Chapter VIII, specific recommendations follow.

1. Implement wherever and whenever feasible, actions to bring about the following conditions (summarized from Table 3 in Chapter VIII) for each of four land use categories.

In coastal areas:	maintain or increase presettlement vegetation types; increase linkages among habitats; maintain or increase land in wetland state to support biota; increase wetland acreage; protect and inventory threatened and endangered species.
In forested areas:	maintain quality headwaters; protect headwaters at road crossings; increase soil stabilization, particularly at road crossings; maintain or increase presettlement vegetation; maintain flow regimes; in logging areas, implement water quality BMPs; implement ecosystem forest management to support biota; maintain floodplains; increase wetland acreage; protect and inventory threatened and endangered species.
In urban areas:	control storm water runoff for flow and water quality benefits; enhance habitat linkages in river corridors; enhance habitat linkages with park planning; increase wetland acreage;

In agricultural areas: protect and buffer headwaters;
increase soil stabilization to protect water quality;
protect areas near rivers and drains;
increase wetland and floodplain areas to stabilize flow regimes;
prevent pesticide and fertilizer runoff;
increase habitat linkages;
increase floodplains by moving dikes back from rivers;
increase wetland acreage, especially adjacent to streams/drains.

Status - proposed
Schedule - as needed
Cost - dependent on areal extent and methods used
Funding - federal, state, local

2. Implement actions to protect coastal areas.

Status - proposed
Schedule - as needed
Cost - dependent on areal extent and methods used
Funding - federal, state, local

3. Implement actions to protect and improve areas with threatened and endangered species.

Status - proposed
Schedule - as needed
Cost - dependent on areal extent and methods used
Funding - federal, state, local

4. Develop a map of current land use in a GIS system.

Status - proposed
Schedule - 2 years
Cost - undetermined
Funding - federal, state, local

5. Implement the actions identified in the Saginaw Bay Strategy for Wetland Restoration discussed in Chapter VIII.

Status - proposed
Schedule - ongoing
Cost - undetermined
Funding - federal, state, local

APPENDIX ONE: PARTICIPANTS

Several formal committees were established under the Saginaw Bay National Watershed Initiative program and utilized for the development of this RAP. Each committee consisted of a diverse range of participants (listed on the following pages) from local, state and federal agencies, local government, industry, agriculture, and public organizations.

The Program Advisory Committee was the principal committee used to provide broad-based input and direction to the Initiative, and to facilitate the development of cooperative long-term strategies for the restoration and protection of the Saginaw Bay watershed. To assist with these tasks, the Program Advisory Committee established four Technical Advisory Committees (TACs). Each TAC addressed one of four specific topic areas: Water Quality, Soil Erosion and Sedimentation, Contaminated Sediments, and Habitat. Specific charges to the TACs were discussed earlier in the Introduction. The work products of the TACs comprise the bulk of this RAP document.

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APPENDIX TWO

HISTORY OF SAGINAW RIVER/BAY RAP PROGRAM

A. BACKGROUND

1. History of Area of Concern Designations

The Great Lakes are a unique natural resource containing 20% of the world's surface fresh water. These waters also form a portion of the international boundary between the United States and Canada and both countries have jurisdiction over their use. To protect this vast resource and cooperatively address problems along their common border, the U.S. and Canada interact through an agency known as the International Joint Commission (IJC).

The IJC was established by the U.S. and Canada as a result of the Boundary Waters Treaty of 1909, which set forth the rights and obligations of both countries regarding common boundary waters. The responsibilities of the IJC, as identified in the Boundary Waters Treaty, include collecting, analyzing and disseminating data, and tendering recommendations to the U.S. and Canadian governments regarding water quality problems in the boundary waters.

As early as 1912, the U.S. and Canadian governments asked the IJC to investigate the extent and causes of pollution in the Great Lakes. The initial concern was with areas such as the St. Marys, St. Clair and Detroit rivers, which were polluted with raw sewage. This pollution resulted in nearby human populations contracting waterborne diseases like typhoid fever and cholera. Subsequent pollution control efforts and drinking water purification eventually led to the elimination of waterborne disease epidemics in the Great Lakes basin.

With the passage of time, other problems became evident, particularly cultural eutrophication. Cultural eutrophication is the accelerated enrichment of natural waters with plant nutrients. Associated problems are nuisance levels of blue-green algae and macrophytes, changes in aquatic community species composition, turbidity, aesthetic degradation, filter clogging and taste and odor problems in water supplies, and oxygen depletion in lake waters. Concern for cultural eutrophication in certain areas of the Great Lakes led to the signing of the first Great Lakes Water Quality Agreement (GLWQA) by the U.S. and Canadian governments in 1972. This agreement affirmed both countries' determination to restore and enhance Great Lakes water quality, and established objectives and criteria for the Great Lakes system. The primary focus was on controlling phosphorus inputs to abate cultural eutrophication problems.

Since 1973, in its annual and biennial reports on Great Lakes water quality, the IJC Water Quality Board (WQB) has identified specific areas throughout the Great Lakes basin that have serious water pollution problems. These areas are principally near coastal urban centers and generally consist of harbors, bays and river mouths. In 1973, the IJC called them "Problem Areas" and defined them as geographical locations in the boundary waters where one or more of the general or specific water quality objectives in the 1972 GLWQA or jurisdictional standards or criteria were not being met. These areas varied in geographic scope, problem complexity, and severity.

In 1974, the WQB (made up of representatives from state and federal agencies of both countries) identified 69 Problem Areas. In 1975, the WQB described the water quality conditions, significant dischargers, and pollution control efforts for a modified list of 63 Problem Areas. During the following years, many of the problems in these areas were resolved through the implementation of water quality standards, effluent discharge regulations, industrial pretreatment programs, more environmentally sound land use practices -- particularly agricultural best management practices -- and the construction and upgrading of wastewater treatment plants. Because of the improvements produced by these programs, and the identification of new concerns, there have been many deletions from, and additions to, the original list of Problem Areas.

Based on several years of data and experience with the initial agreement, a new GLWQA was signed in 1978, which recognized the need to understand and effectively reduce toxic substance loads the Great Lakes. The 1978 agreement adopted both general and specific objectives, and outlined programs and practices necessary to reduce pollutant discharges to the Great Lakes system to the maximum extent possible.

In 1981, the IJC Water Quality Board determined that there were deficiencies in the Problem Area approach. One, it lacked consistency in problem identification and assessment, and two, it usually relied on water quality indications alone. In order to increase consistency with the 1978 GLWQA and provide an ecosystem perspective, the WQB decided to rename the Problem Areas as "Areas of Concern" (AOCs). The name change reflected a shift in the problem perspective from limited water quality issues to a broader approach based on environmental quality data for water, sediments and biota, and an attempt to evaluate the areas with uniform criteria. An AOC was defined by the WQB as an area where a known impairment of a beneficial water use existed.

The 1981 WQB report listed 39 AOCs that were divided into two classes based on consideration of which GLWQA objectives or jurisdictional values were being exceeded; the concentration, persistence, and toxicity of contaminants found; the geographic extent of the area affected; which uses were impacted; whether the pollutants that exceeded criteria were related to current discharges; whether there were any transboundary implications; and professional judgement. Class "A" areas were those that exhibited significant environmental degradation -- where impairment of beneficial uses was deemed to be severe. Class "B" areas were those exhibiting environmental degradation where uses may be impaired. Eighteen Class A and 21 Class B AOCs were identified and reported in 1981.

In the 1985 Water Quality Board Report on Great Lakes Water Quality (IJC, 1985), yet another change in the AOC categorization approach was presented to overcome difficulties in determining whether an area should be designated as Class A or Class B due to how various issues/impacts were interpreted. The two class system was dropped, thereby eliminating attempts to distinguish different levels of problem severity among AOCs. Now, an AOC was classified into one of six categories based on a sequence for problem solving and resolution. The categories identified the status of the data base, programs underway to fill data gaps, and remedial actions taken to address the identified problems. The 1985 list included the previous 39 areas plus three new AOCs, increasing the total to 42. Presque Isle Bay, on Lake Erie, was designated as an AOC in 1991, bringing the current number of AOCs to 43 (Figure 2-1).

2. RAP Process

In 1985, the jurisdictions and the IJC acknowledged that more detailed, site-specific guidance was needed to resolve the persistent pollution problems that remained in most of the AOCs. Therefore, the eight Great Lakes states and the Canadian province of Ontario agreed to develop Remedial Action Plans (RAPs) for AOCs within their jurisdictional boundaries. At that time, RAPs were viewed by the IJC, federal, state and provincial governments as cleanup plans to address known environmental problems and restore beneficial uses in the AOCs.

The WQB's 1985 Report on Great Lakes Water Quality outlined general guidance on the contents of a RAP and listed 42 AOCs (as originally identified by the Great Lakes jurisdictions) for which RAPs would be developed. The 1985 report also identified the environmental problems to be addressed in each RAP. The problem definitions were very broad and vague (e.g. "impacted biota", "toxic organic substances"), and very little guidance was provided in terms of the expected scope for describing and addressing these problems in a RAP. In response to the 1985 WQB report, the U.S. Environmental Protection Agency (EPA) Great Lakes National Program Office (GLNPO) developed a guidance document for preparing U.S. RAPs. This document was fairly detailed and provided a relatively clear description of the expected contents of a RAP, with water quality considerations clearly being the major focus.

In 1987, the United States and Canada formally agreed to develop and implement RAPs when the two federal governments signed the Protocol amending the 1978 GLWQA. The amendments strengthened certain aspects of the agreement, particularly with regard to toxic substances, and further clarified some parts by adding specific programs, activities and timetables. Additionally, they provided for greater incorporation of an ecosystem approach to water quality management. Annex 2 of the amended agreement mandates that the federal governments cooperate with the state and provincial governments to ensure that RAPs are developed and implemented for the AOCs. The RAPs are to serve as an important step toward virtual elimination of persistent toxic substances and toward restoring and maintaining the chemical, physical and biological integrity of the Great Lakes system.

Lake Superior

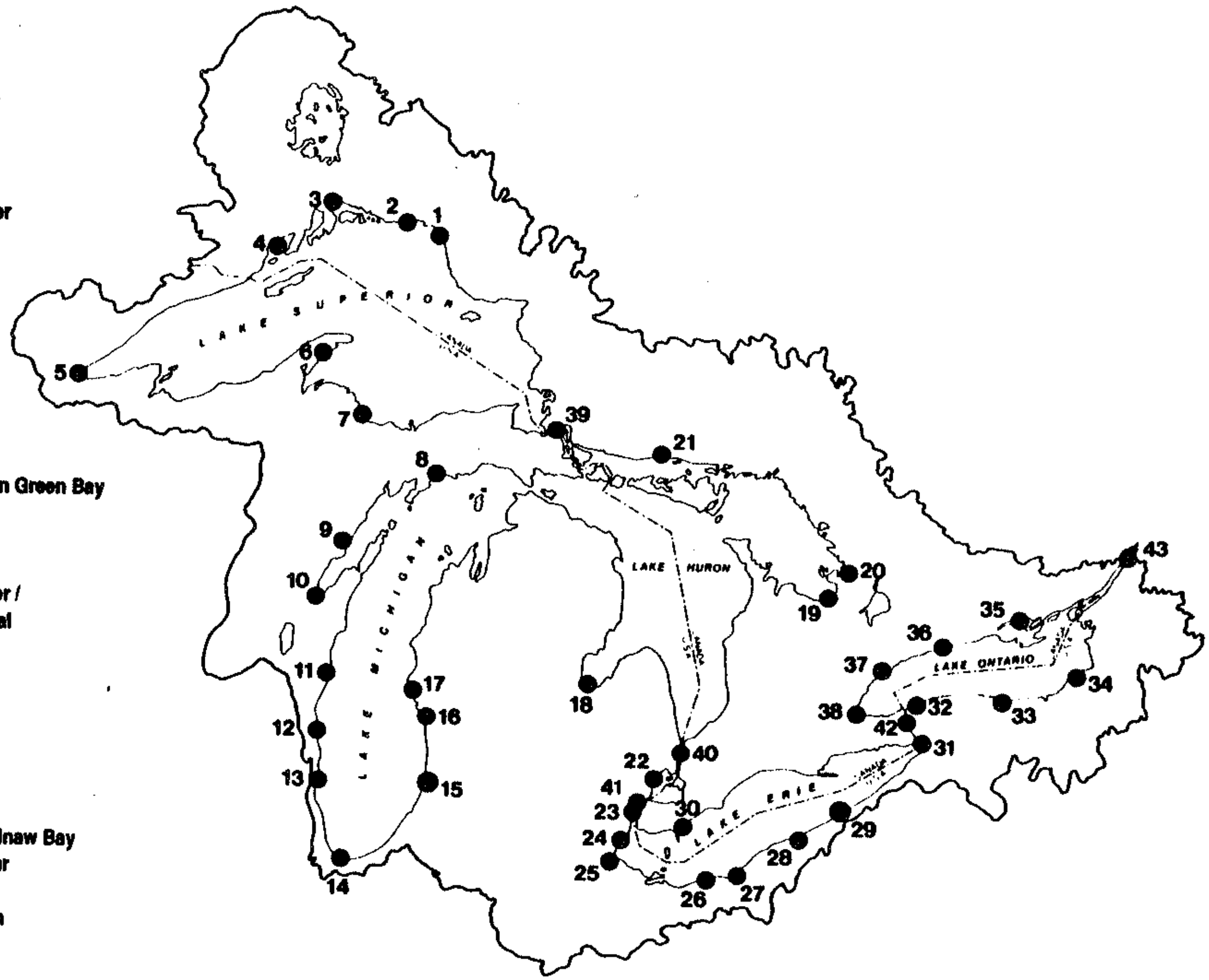
1 Peninsula Harbour
2 Jackfish Bay
3 Nipigon Bay
4 Thunder Bay
5 St. Louis Bay / River
6 Torch Lake
7 Deer Lake - Carp Creek / River

Lake Michigan

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

Lake Huron

18 Saginaw River / Saginaw Bay
19 Collingwood Harbour
20 Severn Sound
21 Spanish River Mouth



Lake Erie

22 Clinton River
23 Rouge River
24 River Raisin
25 Maumee River
26 Black River
27 Cuyahoga River
28 Ashtabula River
29 Presque Isle Bay
30 Wheatley Harbour

Lake Ontario

31 Buffalo River
32 Eighteen Mile Creek
33 Rochester Embayment
34 Oswego River
35 Bay of Quinte
36 Port Hope
37 Metro Toronto
38 Hamilton Harbour

Connecting Channels

39 St. Marys River
40 St. Clair River
41 Detroit River
42 Niagara River
43 St. Lawrence River (Cornwall / Massena)

Figure 2-1. Areas of Concern in the Great Lakes Basin.

An AOC is defined in Annex 2 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". Impairment of beneficial use is defined as a change in the chemical, physical or biological integrity of the Great Lakes System sufficient to cause any of the following:

1) Restrictions on fish and wildlife consumption;
2) Tainting of fish and wildlife flavor;
3) Degradation of fish and wildlife populations;
4) Fish tumors or other deformities;
5) Bird or animal deformities or reproductive 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 closing;
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.

In 1988, the WQB developed additional guidance for the parties to the GLWQA (the federal governments of the U.S. and Canada) and the jurisdictions (the Great Lakes states and provinces) to identify AOCs and impaired beneficial uses. The Listing/Delisting Criteria for Great Lakes AOCs (Table 2) identifies specific types of geographic areas that are eligible to be AOCs, and establishes listing and delisting criteria for each of the 14 beneficial uses. Since some of the criteria are subjective, good judgement must be used when listing AOCs and identifying impaired uses. When making such decisions, it is important that the overall goal of the AOC program -- to resolve specific problems that affect the Great Lakes -- be used as a guide.

Annex 2 of also identifies what should be included in each RAP, and specifies that the RAP be submitted to the IJC for review and comment at three stages. The three stages and the contents of the RAP at each stage are defined in the GLWQA as follows.

Stage 1 - This portion of the RAP will include (1) a definition and detailed description of the environmental problem in the AOC, including a definition of the beneficial uses that are impaired, the degree of impairment and the geographical extent of the impairment; and (2) a definition of the causes of the use impairment, including a description of all known sources of pollutants involved and an evaluation of other possible sources.

TABLE 2. GUIDELINES FOR RECOMMENDING THE LISTING AND DELISTING OF GREAT LAKES AREAS OF CONCERN

USE IMPAIRMENT	LISTING GUIDELINE	DELISTING GUIDELINE	RATIONALE
RESTRICTIONS ON FISH AND WILDLIFE CONSUMPTION	When contaminant levels in fish or wildlife populations exceed current standards, objectives or guidelines, or public health advisories are in effect for human consumption of fish or wildlife. Contaminant levels in fish and wildlife must be due to contaminant input from the watershed.	When contaminant levels in fish and wildlife populations do not exceed current standards, objectives or guidelines, and no public health advisories are in effect for human consumption of fish or wildlife. Contaminant levels in fish and wildlife must be due to contaminant input from the watershed.	Accounts for jurisdictional and federal standards; emphasizes local watershed sources.
TAINTING OF FISH AND WILDLIFE FLAVOR	When ambient water quality standards, objectives, or guidelines for the anthropogenic substance(s) known to cause tainting are being exceeded or survey results have identified tainting of fish or wildlife flavor.	When survey results confirm no tainting of fish or wildlife flavor.	Sensitive to ambient water quality standards for tainting substances; emphasizes survey results.
DEGRADED FISH AND WILDLIFE POPULATIONS	When fish and wildlife management programs have identified degraded fish or wildlife populations due to a cause within the watershed. In addition, this use will be considered impaired when relevant, field-validated, fish or wildlife bioassays with appropriate quality assurance/quality controls confirm significant toxicity from water column or sediment contaminants.	When environmental conditions support healthy, self-sustaining communities of desired fish and wildlife at predetermined levels of abundance that would be expected from the amount and quality of suitable physical, chemical and biological habitat present. An effort must be made to ensure that fish and wildlife objectives for Areas of Concern are consistent with Great Lakes ecosystem objectives and Great Lakes Fishery Commission fish community goals. Further, in the absence of community structure data, this use will be considered restored when fish and wildlife bioassays confirm no significant toxicity from water column or sediment contaminants.	Emphasizes fish and wildlife management program goals; consistent with GLWQA and Great Lakes Fishery Commission goals; accounts for toxicity bioassays.
FISH TUMORS OR OTHER DEFORMITIES	When the incidence rates of fish tumors or other deformities exceed rates at unimpacted control sites or when survey data confirm the presence of neoplastic or preneoplastic liver tumors in bullheads or suckers.	When the incidence rates of fish tumors or other deformities do not exceed rates at unimpacted control sites and when survey data confirm the absence of neoplastic or preneoplastic liver tumors in bullheads or suckers.	Consistent with expert opinion on tumors; acknowledges background incidence rates.

BIRD OR ANIMAL DEFORMITIES OR REPRODUCTIVE PROBLEMS	When wildlife survey data confirm the presence of deformities (e.g. cross-bill syndrome) or other reproductive problems (e.g. egg-shell thinning) in sentinel wildlife species.	When the incidence rates of deformities (e.g. cross-bill syndrome) or reproductive problems (e.g. egg-shell thinning) in sentinel wildlife species do not exceed background levels in inland control populations.	[illegible] through survey data; makes necessary control compar[illegible]
DEGRADATION OF BENTHOS	When the benthic macroinvertebrate community structure significantly diverges from unimpacted control sites of comparable physical and chemical characteristics. In addition, this use will be considered impaired when toxicity (as defined by relevant, field-validated bioassays with appropriate quality assurance/quality controls) of sediment-associated contaminants at a site is significantly higher than controls.	When the benthic macroinvertebrate community structure does not significantly diverge from unimpacted control sites of comparable physical and chemical characteristics. Further, in the absence of community structure data, this use will be considered restored when toxicity of sediment-associated contaminants is not significantly higher than controls.	Accounts for community structure and composition; recognizes sediment toxicity; uses appropriate control sites.
RESTRICTIONS ON DREDGING ACTIVITIES	When contaminants in sediments exceed standards, criteria or guidelines such that there are restrictions on dredging or disposal activities.	When contaminants in sediments do not exceed standards, criteria, or guidelines such that there are restrictions on dredging or disposal activities.	Accounts for jurisdictional and federal standards; emphasizes dredging and disposal activities.
EUTROPHICATION OR UNDESIRABLE ALGAE	When there are persistent water quality problems (e.g. dissolved oxygen depletion of bottom waters, nuisance algal blooms or accumulation, decreased water clarity, etc.) attributed to cultural eutrophication.	When there are no persistent water quality problems (e.g. dissolved oxygen depletion of bottom waters, nuisance algal blooms or accumulation, decreased water clarity, etc.) attributed to cultural eutrophication.	Consistent with Annex 3 of GLWQA; accounts for persistence of problems.
RESTRICTIONS ON DRINKING WATER CONSUMPTION OR TASTE AND ODOR PROBLEMS	When treated drinking water supplies are impacted to the extent that: 1) densities of disease-causing organisms or concentrations of hazardous or toxic chemicals or radioactive substances exceed human health standards, objectives or guidelines; 2) taste and odor problems are present; or 3) treatment needed to make raw water suitable for drinking is beyond the standard treatment used in comparable portions of the Great Lakes which are not degraded (i.e. settling, coagulation, disinfection).	For treated drinking water supplies: 1) when densities of disease-causing organisms or concentrations of hazardous or toxic chemicals or radioactive substances do not exceed human health objectives, standards or guidelines; 2) when taste and odor problems are absent; and 3) when treatment needed to make raw water suitable for drinking does not exceed the standard treatment used in comparable portions of the Great Lakes which are not degraded (i.e. settling, coagulation, disinfection).	Consistency with GLWQA; accounts for jurisdictional standards; practical; sensitive to increased cost as a measure of impairment.
BEACH CLOSINGS	When waters, which are commonly used for total-body contact or partial-body contact recreation, exceed standards, objectives or guidelines for such use.	When waters, which are commonly used for total-body contact or partial-body contact recreation, do not exceed standards, objectives or guidelines for such use.	Accounts for use of waters; sensitive to jurisdictional standards; addresses water contact recreation; consistent with GLWQA.

TABLE 2. GUIDELINES FOR RECOMMENDING THE LISTING AND DELISTING OF GREAT LAKES AREAS OF CONCERN
(cont'd)

USE IMPAIRMENT	LISTING GUIDELINE	DELISTING GUIDELINE	RATIONALE
DEGRADATION OF AESTHETICS	When any substance in water produces a persistent objectionable deposit, unnatural color or turbidity, or unnatural odor (e.g. oil slick, surface scum).	When the waters are devoid of any substance which produces a persistent objectionable deposit, unnatural color or turbidity, or unnatural odor (e.g. oil slick, surface scum).	Emphasizes aesthetics in water; accounts for persistence.
ADDED COSTS TO AGRICULTURE OR INDUSTRY	When there are additional costs required to treat the water prior to use for agricultural purposes (i.e. including, but not limited to, livestock watering, irrigation and crop-spraying) or industrial purposes (i.e. intended for commercial or industrial applications and noncontact food processing).	When there are no additional costs required to treat the water prior to use for agricultural purposes (i.e. including, but not limited to, livestock watering, irrigation and crop-spraying) and industrial purposes (i.e. intended for commercial or industrial applications and noncontact food processing).	Sensitive to increased cost and a measure of impairment.
DEGRADATION OF PHYTOPLANKTON AND ZOOPLANKTON POPULATIONS	When phytoplankton or zooplankton community structure significantly diverges from unimpacted control sites of comparable physical and chemical characteristics. In addition, this use will be considered impaired when relevant, field-validated, phytoplankton or zooplankton bioassays (e.g. Ceriodaphnia; algal fractionation bioassays) with appropriate quality assurance/quality controls confirm toxicity in ambient waters.	When phytoplankton and zooplankton community structure does not significantly diverge from unimpacted control sites of comparable physical and chemical characteristics. Further, in the absence of community structure data, this use will be considered restored when phytoplankton and zooplankton bioassays confirm no significant toxicity in ambient waters.	Accounts for community structure and composition; recognizes water column toxicity; uses appropriate control sites.
LOSS OF FISH AND WILDLIFE HABITAT	When fish and wildlife management goals have not been met as a result of loss of fish and wildlife habitat due to a perturbation in the physical, chemical or biological integrity of the Boundary Waters, including wetlands.	When the amount and quality of physical, chemical, and biological habitat required to meet fish and wildlife management goals has been achieved and protected.	Emphasizes fish and wildlife management program goals; emphasizes water component of Boundary Waters.

State 2 - This portion of the RAP will define the water use goals for the AOC and describe the remedial and regulatory measures selected to meet those goals. The Stage 2 RAP will include (1) an evaluation of remedial measures in place; (2) an evaluation of alternative additional measures to restore beneficial uses; (3) a selection of additional remedial measures to restore beneficial uses and a schedule for their implementation; and (4) an identification of the persons, agencies, or organizations responsible for implementation of the selected remedial measures. If some impaired beneficial uses cannot be restored, this stage must contain an explanation of why they cannot be restored.

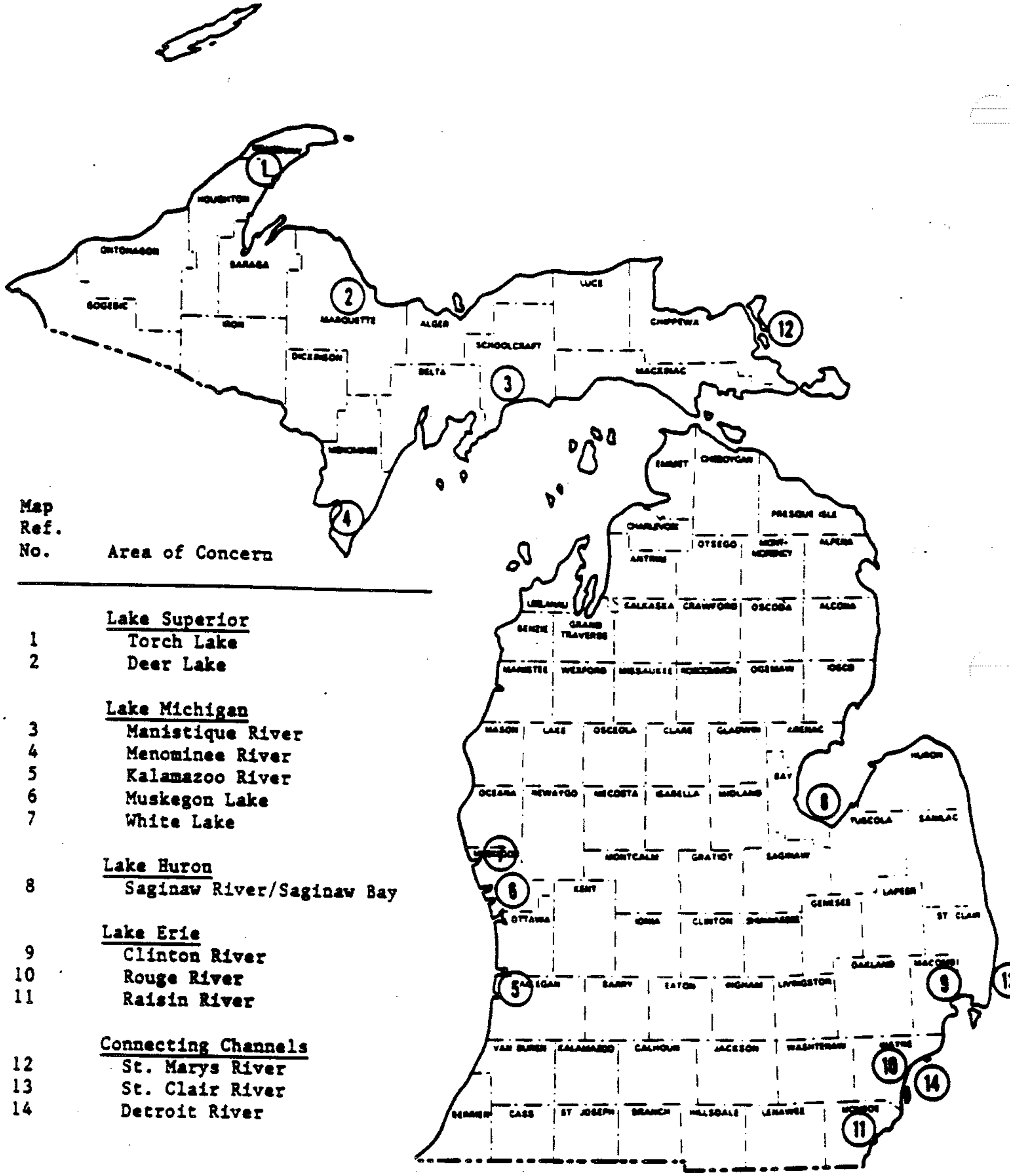
Stage 3 - This portion of the RAP will be submitted when identified impaired beneficial uses are restored. The Stage 3 RAP will include (1) a process for evaluation the implementation and effectiveness of remedial measures; and (2) a description of surveillance and monitoring processes to track the effectiveness of remedial measures and the eventual confirmation of the restoration of uses.

3. RAP Development in Michigan

The Michigan Department of Natural Resources (MDNR), Surface Water Quality Division (SWQD) accepted the lead responsibility in Michigan to develop and oversee the implementation of RAPs for the 14 AOCs within Michigan's political jurisdiction (Figure 1). Three AOCs (St. Marys, St. Clair and Detroit rivers) are shared with Ontario, and one AOC (Menominee River) is shared with Wisconsin. Consequently, responsibility for these RAPs is shared with the Ontario Ministry of the Environment (OMOE) and the Wisconsin Department of Natural Resources (WDNR), respectively. The MDNR initiated its AOC Program in 1986, and the SWQD committed significant resources to RAP development in an effort to continue progress toward resolution of environmental problems identified in the AOCs.

The MDNR began to develop RAPs, using the guidance provided by the U.S. EPA, GLNPO, and the IJC WQB in 1985, to address the environmental problems identified by the WQB in its 1985 report. Six RAPs (Muskegon Lake, White Lake, Deer Lake, Torch Lake, Manistique River and River Raisin) were completed and submitted to the IJC for review by October 1987. The RAPs for the **Saginaw River/Bay**, Rouge River, and Clinton River AOCs were substantially completed by this time, also following the 1985 guidance. By the time these nine RAPs were reviewed by the IJC in 1988, new criteria and guidance for developing RAPs had been established in the GLWQA, as amended in 1987, and by the IJC.

The RAPs developed under the 1985 guidance did not meet all the new requirements for Stage 1 RAPs outlined in the GLWQA or in the criteria established by the IJC. However, they did provide much additional information because the RAPs went beyond Stage 1 and included many components of Stage 2 and Stage 3 RAPs. They not only described the water quality



Map Ref. No.	Area of Concern
	Lake Superior
1	Torch Lake
2	Deer Lake
	Lake Michigan
3	Manistique River
4	Menominee River
5	Kalamazoo River
6	Muskegon Lake
7	White Lake
	Lake Huron
8	Saginaw River/Saginaw Bay
	Lake Erie
9	Clinton River
10	Rouge River
11	Raisin River
	Connecting Channels
12	St. Marys River
13	St. Clair River
14	Detroit River

FIGURE 1. GREAT LAKES AREAS OF CONCERN WITHIN MICHIGAN'S JURISDICTION

problems in the AOCs, but also provided recommendations for the next actions that needed to be taken to address the problems, which is a major component of Stage 2 RAPs.

Beginning in 1989, Michigan RAP documents were developed in the new stage format to better meet the formal guidelines and objectives for RAPs established in the revised GLWQA. In the following years, this process became very complex, time consuming and cumbersome as a result of incorporating the fragmented stage approach on one hand, while trying to comprehensively address all aspects within the broader multimedia, ecosystem context simultaneously. The diversity of problems and their severity, and the inability to resolve all the problems in the same time frame required a more flexible framework for reporting progress and identifying actions. Furthermore, the focus of the RAP process increasingly became the development of detailed, voluminous documents rather than identification and implementation of actions to address priority environmental issues in an AOC.

Accordingly, in November 1993, the MDNR embarked on a new approach to the Michigan RAP process that focuses on streamlining the RAP document, expediting its development and review, and increasing the focus on action in the AOCs. The unique nature of each RAP and the resulting need to maintain a very flexible process is inherent in the new process. The specific strategies for improving the efficiency and effectiveness of each Michigan RAP are as follows.

- Agree on a long-term "vision" and short-term goals/objectives.
- Prioritize environmental issues and focus RAP activities on the highest priorities first.
- Document the issues and actions in a series of biennial reports, each containing components of Stage 1, Stage 2, and Stage 3 RAPs as appropriate.
- Submit each biennial report to the EPA and IJC.
- Within the MDNR, delegate the responsibility and the authority to "approve" the RAP (biennial reports) on behalf of the MDNR to the MDNR "RAP Team" members.

A long-term goal, or vision, tends to be very general and serves the purpose of providing overall direction for the RAP process. These are often based on the general goals of the AOC program to restore and protect beneficial uses. Short-term goals help RAP participants focus on "bite-size" pieces that when taken together move the area closer to the desired state. The short-term goals should be realistic, specific and quantitative where possible. These goals should be based on a prioritization of environmental issues in an AOC to most efficiently use limited resources.

Michigan's RAP documents will become a series of biennial reports, each containing components of the Stage 1, Stage 2, and Stage 3 RAPs as identified in the GLWQA. Each biennial report will be a concise, yet comprehensive summary of progress achieved in the AOC over the two-year period and a description of the next steps required to move toward RAP goals. In general, the reports will include an introduction (including a summary of the use impairments, causes of the problems, and sources of concern), a summary of progress during the two-year period, a list of actions that need to be taken, and a list of participants and their roles. The biennial reports will be written by RAP participants as appropriate for the individual RAP process. This generally includes a variety of committees to promote widespread representation among the groups participating in the RAP process.

B. SAGINAW RIVER/BAY AOC

The Saginaw River and Saginaw Bay were identified on the original 1973 IJC Problem Area list discussed earlier. Environmental programs produced substantial improvements in Saginaw River and Saginaw Bay water quality during the following decade. Never-the-less, by 1985, when the Great Lakes RAP process started, the IJC Water Quality Board Report on Great Lakes Water Quality identified the following five problems in the Saginaw River/Bay AOC.

-- toxic organic substances
-- contaminated sediments
-- eutrophication
-- fish consumption advisories
-- biota impacted

These five water quality problems were therefore the major issues that were to be addressed when development of the Saginaw River/Bay RAP began.

The structure of the initial RAP was designed to include the following items, which were also specified for RAPs in the 1985 WQB report.

-- Description of the historic and present environmental conditions.

-- Definition of the geographic extent of the area affected.

-- Identification of the materials causing degraded water quality.

-- Identification of the sources of contaminant materials.

-- Identification of the impaired beneficial water uses.

-- Recommendations and descriptions of remedial measures that should be implemented to restore the impaired beneficial uses.

-- Schedule for implementation and completion of remedial measures.

-- Identification of jurisdiction and agencies responsible for implementing and overseeing remedial measures.

-- Process for evaluating remedial program implementation and effectiveness.

-- Recommendations and descriptions of monitoring and/or research programs needed to acquire information necessary to (1) recommend and design specific remedial actions, (2) evaluate the effectiveness of implemented remedial actions, and (3) confirm restoration of uses.

Work began on the Saginaw River/Bay RAP in July 1986 with the appointment of a MDNR site coordinator. In October 1986, the MDNR contracted with the East Central Michigan Planning and Development Region (ECMPDR), a 14-county regional planning agency located in Saginaw, to prepare a first draft of the RAP by September 1987. The ECMPDR subcontracted a large portion of the RAP preparation work to the National Wildlife Federation (NWF) Great Lakes Natural Resource Center in Ann Arbor. The NWF, in turn, secured the services of seven graduate students from the University of Michigan (U-M) School of Natural Resources to work on various aspects of the RAP as a Master's program project. The first draft of the RAP was completed on schedule in September 1987.

During the next year, the Saginaw Basin Natural Resources Steering Committee (a public committee formed for the Saginaw River/Bay RAP process) reviewed the draft document, provided MDNR with comments, and developed the Remedial Actions section. Concurrently, the MDNR refined the technical portions of the draft document following review by the steering committee and a technical work group composed of environmental scientists from local, state and federal agencies. The final version of the initial Saginaw River/Bay RAP was completed in September 1988.

It is important to note that most of the development work on this initial Saginaw River/Bay RAP document preceded the 1987 amendments to the Great Lakes Water Quality Agreement. This had a direct bearing on two major aspects of RAPs as they are defined today. First, the September 1988 Saginaw River/Bay RAP combined the major elements of Stage 1, Stage 2 and Stage 3 RAPs into one document -- thereby not only identifying the water quality problems, causes and sources, but also the next-step actions that needed to be taken to ultimately resolve the problems. Second, the RAP addressed the water quality problems in the AOC in terms of the two major issues of eutrophication and toxic material contamination, and did not discuss these problems in terms of the 14 beneficial uses later defined in the 1987 GLWQA amendments, though it did address all the corresponding impairments.

The 1988 Saginaw River/Bay Remedial Action Plan was developed to address the specific water quality problems of toxic materials and cultural eutrophication in the Saginaw River and Saginaw Bay. The specific goals were to (1) reduce toxic material levels in fish tissue to the point where public health fish consumption advisories were no longer needed for any fish species in the AOC, (2) reduce toxic material levels in the AOC to those of Michigan's water quality standards, and (3) reduce eutrophication in Saginaw Bay to a level where the bay will support a balanced mesotrophic biological community.

The initial 1988 RAP identified 101 actions that were needed to further address the environmental problems in the Saginaw River/Bay AOC. The estimated cost of implementing the actions over the next 10-year period was $170 million, and this did not include any cost estimates for sediment cleanups if needed. By December 1991, only three years later, two-thirds

(68) of the 101 actions had been at least partially implemented. Of the 37 priority actions identified, all have been at least partially implemented.

This is remarkable implementation success given this era of decreased financial resources at the federal, state and local levels. The widespread support can be partially attributed to the relatively high priority given to this AOC at the state and federal level, as well as the involvement of local citizens, businesses and communities in the RAP process due to their desire to improve the environmental conditions that affect their quality of life.

Because of this success in implementing actions, in 1991 it was determined that it would be appropriate to update the RAP in order to (1) incorporate the new data, (2) consider the new data results in evaluating past, ongoing or proposed actions, and (3) further develop and prioritize actions appropriate for the current situation. Also in 1991, the U.S. Environmental Protection Agency (EPA) awarded additional funds to the MDNR to support the RAP program effort. This allowed for additional staff resources to be allocated to the Saginaw River/Bay RAP process. Additionally, in September 1991, Saginaw Bay was designated as a National Watershed Initiative Program site, further facilitating the Saginaw RAP process.

One might consider the effort to revise the Saginaw River/Bay RAP to have actually begun back in September 1990, when the local community and the MDNR started to work on the process to nominate Saginaw Bay for inclusion in the EPA National Estuary Program (this was the process that ultimately resulted in the Saginaw Bay National Watershed Initiative). During the following months, the RAP was reviewed to identify environmental problems that could be addressed under the National Estuary Program. In preparing the nomination document, the environmental problems identified in the RAP were defined in terms of the same beneficial use impairments used in the 1987 amendments to the GLWQA to maintain consistency with that agreement and future versions of the RAP.

This review process required that the water quality problems described in the RAP be compared with (1) the beneficial uses described in the GLWQA, (2) the IJC listing/delisting criteria for AOCs; (3) other provisions of the GLWQA; and, (4) as in the RAP, Michigan's water quality standards. It was noted that some environmental problems in the Saginaw River and Saginaw Bay are common to the entire Great Lakes basin, and other problems are caused by physical factors (such as dredge and fill activities or bulkheading) as opposed to water quality issues. Though these environmental concerns are discussed in this RAP, they also need to be highlighted for basin-wide remediation efforts (such as Lakewide Management Plans) or addressed by local land use planning agencies or similar groups.

In June 1992, work began on this second iteration of the Saginaw River/Bay Remedial Action Plan document. It was prepared jointly under the Saginaw River/Bay RAP Program and the Saginaw Bay National Watershed Initiative by numerous agencies, local governments, public and business organizations, and basin residents. It uses the terminology specified by the 1987 amendments to the GLWQA and defines the water quality problems in the Saginaw River and Saginaw Bay in terms of the 14 beneficial uses. It also includes relevant elements of all three

RAP stages defined by the GLWQA. Additionally, it is a much broader, though more refined, document than the 1988 version, as described below.

This report is the first Saginaw River/Bay RAP to be developed under the new biennial approach to Michigan RAPs. It encompasses numerous differences from, and improvements on, the initial 1988 RAP document, the most significant of which are the following.

- A vision and numerous long-term and short-term goals have been developed to provide more specific guidance and quantitative measures for the overall RAP process.

- The "water quality problems" in the Saginaw River and Saginaw Bay addressed by the initial RAP are now described in terms of the GLWQA beneficial uses.

- This report takes a broader, ecosystem approach to the water quality problems, which has resulted in greater emphasis on habitat issues, fish populations, and wildlife communities.

- This document identifies, to a much greater degree, which small watersheds are contributing the most to the impairment of beneficial uses in the Saginaw River and Saginaw Bay.

- The report deals with environmental problems throughout the watershed, instead of addressing upstream areas only if they were contributing to the degradation of the Saginaw River or Saginaw Bay (the "Area of Concern").

- A major component, that will greatly assist efforts to address the environmental problems in such a large drainage basin, is the comprehensive small watershed prioritization process to rank watersheds with respect to each other on local conditions as well as impacts on the bay.

- This first biennial report focuses on nutrient, conventional parameter, and habitat issues. Toxic substances and contaminated sediments will be addressed in the next biennial report.