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PROLOGUE

As is the case for all of recorded history, there remains a long and unbroken chain of events which preceded the St. Louis River System Remedial Action Plan. One of the most significant of these was the 1909 signing of the Boundary Waters Treaty between the United States and Great Britain [Canada was not a sovereign nation at this time]. The 1909 Boundary Waters Treaty established the International Joint Commission (IJC) as the bi-national organization responsible for the Great Lakes and other international boundary waters. The three principal responsibilities entrusted to IJC by the 1909 Treaty included the regulation of Great Lakes water levels, an obligation to carry out specific studies as requested by the parties, and as arbitrator for international water resource disputes. As one of it's first responsibilities, IJC was asked to conduct a study of water quality problems resulting from discharges of raw sewage into the Great Lakes. IJC issued a report in 1919 that strongly recommended the establishment of a comprehensive treaty to combat such problems and to protect Great Lakes water quality. This recommendation was virtually ignored.

Degradation of the Great Lakes ecosystem proceeded for years before mounting scientific evidence and public pressure compelled the governments of the United States and Canada to enact the 1972 Water Quality Agreement. The circumstances that provoked this precedent setting action included wide spread and pervasive algae blooms in the lower Great Lakes, disease outbreaks attributable to discharges of raw sewage, and the devastating impact of the 1940s invasion of the sea lamprey on Great Lakes fisheries resources. These issues culminated in 1955 with the establishment of the Great Lakes Fisheries Commission (GLFC) and the 1972 signing of the Great Lakes Water Quality Agreement. Control of the sea lamprey served as the impetus for the 1955 establishment of GLFC. The 1972 Water Quality Agreement required that the governments take specific steps to reduce the discharge of conventional pollutants and signaled a commitment to reverse the progressive decline and deterioration of the Great Lakes ecosystem.

There were noticeable improvements in Great Lakes water quality following the implementation of the 1972 Water Quality Agreement. An estimated nine billion dollars was expended in controlling conventional pollutants by the upgrading or creation of waste water treatment plants. In the years following the signing of the 1972 Agreement, continued monitoring and research made it clear that toxic chemicals in the environment presented a threat equal or greater in significance than that posed by conventional pollutants. The gravity of this realization brought the signatories of the Water Quality Agreement together to amend the Agreement in 1978. The 1978 Agreement retained the essential components of the 1972 Agreement and added a new focus on toxic pollutants. After period of time, it became obvious that the amendments to the Agreement lacked an effective means of implementation. In 1987, the Agreement was modified to establish Remedial Action Plans (RAPs) as one of the principal mechanisms to implement provisions of the Agreement and to address the most severely impacted geographic areas around the Great Lakes Basin. The plans themselves are to embody a comprehensive ecosystem approach and to include substantial citizen participation.

EXECUTIVE SUMMARY

The Transformation and Legacy of the St. Louis River Area of Concern

Settlement and the consequent development of the lower St. Louis River and its watershed followed a pattern similar to other Great Lakes Areas of Concern (AOC). The shoreline and open waters of the river's mouth or estuary were transformed from a large, shallow, marshy area, to the slips and waterfront operations which make it one of the largest ports on the Great Lakes today. In this transformation, an estimated 3000 acres of open water and wetlands were filled and another 4000 acres of the harbor or estuary dredged. Other major hydrologic modifications included the development of 630 miles of drainage ditches in the western and central parts of the St. Louis River Watershed, the creation of a lake reservoir system, and the placement of five hydro-power dams in the river reach from the City of Cloquet, Minnesota to the upper reaches of the estuary. Each of these changes and many others have altered historic hydrologic conditions. Some of the known consequences of these physical alterations are manifested as barriers to fish movement, changes in flow regimes and aquatic habitats, and in the delivery of storm water and its associated pollutants.

The St. Louis River has undergone a long history of degradation resulting from pollution. As a consequence of a 1928 - 1929 investigation, the Minnesota State Board of Health classified the river reach from the City of Cloquet to Lake Superior as "pollutional". A follow up study in 1948 confirmed the 1928 study's classification of the river and concluded that 20 years had elapsed with significant increases in waste discharges and no improvements in treatment. Oxygen deficiencies and sludge deposits in river bottom areas were commonplace at this time. Complaints of tainted fish flavor and fish kills were also frequent occurrences from the 1940's through 1970's. A 1967 fisheries potential study reported that "fish caught in the river reportedly have a very strong flavor and are scarcely edible without strong seasoning". Fish kills occurred at various intervals during late spring and summer from 1956 to 1980. Waste water treatment improvements in the 1980s alleviated most of the problems associated with discharges of conventional pollutants. Issues of toxic substances in the environment have since moved to the forefront of the public agenda, as evidenced by issuance of fish consumption advisories. Minnesota and Wisconsin issued fish consumption advisories for the presence of toxic residues in fish in the St. Louis River in 1985.

Major industrial and municipal discharges to the St. Louis River were occurring throughout the time frame when fish kills and tainting problems were commonplace. Industrial byproducts were discharged, as one example, from the a ravine/stream on the northern edge of the US Steel/Duluth Works Site to the St. Louis River for some 65 years. Wood products industries in Cloquet also discharged a variety of wastes to the river for over 75 years. These sources were joined by an agglomeration of industrial and municipal point sources from both Minnesota and Wisconsin that discharged into tributaries, slips, and at a multitude of locations in St. Louis or Superior Bay. Establishment of the Western Lake Superior Sanitary District in 1978 consolidated the Minnesota industrial and municipal dischargers into a single waste treatment plant and had a significant positive impact on river water quality. In the past, studies had characterized the lower St. Louis River as eutrophic. With the start up of the treatment plant, dissolved oxygen deficiencies and the frequency of violations diminished from 25% to less than 1% over the period of 1979-87. Another study estimated that total phosphorous loadings from nine former sewage treatment plants had been reduced by about 80%.

Where and What is the Area of Concern?

The St. Louis River System is varied and complex, and includes several major bays and tributaries. The term "St. Louis River System Area of Concern" is used to describe the geographic area being addressed by the RAP, without naming all of the individual regions and waterways it represents. The St. Louis River System RAP primarily focuses on the St. Louis River below Cloquet, including St. Louis Bay, Superior Bay, Allouez Bay and the lower Nemadji River. The 39 river miles of the St. Louis River between the City of Cloquet and its entrance to Lake Superior has been the region of most intense water uses, development, and industrial activities on the River throughout the period of settlement. The RAP also considers activities throughout the St. Louis and Nemadji River watersheds which affect water quality. Atmospheric sources which may originate beyond the watershed are also considered.

What Do We Know About Pollutant Sources in the Area of Concern?

A multitude of lingering historical problems and continuing sources of pollution contribute to the degradation of the aquatic ecosystem of the St. Louis River system. The significance of individual sources to the overall problems may never be truly known. These sources are largely and collectively responsible for the integrity of the lower river, including its contaminated fish and sediment.
Historical discharges have left continuing problems: sediments contaminated with mercury, PCBs, dioxins, polynuclear aromatic hydrocarbons (PAHs), and a variety of other metals and organic compounds. These contaminants have been found throughout sediments in the area of concern, although large regions have not been sampled. Certain areas have been identified as having particularly elevated levels of sediment contaminants:

(1) The embayment that receives discharge from WLSSD, and historically received discharge from previous treatment plants in Duluth, MN;
(2) The Interlake Superfund site vicinity in Duluth, MN;
(3) The U.S. Steel Superfund site vicinity in Duluth, MN;
(4) Newton Creek and Hog Island Inlet of Superior Bay in Superior, WI;
(5) Crawford Creek wetland/Koppers Co. vicinity in Superior, WI.

At each of these locations, a variety of polynuclear aromatic hydrocarbons and/or heavy metals (i.e., mercury, lead, arsenic, etc.) have been detected at elevated levels in bottom sediments. In addition, degraded communities of bottom dwelling organisms have been documented at the Interlake and Newton Creek/Hog Island Inlet sites. Contaminated sediments in the five areas listed above may act as sources of contaminants to the overall ecosystem of the lower river and estuary.

In addition to continuing contributions of contaminants from these sites, other established or potential pollutant sources include continuing industrial and municipal discharges and a significant number of major and minor landfills. Point source dischargers contribute a range of toxic and conventional pollutants to the St. Louis River Area of Concern. The major active discharges are the Western Lake Superior Sanitary District, the City of Superior, Murphy Oil and Superior Fiber Products. Annual loadings estimates of heavy metals and organic compounds from these sources range from undetectable to 11,000 pounds per year. Among the landfill sites are the Superior-Wisconsin Point Landfill, the Engineers Realty Landfill in Duluth, and the Potlatch Landfill in Cloquet, MN. In addition, a compilation of records for the last decade has shown continuing inputs of untreated sewage, industrial wastewater, and petroleum products through bypassing, spills, and other accidental releases.

Little quantitative information exists for the multitude of waterborne non-point sources of pollution delivered to the St. Louis River. Of these sources, groundwater and surface water represent two of the principal mechanisms for the transport of non-point sources of pollution. No systematic attempt has been undertaken to assess the significance of groundwater as a pollutant source, despite the existence of a number of contaminated sites within the drainage basin of the St. Louis River system. Investigations are generally carried out within the context of specific sites and focus on human health considerations.
The significance of the other principal transport mechanism, surface water, also remains poorly defined. There is a serious lack of data from the AOC's urban areas which quantify pollutant inputs from the 30 or so tributaries that drain the steep slopes of the City of Duluth and from the numerous small streams which dissect the semi-impermeable red clay region of Superior, Wisconsin. Most of what is known about non-point source pollution in the St. Louis River AOC is of general knowledge. For instance, constituents commonly identified in urban storm water by the U.S. Environmental Protection Agency's (EPA) National Urban Runoff Program (NURP) included sediment, nutrients, trace metals, hydrocarbons, and chlorides. It would be reasonable to expect the same range of pollutants in surface water runoff from the AOC. The significance of sediment loading is well illustrated by the 150,000 to 200,000 yds^3 of sediment dredged annually from the Duluth-Superior Harbor. One half of this amount is believed to originate from the Nemadji River. The cost of managing this sediment is approximately \$7.00 per cubic yard.

Atmospheric deposition represents another important mechanism for the delivery of non-point source pollutants to Lake Superior and to a lessor degree, the AOC. Studies indicate that most long-range transport of air pollution to northern Minnesota, and presumably Lake Superior and the St. Louis River, originates from the Ohio River Valley, the St. Louis, Missouri region, and from the Texas/Louisiana oil and petro-chemical complexes. There are also 63 local sources which are authorized by the states of Minnesota and Wisconsin to emit particulates, lead, carbon dioxide, sulfur dioxide, nitrogen oxides, and/or total volatile organic compounds. Some of the substances emitted locally are considered toxic. Atmospheric deposition is believed to contribute less than 30% of the mercury found in the St. Louis River Estuary. The primary source of mercury is the wastewater discharge for the Western Lake Superior Sanitary District (WLSSD) facility. Due to the large surface area of Lake Superior, atmospheric deposition constitutes 88% of the PCB loadings. The contribution of PCBs to the St. Louis River has not been quantified. Sources of atmospheric PCBs include the WLSSD sludge incinerator, local waste oil burners, and distant emissions. There is very little information on atmospheric deposition of dioxin to the St. Louis River. While there are at least two local sources (WLSSD and Potlatch), much of the dioxin could originate from distant sources.

Summary of IJC's 14 Beneficial Use Categories in the St. Louis River AOC

The International Joint Commission developed 14 impaired use categories to designate Great Lakes Areas of Concern. Impaired use criteria, which are summarized on the following pages, provide a framework for the development of RAPs. Status of these categories serve as indicators of past actions and of the biological, physical, and chemical integrity of the resource. The impaired use categories and the goals of the RAP Citizens Advisory Committee will guide development of recommendations during Stage II. The ultimate goal of Stage II and its implementation being to restore impaired uses and to protect those unimpaired.

IJC Impaired Use Criteria Summary for the St. Louis River AOC

Impairment Identified in AOC		
IJC Criteria	**Reason**	**Comments**
Fish Consumption Advisories	Advisories issued by MN and WI	PCBs, dioxin, mercury
Degraded Fish Populations	Impact of ruffe (exotic fish species)	-
Degraded Wildlife Populations	Decline in threatened and endangered Species	-
Fish Tumors and Other Deformities	Observations in 1991 (harbor) and 1985 (Crawford Creek)	Data on incidence of tumors and deformities needed
Degradation of Benthos	Documented at Stryker Bay/Hog Island Inlet	Surveys are needed to document extent of problem in AOC
Restrictions on Dredging	Contaminated sediment	Data lacking for many parts of the AOC
Excessive Loading of Sediments and Nutrients to Lake Superior[1]	High Sediment/Nutrient Load from AOC	-
Beach Closings/Body Contact	Sewage bypasses	Probable site specific bacterial problems from bypasses, spills, etc.
Degradation of Aesthetics	Aesthetics of water degraded by oily materials at Stryker Bay/Interlake and at Hog Island/Newton Creek	Other areas may have aesthetic impairment
Loss of Fish and Wildlife Habitat	Documented loss of habitat at Stryker Bay and Hog Island due to Contamination	Continuing loss of physical habitat limits population
Impairment Not Clear		
Fish Tainting	Historical problem, currently conflicting evidence	Clarify existence or extent of fish tainting in Stage II
Bird or Animal Deformities or Reproductive Problems	Low reproductive success in common terns - reasons not clear. Potential factors include toxics, competition, physical habitat loss.	Additional data on toxics in terns and other species needed.

IJC Impaired Use Criteria Summary for the St. Louis River AOC

Not Impaired Currently		
Wildlife Consumption Advisories	No advisories issued	Limited data
Restrictions on Drinking Water Consumption	Drinking water not taken from AOC	Concerns for spills
Eutrophication or Undesirable Algae[2]	High nutrient levels, but no clear evidence of eutrophication	High nutrient loading to Lake Superior is of concern
Added Costs to Agriculture or Industry	No impairment currently	Zebra Mussel could cause problems
Degradation of Phytoplankton and Zooplankton	No evidence of impairment	Future impairment possible due to exotics (BC and Zebra Mussel)

[1] Adaptation of Eutrophication Criteria to Fit Local Conditions
[2]IJC Eutrophication Criterion not Impaired, see "Excessive Loadings" Criterion

Restrictions on Fish Consumption

IJC Listing Criteria: When contaminant levels in fish or wildlife populations exceed current standards, objectives, 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.

Is the Beneficial Use Impaired? -Yes

The states of Wisconsin and Minnesota issue fish consumption advisories for Lake Superior and the St. Louis River. Advisories are issued for the presence of mercury, dioxin, and polychlorinated biphenyls (PCBs) in fish tissue. Fish tissue residues of mercury and PCBs also exceed the .5 mg/kg and .1 mg/kg standards established in the 1978 Great Lakes Water Quality Agreement for the protection of aquatic life and fish consuming birds.

Degraded Fish and Wildlife Populations

IJC Listing Criteria: 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.

Is the Beneficial Use Impaired? -Yes

During the period of severe organic pollution before 1979, fish populations were degraded and fish kills were common. Fish populations have been recovering from that era because of improvements in wastewater treatment. However, fish populations are now adversely affected by the proliferation of the ruffe, an exotic species first found in the AOC in 1987. Other exotics threaten fish populations. The potential effects of toxic substances on fish population health in the AOC is largely unknown. Continuing loss of physical habitat also threatens populations. The loss of wetland habitat and the infestation of the exotic plant, purple loosestrife, have the potential to cause declining fish and wildlife populations. Little population data is available *for wildlife with the exception of colonial nesting birds in the AOC. Populations of the common tern and the piping plover (threatened and endangered species) have declined probably due to a combination of local and regional factors.*

Fish Tumors and Other Deformities

IJC Listing Criteria: 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.

Is the Beneficial Use Impaired? -Yes

Observations suggest that fish tumors and deformities represent an impaired use in the St. Louis River estuary. However, at present, there are no studies which document the incidence rates of tumors in fish. Additional work is needed to fully determine the incidence of fish tumors and deformities in the AOC.

Degradation of Benthos

IJC Listing Criteria: 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.

Is the Beneficial Use Impaired? -Yes

Degradation of benthos has been documented in two areas: Stryker Bay/Interlake Superfund Site, and Newton Creek/Hog Island Inlet of Superior Bay. Investigations conducted in 1989-1991 indicate degraded benthos in these areas. Macroinvertebrate surveys in Stryker Bay show a marked paucity in numbers and diversity. In Newton Creek/Hog Island Inlet, tests have demonstrated sediment toxicity to benthic organisms. Although contaminated sediments may be causing degradation in other river areas, no system-wide benthic studies have been conducted.

Restrictions on Dredging

IJC Listing Criteria: When contaminants in sediments exceed standards, criteria, or guidelines such that there are restrictions on dredging or disposal activities.

Is the Beneficial Use Impaired? -Yes

Restrictions on dredging is a use that can be clearly identified as impaired in the St. Louis River AOC. Sediments in many parts of the AOC exceed guidelines developed by regulatory agencies to characterize in-place sediments and contain a variety of toxic, bio-accumulative contaminants which have been shown to cause adverse effects to aquatic and terrestrial organisms. Serious economic and social consequences are also imposed upon some resource users through special dredging requirements and obligations for long term sediment containment.

Excessive Loading of Sediment and Nutrients to Lake Superior

Listing Criteria: Adaptation of IJC criteria to fit local conditions.

Is the Beneficial Use Impaired -Yes

Despite high levels of phosphorous in AOC waters, little evidence exists of widespread or pervasive water quality problems associated with eutrophication. Algal growth may be suppressed in the lower St. Louis River by persistent turbidity and it's consequent light limitations. Nonetheless, these excessive loadings of this phosphorous and sediment to Lake Superior remain a concern. Excessive loadings of sediment and nutrients to Lake Superior are of importance to fish habitat and the trophic status of littoral and/or near shore areas.

Beach Closings, Body Contact

IJC Listing Criteria: When waters, which are commonly used for total body contact recreation, exceed standards, objectives, or guidelines for such use.

Is the Beneficial Use Impaired? -Yes

Water quality data indicate that improvements have occurred in bacterial contamination levels since the 1970s. Episodic sources such as sewage bypasses and marine traffic, however, continue to represent sources of localized bacterial contamination. Body contact recreation is considered impaired because of documented sewage bypasses into the St. Louis River system from Wisconsin and Minnesota sources.

Degradation of Aesthetics

IJC Listing Criteria: When any substance in water produces a persistent objectionable deposit, unnatural color or turbidity, or unnatural odor (e.g., oil slick, surface scum).

Is the Beneficial Use Impaired? -Yes

Visual inspections and complaint logs maintained by both states confirm that aesthetic values are degraded in a number of areas in the St. Louis River Area of Concern. Oils slicks have been repeatedly observed in Hog Island Inlet and in Stryker Embayment at the Interlake Steel Superfund Site. These areas and others should be systematically identified and addressed through remediation or separate riparian actions.

Loss of Fish and Wildlife Habitat

IJC Listing Criteria: 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.

Is the Beneficial Use Impaired? -Yes

In the past, fish habitat in the estuary was degraded because of impaired water quality. Currently, contaminated sediments may cause habitat degradation in several areas of the river system. Habitat degradation due to sediment contamination has been documented in two areas: Stryker Bay (Interlake Superfund site vicinity), and Newton Creek/Hog Island Inlet of Superior Bay. High rates of sedimentation in the estuary during the twentieth century, with ensuing turbidity and reduced light penetration, may limit macrophyte growth and therefore limit fish and wildlife habitat. Habitat loss due to sedimentation has not been documented for specific areas. Wetland habitat is being degraded due to the infestation of purple loosestrife. Fish and wildlife populations have not yet been noticeably affected by this infestation, but the potential exists if the loosestrife continues to spread.

The St. Louis River estuary has relatively large areas of undeveloped shoreline and wetland habitats, compared with many other Great Lakes Areas of Concern. Protection of these habitats is important to the stability of fish and wildlife communities. Critical habitats for some important fish and wildlife species have been identified and should be protected from loss through development or other degradation. Identification of important and critical habitats in the river system will be a continuing activity through the RAP and other planning efforts.

Tainting of Fish and Wildlife Flavor

IJC Listing Criteria: When ambient water quality standards, objectives, or guidelines, for the anthropogenic substance(s) known to cause tainting, are being exceeded or when survey results have identified tainting of fish or wildlife flavor.

Is the Beneficial Use Impaired? -Impairment Not Clear

Informal surveys of fisheries personnel and area game wardens indicate that fish tainting problems are no longer pervasive and wide-spread. A fish tasting study and survey conducted in the 1980s, however, raises questions as to whether this problem was simply transferred from upper river sites, where paper mill wastes were formerly discharged, to areas near the mixing zone of the Western Lake Superior Sanitary District waste treatment plant. This study compared fish trapped near the treatment plant outfall with those from upper river sites and other parts of the estuary. Fish tasting participants judged the upper river fish to be of better flavor than those from St. Louis Bay. To determine the present day status of fish tainting problems in the St. Louis River, a study of a similar nature should be undertaken.

Bird and Animal Deformities or Reproductive Problems

Is the Beneficial Use Impaired? -Impairment not Clear

With the exception of colonial nesting birds, there is little population data available to characterize wildlife in the Area of Concern. The common tern, whose populations have been extensively monitoring in the harbor, have experienced less than desirable reproductive success. At this time, however, there is no evidence to tie the population decline to toxic contaminants or a degraded food supply. Additional study of wildlife populations, with a particular emphasis on eagles and terns, is needed along with information on toxic substance residues in species with aquatic based diets.

Restrictions on Wildlife Consumption

IJC Listing Criteria: When contaminant levels in fish or wildlife populations exceed current standards, objectives, 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.

Is the Beneficial Use Impaired? -Not Impaired Currently

No wildlife consumption advisories are in effect or under consideration for any portion of the St. Louis River AOC. There exists concern, nonetheless, that wildlife are exposed to and may be bioaccumulating the same range of contaminants found in area sediments and fish.

Restrictions on Drinking Water Consumption or Taste and Odor Problems

IJC Listing Criteria: When treated 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 comparable portions of the Great Lakes which are not degraded (i.e. settling, coagulation, disinfection).

Is the Beneficial Use Impaired? -Not Impaired Currently

There are no restrictions on drinking water consumption or reports of taste and odor problems attributable to drinking water supplies in the St. Louis River AOC. At least two conditions help explain this situation: 1) area communities do not rely on the lower St. Louis River as a water supply source; and 2) neither Wisconsin or Minnesota classify the St. Louis River as a water supply source for human consumption. Nonetheless, there are several notable historical events which demonstrate the precarious nature of surface water drinking supplies in general. One of these events, which was an outbreak of typhoid fever in 1895, prompted officials in Duluth, Minnesota to move their water intake away from the harbor to its present location further up the north shore of Lake Superior. The 1970s discovery of asbestos fibers in the drinking water supply of Duluth was another event which required officials to provide emergency water supplies and resulted in the construction of the City of Duluth's Lakewood Pumping Station. A number of people continue to express concern about the potential for water supply contamination by spills, sewage bypasses, and chemical discharges.

Eutrophication and Undesirable Algae

IJC Listing Criteria: 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.

Is the Beneficial Use Impaired? -Not Impaired Currently

The St. Louis estuary was characterized as eutrophic prior to the improvements in wastewater treatment in the late 1970's. Since that time, many indicators of trophic status have shown improvements. The loading of phosphorus to the estuary from point sources was reduced substantially. Despite the reductions in point source loadings, phosphorus concentrations in the estuary remain at levels where eutrophic conditions might be expected. However, algal biomass in the estuary has been similar to levels found in mesotrophic or oligotrophic waters. Reduced light penetration due to turbidity and color may be a limiting factor for algal growth in the estuary. The high sedimentation rate as well as the high phosphorus concentrations measured in the estuary point to the need for further work to ascertain the effects of non-point source loadings to the system and to Lake Superior.

Added Costs to Agriculture and Industry

IJC Listing Criteria: Where there are additional costs required to treat the water prior to use for agricultural purposes (i.e. intended for commercial or industrial applications and non-contact food processing).

Is the Beneficial Use Impaired? -Not Impaired Currently

At the present time, there are no adverse impacts or special costs incurred by industrial users of surface water in the St. Louis River Area of Concern. At least two arguments help explain this situation: 1) the only major industrial use of the river water is for non-contact cooling waters; and 2) Lake Superior provides an alternative water supply which is both inexpensive and of outstanding quality. The effects of exotics species such as the zebra mussel and sewage bypasses or spills are several issues of potential concern.

Degradation of Phytoplankton and Zooplankton Populations

IJC Listing Criteria: 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 fractional bioassays) with appropriate quality assurance/quality controls confirm toxicity in ambient waters.

Is the Beneficial Use Impaired? -Not Impaired Currently

The information available on phytoplankton and zooplankton communities does not suggest that they are currently degraded. Exotic species, particularly the zebra mussel (Dreissena polymorpha)and the spiny water flea (Bythotrephes cederstroemi), threaten plankton populations. This situation, in turn, affect the fish populations that make use of zooplankton as a food source during their juvenile life stages.

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I. INTRODUCTION

A. BACKGROUND

The Remedial Action Plan process was the result of the International Joint Commission's (IJC) efforts to halt the degradation of water quality in the Great Lakes. The 1972 Great Lakes Water Quality Agreement between the United States and Canada initially focused on controlling phosphorus inputs to the lakes. The 1978 Agreement expanded the issues of concern to include the effects of toxic substances on the Great Lakes water quality (Table I.1). The agreement adopted an ecosystem approach to water quality problems by encouraging consideration of the interrelationship among water, air, land, and all living things.

After the signing of the 1978 Agreement, IJC identified and designated 43 areas in the Great Lakes Basin as having impaired beneficial uses of the water resource due to pollution. Remedial Action Plans (RAPs) are to be developed for each of the 43 Areas of Concern (AOC). The Great Lakes Water Quality Agreement, as amended on November 18, 1987, defines AOC as "...a geographic area that fails to meet the general or specific objectives of the Agreement, or where such failure has caused or is likely to cause impairment of beneficial use or of the area's ability to support aquatic life." AOCs typically include major urban and industrial centers near rivers, harbors and connecting channels where pollution from a variety of sources, development of shoreline areas and other ecosystem impacts have impaired beneficial uses. Contamination from toxic substances is typically a major concern. The goal of RAPs is to define problems and their causes, and then recommend actions and timetables to restore all beneficial uses of the AOCs. Restoring uses is to be achieved through implementation of programs and measures to control pollution sources and remediate environmental problems.

That portion of the St. Louis River watershed initially designated as the Area of Concern included the section of the St. Louis River below Fond du Lac Dam, including St. Louis Bay and Superior Bay. This definition was later expanded to include the river reach from the City of Cloquet to Lake Superior (Figure I.1). This is the area of the river, that by virtue of population density and industrial concentration, will be the main focus of the RAP. In addition, the Nemadji River will be included in the plan and any factor within the St. Louis River watershed contributing to problems of the water resource will be considered in the plan. The St. Louis River AOC is shared by Wisconsin and Minnesota and both are actively cooperating and involved in development of the Remedial Action Plan.

The St. Louis River was originally designated an AOC due to the large loads of suspended solids, nutrients, and biochemical oxygen demand directly discharged into the river by various industries and communities. This pollution had significant adverse impacts on the beneficial uses of the area and placed severe stresses on the fish populations inhabiting the area. In the early 1970's, the adverse impacts of the pollution and objectionable tasting fish resulted in little or no sportfishing interest. Other recreational uses of the area such as boating and aesthetic viewing were similarly impaired.

II. PROCESS OVERVIEW AND ORGANIZATIONAL STRUCTURE

A. PROCESS OVERVIEW

Consistent with International Joint Commission protocol, the RAP development will proceed in the following three stages:

Stage I: Problem Identification
Stage II: Action Plan
Stage III: Implementation

Stage I involves the identification and description of the problems in the Area of Concern. This includes an examination of the IJC's "impaired beneficial use" criteria for designating areas of concern. The sources and causes of the problems will be established in order that cleanup, restoration of impaired beneficial uses, and protection of the resources can be undertaken.

Stage II of the process will involve the continuation and completion of some transitional activities that were begun in Stage I, recommendations or "action items" to solve the problems will be developed, and a range of alternative actions to meet the RAP goals and objectives will be proposed. Overall priorities for problems and recommendations will then be established. Finally, actions will be recommended that achieve the goals and objectives of the RAP. The recommended actions will identify those responsible for implementation and will include schedules for implementation to the extent possible.

Stage III involves the implementation of the actions recommended in Stage II. The implementation of RAP recommendations will occur at different rates based on their difficulty and complexity. Some recommendations may be implemented during the planning process; others will be of longer term. Stage III will also include monitoring to determine the effectiveness of remedial measures and to confirm restoration of impaired uses.

B. ORGANIZATIONAL STRUCTURE

An initial RAP draft was completed in 1985 and was submitted to the EPA by the MPCA. The EPA indicated there was a need for a more comprehensive document to address problems of the AOC and necessary solutions and remedial actions. EPA contracted with Science Applications International Corporation (SAIC) to put the available information and data into an appropriate RAP format. Minnesota and Wisconsin reviewed the efforts of the consulting firm and decided that a significant change, revision, and expansion of the document was necessary. The need to expand public input and involvement in the RAP process was also evident.

To address these concerns, a 32-member Citizens Advisory Committee (CAC) was formed in June of 1989 to oversee the development of the RAP. The committee was to identify issues to be considered, set goals for remedial action activities, approve the final plan, and advise the MPCA and WDNR. A list of CAC members is included in the Acknowledgements.

The CAC formed two subcommittees, a Steering Committee and a Public Relations/Information and Education Committee. The seven-member Steering Committee is comprised of CAC members. It guides the CAC by organizing, developing, and recommending activities or options that the CAC may want to pursue. The Public Relations/Information and Education Committee, active in 1990, organized public meetings to report on the RAP progress.

In late 1989, five Technical Advisory Committees (TACs) were formed based on the recommendations of the CAC. The TACs provide the scientific and technical advice needed to analyze complex issues and recommend a range of possible solutions. The TACs established are as follows: Toxics, Water Quality, Sedimentation and Erosion, Habitat and Biota, and Institutional Arrangements.

The committees are composed of technical experts from local state and federal agencies, institutions, and other appropriate areas. TAC membership lists are included in the Acknowledgements.

The Toxics, Water Quality, Sedimentation and Erosion, and Habitat and Biota TACs advise the CAC. The TACs are responsible for identifying impaired beneficial uses and their causes, proposing goals and objectives to restore such uses, and recommending innovative and active solutions to preserve and rehabilitate the St. Louis River Area of Concern. In addition, they are asked to identify the persons and agencies that will provide funding and implementation of the remedial measures. These recommendations are forwarded to the Institutional Arrangements TAC for evaluation.

The mission of the Institutional Arrangements TAC is to determine how recommendations can be implemented considering policy, economic, political, and social factors. The Institutional Arrangements TAC examines advantages and disadvantages of recommended actions and identifies parties responsible and necessary for implementation. The members of this TAC are representatives of groups which will likely be implementing RAP recommendations. The Institutional Arrangements TAC will play a vital role in Stage II.

Following the Institutional Arrangements TAC evaluation, recommendations are sent to the CAC which then produces final recommendations in cooperation with the TACs. Overseeing these activities are the RAP coordinators from the Minnesota Pollution Control Agency and the Wisconsin Department of Natural Resources, the coordinators must then report back to the Environmental Protection Agency. Figure II.1 depicts the organizational structure of the RAP.

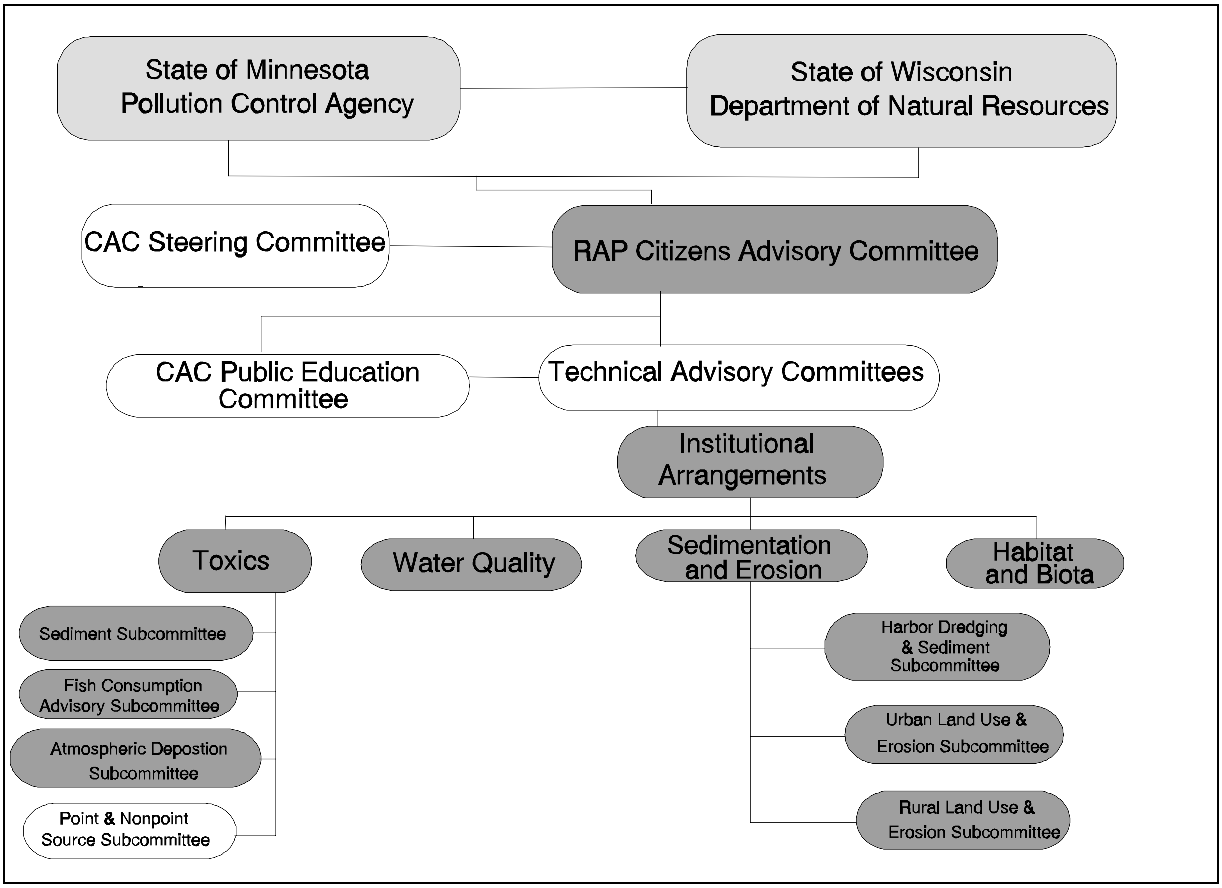
The Toxics TAC formed three subcommittees to address the principle problem areas of fish consumption advisories, contaminated sediments, and point and nonpoint source contamination, including atmospheric deposition. The impaired uses examined include restrictions on fish and wildlife consumption, fish tumors and other deformities, and dredging restrictions.

The Water Quality TAC has examined 11 different issues for the RAP:

-fish and wildlife tainting
-water quality effects of dredging
-failing septic systems
-beach closings
-bilge water disposal impacts
-fish kills
-eutrophication/undesirable algae
-combined sewer overflows
-water quality of the St. Louis River/Bay
-aesthetics
-water suitability for industry/drinking

Issues addressed further include: stormwater infiltration/inflow problems and stormwater management plans and impacts from the disposal of bilge and sanitary water from commercial and recreational watercraft.

Figure II.1 St. Louis River System Remedial Action Plan Organizational Structure



The Sedimentation and Erosion TAC formed three subcommittees to address the principal problems of harbor dredging, urban land use, and rural land use leading to erosion. The major problem examined by this TAC is the accelerated sedimentation from erosion which is increasing dredging operations and altering habitat within the Area of Concern.

The Habitat and Biota TAC has examined 21 different issues for the RAP. The issues cover such topics as:

-amphibian, reptile, mammal, and lake sturgeon populations
-toxic contaminant impacts on fish health
-lack of knowledge regarding habitat requirements
-rate of system change
-fishery in recovery phase
-undesirable exotic species
-degraded waterbird and raptor populations
-bird reproductive problems
-loss of habitat
-wetland protection
-degradation of benthos
-river flow regime
-sea lamprey

The issues addressed further include: exotic species, loss of habitat, creation or enhancement of habitat, contaminant levels and deformities in wildlife, and information on wildlife populations.

To provide a framework to guide development of recommendations, the CAC developed 16 goals for the RAP process.

Goals of the Remedial Action Plan

1. The achievement and maintenance of a quality of water that protects the integrity of the ecosystem and which is amenable to safe recreational uses, including body contact recreation such as swimming.

2. The implementation of a staged river cleanup which results in the remediation of existing polluted sites and prevention of further degradation.

3. The establishment and maintenance of a coordinated monitoring network and information management and analysis system for the St. Louis River System Area of Concern.

4. The identification and evaluation of all existing point and nonpoint pollution sources, including regional airborne contributions, contaminated sediments, and episodic sources such as spills.

5. The reduction of pollutant inputs, including nutrient and sediment loadings from point and nonpoint sources.

6. The reduction of toxic substance inputs to the St. Louis River System Area of Concern through the following steps:

   (a) water quality which meets or exceeds the ambient water quality standards of both states for the classification of the water body;
   (b) initiation or maintenance of a program of no net increase in the discharges of toxic substances (anti-degradation policy);
   (c) over the long term, execution of a program to eliminate discharges of toxic substances; and
   (d) substitution and development of nontoxic substances for use in or in connection with industrial applications, business, home, land management, and other important users (pollution prevention).

7. Lessening of the need for dredging through reductions in sediment loading. Establishment of environmentally sound and economically feasible procedures for maintenance dredging and dredged materials management.

8. Protection and restoration of fish and wildlife habitat, including fish spawning and nursery areas, and aquatic and/or upland breeding, nesting, or migration habitats.

9. Identification and protection of remaining wetlands, including a program of no further loss of wetlands in or along the St. Louis River or estuary, no loss of critical wetlands or wetland functions, no net loss of wetlands in the drainage basin, and an overall policy of restoring and/or enhancing diminished or drained wetlands. Any unavoidable wetland losses shall be compensated for by the establishment of replacement wetlands of equal value on a two for one basis.

10. A healthy and well balanced aquatic ecosystem, where native species can live and reproduce

naturally and are not restricted from thriving due to substrate degradation.

11. Management of the St. Louis and Nemadji River Systems in a geographically and functionally unified manner. A coordinated approach should be taken by both states in the planning and implementation of ecosystem programs.

12. Participation in the Remedial Action Plan process by all stakeholders, ensuring effective community involvement in developing and implementing an achievable plan of action.

13. Planned water dependent development consistent with the other goals stated herein.

14. Expanded public awareness and understanding of the value of attaining and maintaining a healthy ecosystem within the St. Louis River Area of Concern and the role of the individual in that effort.

15. Enhanced variety of water oriented recreational opportunities throughout the Area of Concern, including public access to the water and shore, trails, beaches, and facilities for fishing from shore.

16. The restoration and preservation of as much scenic beauty to the area as possible.

III. ENVIRONMENTAL SETTING

A. INTRODUCTION

The St. Louis River is the second largest tributary to Lake Superior. The river's 66 cubic meter per second mean annual discharge is exceeded only by that of the Nipigon River. The St. Louis River watershed consists of 3,634 square miles in northeastern Minnesota and 263 square miles in northwestern Wisconsin (State of Minnesota, 1964). A majority of the watershed lies within the lower half of St. Louis County in Minnesota with small sections in Aitkin, Itasca, Lake and Carlton counties in Minnesota, and Douglas county in Wisconsin (Figure III.1, III.3). The morphology of the St. Louis River drainage basin could be characterized as diverse. From its source at Seven Beaver Lake, the river flows in a southwesterly direction 179 miles to the estuary near Lake Superior (MDNR, 1979). As the river approaches Duluth and Superior, it takes on the characteristics of a freshwater estuary. This approximately 12,000-acre estuary is characterized by numerous backwater areas and bays, as well as islands. Parts of the upper estuary are almost wilderness-like at present. The lower estuary is flanked by a number of industrial users interspersed with vacant or undeveloped tracts. This section of the estuary includes three major bays: St. Louis Bay, Superior Bay, and Allouez Bay. (Figure III.2) The Nemadji River, a major tributary, enters Superior Bay opposite the Superior Entry. The lower 23 miles of the St. Louis River forms the state border between Minnesota and Wisconsin (SAIC, 1988).

Figure III.1
St. Louis River Watershed

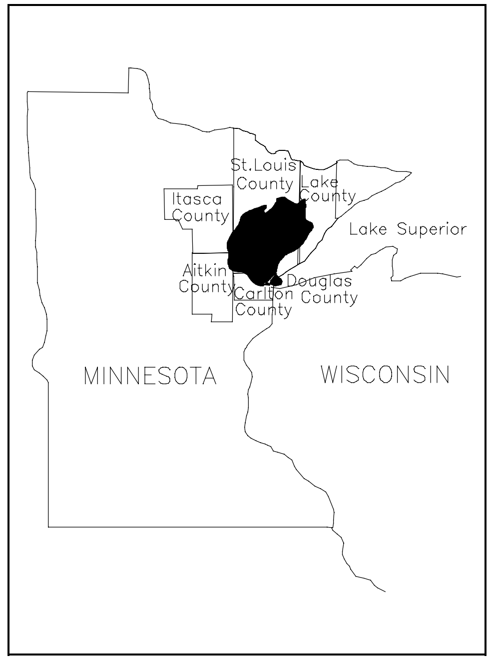


Figure III.2

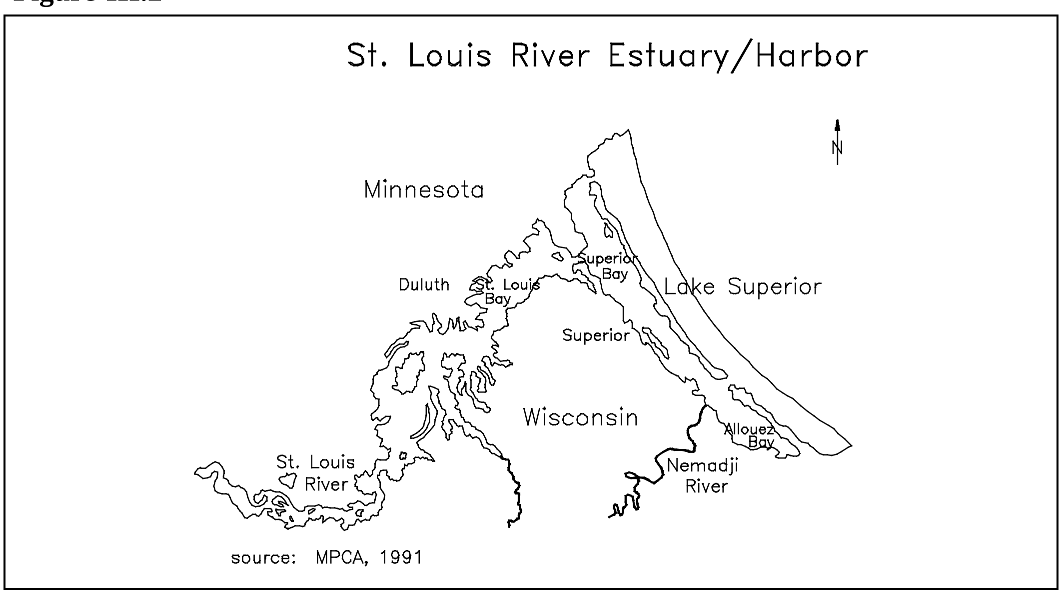


Figure III.3

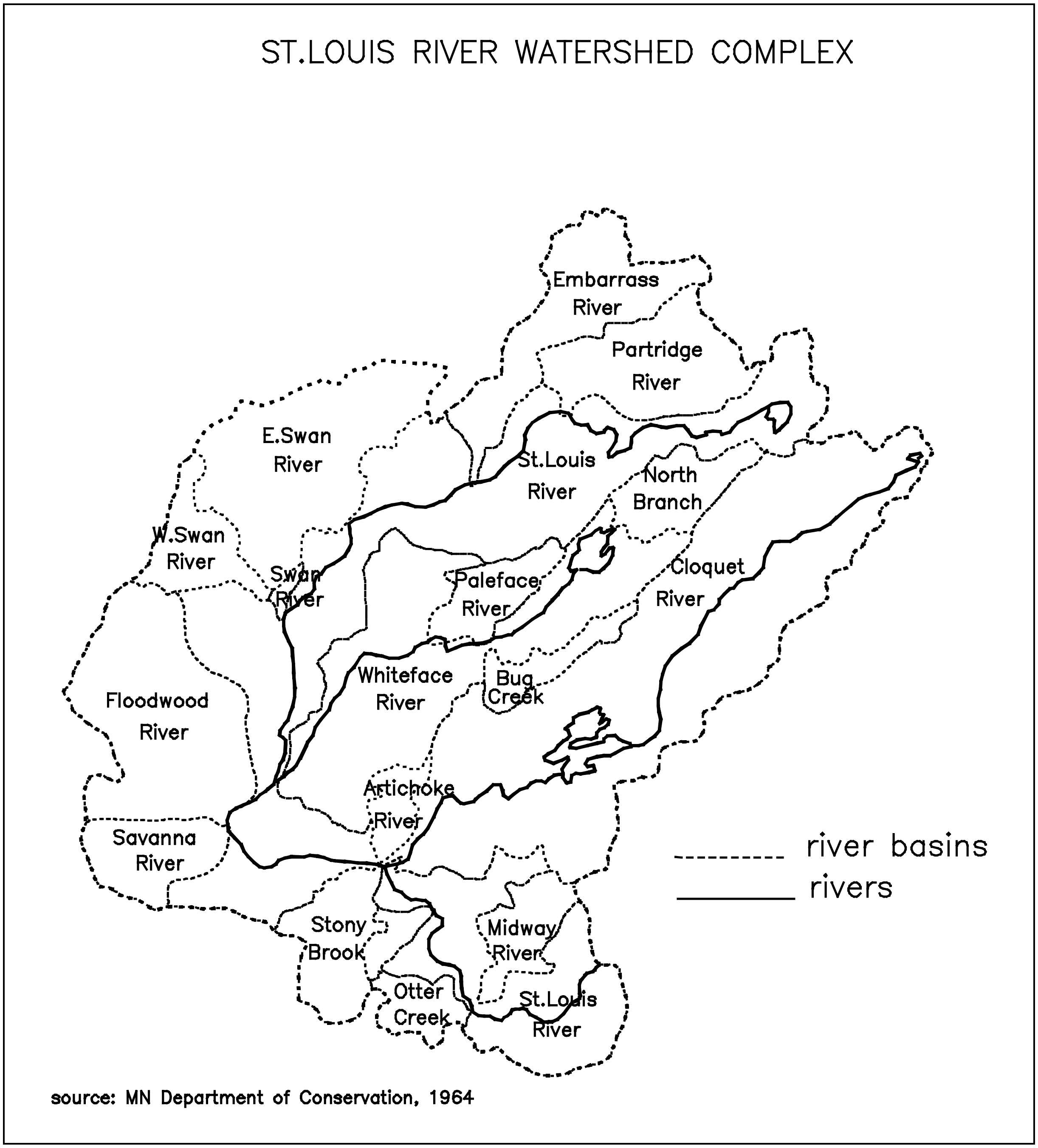
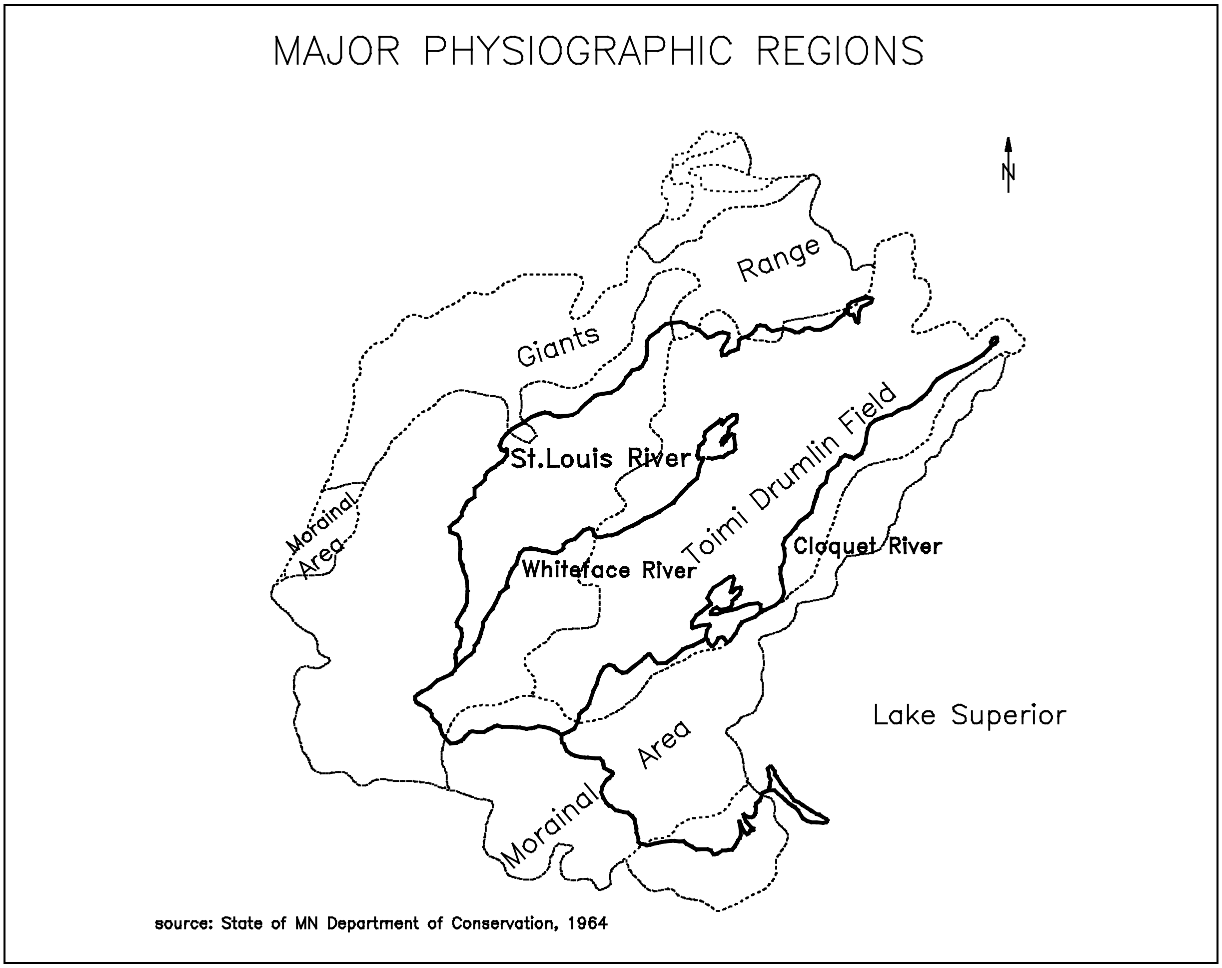

ST.LOUIS RIVER WATERSHED COMPLEX
Embarrass River
Partridge River
E.Swan River
St.Louis River
North Branch
W.Swan River
Swan River
Paleface River
Cloquet River
Whiteface River
Bug Creek
Floodwood River
Artichoke River
Savanna River
Stony Brook
Midway River
Otter Creek
St.Louis River
river basins
rivers
source: MN Department of Conservation, 1964

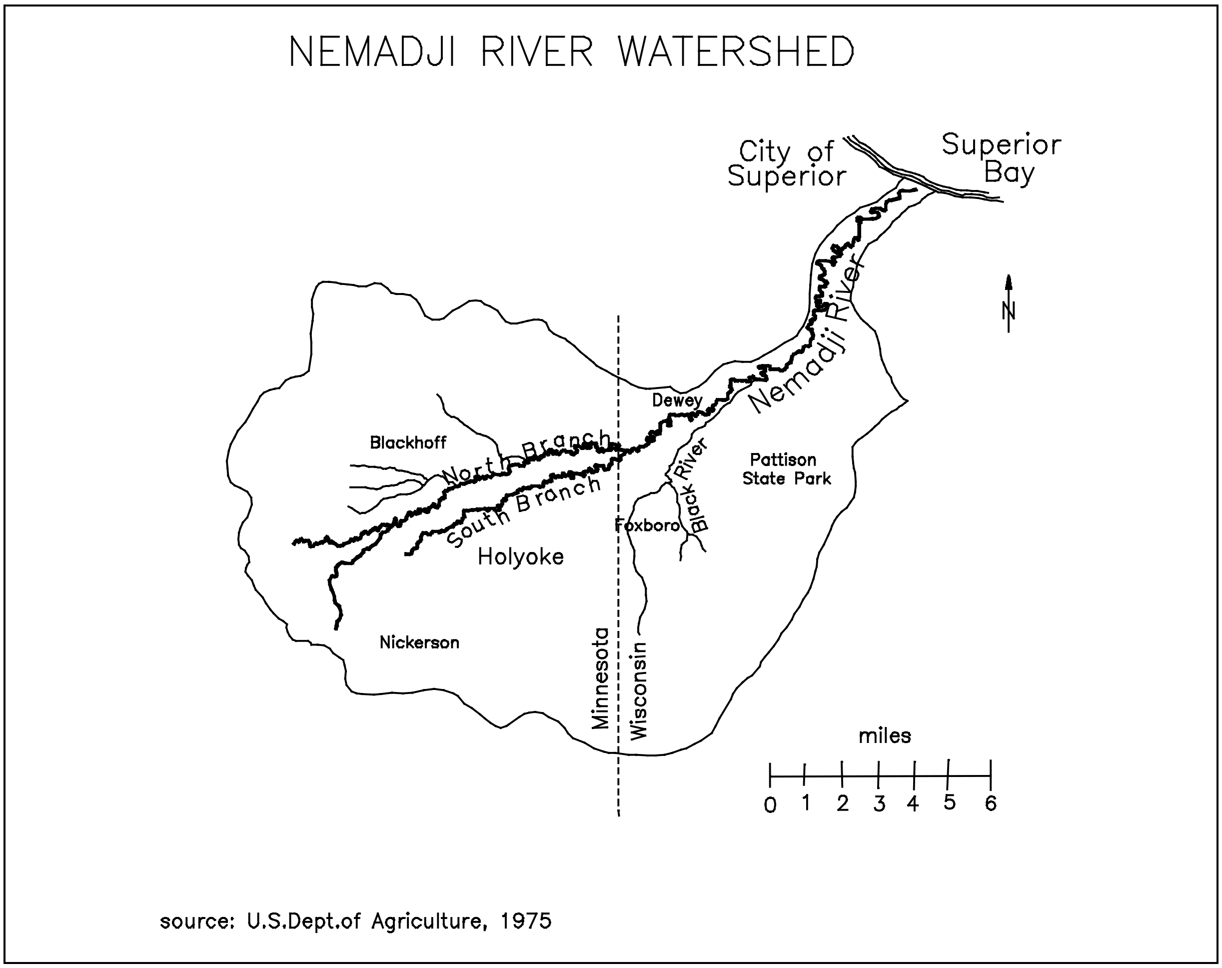
Figure III.4



The river's source area lies in the area near Hoyt Lakes in the Toimi Drumlin field, a predominantly wooded area of bouldery, coarse-loamy glacial till and outwash deposits (Fait pers. comm) (Figure III.4). The river makes a large "C" shape on its course to St. Louis Bay. In the upper part of the St. Louis River, the channel is narrow and deep with a depth ranging from 10 to 30 feet. As the river flows westward across St. Louis County, its passes through forested areas of sand, gravel, and clayey glacial till and outwash deposits. Small tributaries flow through similar wooded landscapes. From the town of Floodwood to Thomson, the river continues to pass through very hilly wooded glacial moraine. The soils in this area are coarse-loamy fine sands, loamy mantles, sands and gravels, interspersed with some fine-loam. Valley slopes increase in size and steepness along the river banks. The Cloquet, another major tributary river, joins just below Brookston. The Cloquet drains predominantly wooded areas of sand and gravel glacial till deposits. Below the Thomson, the St. Louis River changes abruptly as its flows through the deep narrow gorge of Thomson slates and greywackes of Jay Cooke State Park in lower Carlton County. The final reach of the St. Louis drains through the red clay deposits of Glacial Lake Duluth and enters the St. Louis Bay Estuary.

The upper portion of the 360 mi^2 Nemadji River watershed is located in Minnesota and the lower portion is located in Wisconsin. The Nemadji River system starts five miles east of Moose Lake and flows north to the Atkinson area and east through southeastern Carlton County, Minnesota. It then flows northeast into Douglas County, Wisconsin where it enters the Superior Bay. The Nemadji System has a dendritic (branching) drainage pattern (Figure III.5). The headwaters of its branches and tributaries begin in wooded sand and gravel glacial till and outwash deposits. The Nemadji River System enters the red clay deposits early in its path towards Superior Bay. Red clay deposits make up approximately 30% of its watershed, or about 100 square miles.

Figure III.5



B. BEDROCK GEOLOGY

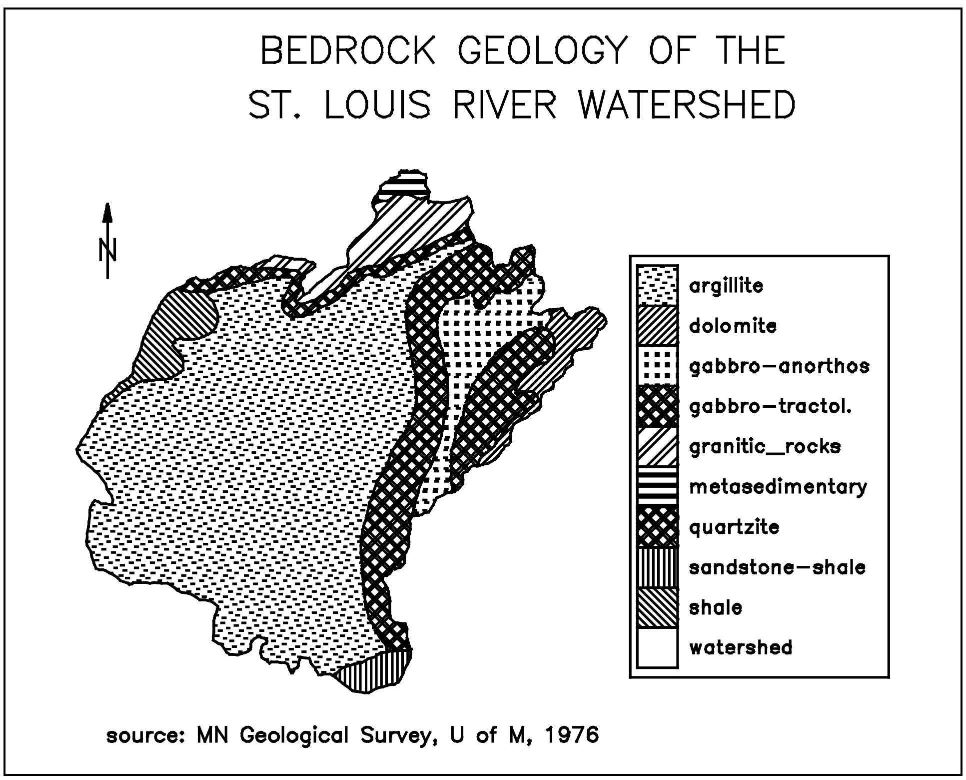
The geological story of northeastern Minnesota begins three billion years ago in an era called the Precambrian. At this time, northeastern Minnesota was covered by an ocean that was dominated by sub-oceanic volcanoes. The lavas extruded from these volcanoes flowed out onto the sea floor hardening to form a thick sequence of rocks referred to as the stable craton. One such layer is known as the Ely Greenstone. Erosional wave forces wore this rock into sand grains which were later deposited forming a sedimentary sequence of rock that can now be seen overlaying the lava sequence. One of the more important aspects of the sedimentary sequence is the formation of the Soudan Iron formation. A time of active tectonism ensued and again lava was injected onto the stable craton. The lava was of different composition than the basaltic lava of the previous extrusion. This lava was more granitic and the result was the Giants Range granitic formation.

The middle Precambrian period was a quieter time of shallow seas and oceans. Erosion of the Giants Range eventually resulted in the Pokegama quartzite sandstone formation. The seas deepened and the sedimentary processes changed. The Biwabik iron formation of slate, chert and iron ore formed during this time. This formation is overlain by the Thomson formation that can be seen near Thomson dam near the St. Louis River and throughout Jay Cooke State Park. The Thomson formation consists of slates and greywackes which are consolidated muds and sandstones that settled out in the deep ocean.

The geology of the North Shore of Lake Superior and Duluth are the result of lava extruding from a rift in the continental crust in the late Precambrian era known as the Keweenawan period. This lava solidified and now forms the impressive cliffs of the rocky North Shore. Subsequent erosion of these lavas formed the Fond du Lac Sandstones which now overly the Thomson and Virginia formations (Figure III.6).

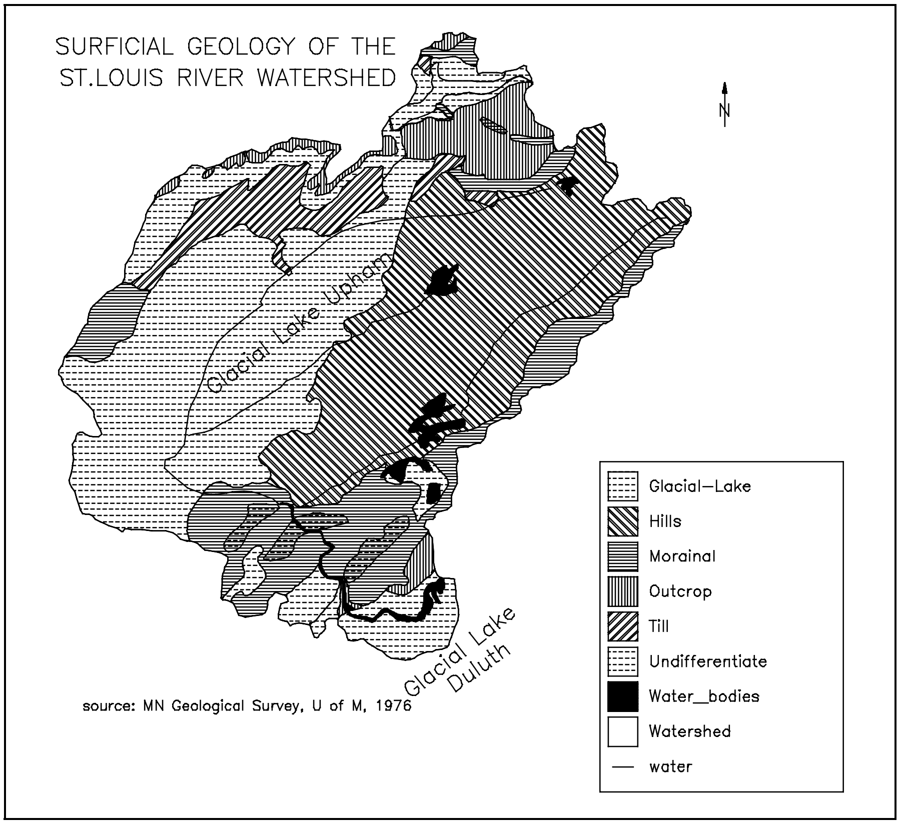
After the active Keweenawan period, there was a quiet time of almost a billion years of unrecorded geological history. Quiet shallow seas advanced and retreated over the southeastern and northwestern sections of Minnesota, but the northeastern section of Minnesota including the Duluth area remained relatively stable and unaffected by the transgressing and regressing seas (Match, 1982).

Figure III.6



C. GLACIAL HISTORY

Figure III.7



Remnants of glacial activity has impacted the St. Louis River drainage. Past glaciers have left a veneer of sand, gravely tills and outwash that form the modern landscape (Figure III.7). About ten million years ago, the polar ice caps of the north grew large enough to extend south across Canada. These thick ice masses began to flow southward into the United States two or three million years ago (Hartley, 1977).

Glaciers advanced and retreated over North America a number of times. Most recent of the glacial events is the Wisconsin Glaciation. About 20,000 years ago, near the end of the Wisconsin Glaciation, the last major ice lobe overrode northeastern Minnesota and northwestern Wisconsin. This lobe called the Superior ice lobe moved across southwest Canada and the Superior basin, entraining large quantities of reddish sand as it scoured and scraped the Keweenawan sandstone beds and well as entraining basalts and gabbros of the upper northeastern bedrock of Minnesota. During a warming trend, the ice retreated leaving a blanket of red sandy till. During this melting phase, a large lake formed known as Glacial Lake Upham formed in the southwestern corner of St. Louis County. Glacial Lake Upham covered much of the western half of the watershed forming a generally flat area of lake silt, and clay covered with bogs and swamps. The northern section of this basin contains many lakes and sandy terraces (Match, 1982). The red clay that settled to the bottom of this lake was entrained by the next surge of ice advancing 16,000 years ago and was deposited as a long thin layer of red clay 60 miles long southwest of the Superior basin.

Another glacial lake formed in approximately the same time frame as the formation of Glacial Lake Upham. This lake laid southwest of Upham and was termed Glacial Lake Duluth. This lake is considered the beginnings of what is now Lake Superior. Sedimentation of iron-laden mud particles were deposited. These red clay deposits were later exposed as the ice retreated (CLSES, 1973). The red clay deposits of the Superior lowland are also known as the Miller Creek Formation. The Miller Creek formation lies above a thick layer of sandy till known as the Copper Falls formation. This layering is important when analyzing stream bank erosion and sedimentation impacting the area of concern. The Nemadji River System flows through these red clay deposits.

D. HYDROLOGIC CHARACTERISTICS

The mean annual precipitation in the St. Louis River watershed ranges from less than 24.5" near the northwest border to more than 29.5" in the southeast corner (State of Minnesota, 1964). The average annual precipitation from 1931-1974 was 27.5 inches. Of this amount, 65% or 17.8" is evaporated and transpired. The remaining 9.7 inches ends up as ground water recharge and runoff in the St. Louis River (U.S. Geological Survey, 1979).

The bedrock formations in the watershed affect groundwater storage and movement. Most of the bedrock formations in the watershed exhibit low porosity and permeability. The reason for this low potential is due to the fact that ground water movement and storage occurs primarily in fractures and joints in bedrock. The natural storage capacity of water in these fractures is a minute percentage of total rock volume, thus retention and slow release of water in bedrock have an insignificant effect on stream flow (State of Minnesota, 1964). The Biwabik Iron Formation is the most important bedrock formation in the watershed due to its ability to store water. Because of natural physical weathering processes and oxidation and leaching of the minerals in the rock, the porosity and permeability of the Biwabik Formation is greater than that of surrounding rock formations. This increased capacity to store water makes the Biwabik a valuable source of ground water. Ten municipalities are currently receiving all or part of their water supply from this aquifer (State of Minnesota, 1959).

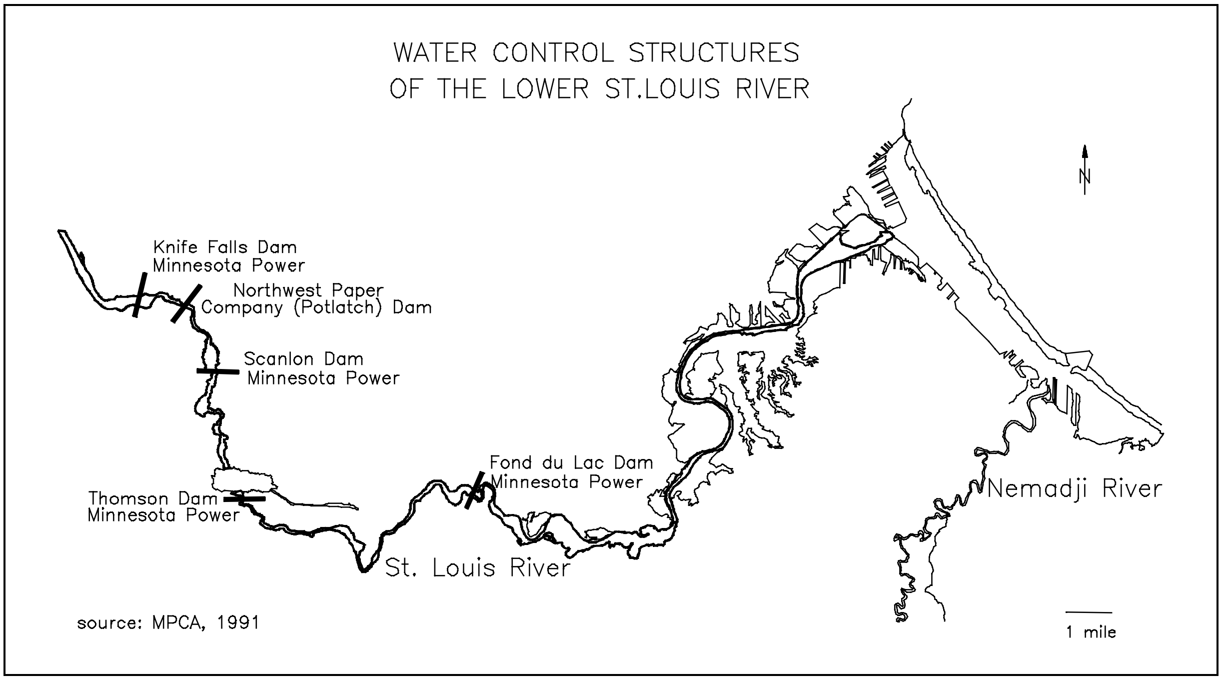
While the Biwabik Formation is an important source of ground water, other major aquifers and recharge areas of the St. Louis River are located in the stratified clayey sand and gravel within the glacial till. These areas of recharge do have an impact on the St. Louis River, but the extent of this impact is not well documented (State of Minnesota, 1964). It is known that in the glacial drift as well as the bedrock, the direction of the groundwater movement is towards the St. Louis River valley and Lake Superior (State of Minnesota, 1959). Thus the streamflow in the St. Louis River is a combination of surface runoff and groundwater discharge.

The streamflow in the downstream portion of the St. Louis River is dependent on another variable, namely the release of water from five reservoirs downstream of Cloquet: Knife Falls, Northwest Paper (Potlatch), Scanlon, Thomson, and Fond du Lac (Figure III.8). During periods of low flow, releases of water from these impoundments can have noticeable effects on water levels and streamflow. These impoundments slow the flow of water and reduce the river's gradient. When the heights of the dams are deducted from the total elevation decrease, the stream gradient from Cloquet to the estuary is reduced from 29.1 feet/mile to 13.8 feet/mile. (Minnesota DNR, 1979).

Maximum streamflow in the St. Louis River normally occurs during spring snowmelt. Periods of low flow generally occur in late summer or late winter. The lowest annual flows usually occur in late winter when precipitation is normally in the form of snow. The median low flow measured at Scanlon from 1909 to 1978, was 20 percent of average flow. The ordinary high flow is 6.4 times higher than the average flow (Minnesota DNR, 1979). The river's mean annual discharge is 2300 ft^3/s (State of Minnesota, 1964).

The Nemadji River flows into Superior Bay near the Superior entry to the harbor. Streamflow in the river measured at County Highway C bridge (7.5 miles upstream of the mouth) during the mid 1970's ranged from 40 ft^3/s to 5800 ft^3/s with an average flow of 387 ft^3/s. Flow in the Nemadji River is extremely variable and is affected by the clay soils of the area which allow little infiltration of precipitation. This lack of infiltration causes heavy runoff which has cut deep, steep gullies in the red clay region of the Nemadji River system creating the characteristic ridge and valley topography. Appendix L provides more information on erosion and sedimentation in the Nemadji River system.

Figure III.8



The streamflow of the St. Louis River and the waters of the harbor are impacted by seiches from Lake Superior. A seiche is the back and forth movement of water in a lake or landlocked body of water that results in the fluctuation of water levels in the waterbody. Weather fronts and wind drive the seiches in Lake Superior which have a period of 7.9 hours (Stortz and Sydor, 1980). Water "piles up" on the west shore of the lake for 7.9 hours and then changes direction and piles up on the eastern shore for 7.9 hours. This back and forth movement of water in Lake Superior is continuous but the magnitude or amplitude of the seiche can vary depending on the weather and winds.

The St. Louis harbor and the river are affected by the seiche oscillations of Lake Superior. Harbor water levels can fluctuate from 3-25 cm during a seiche event. The Lake Superior seiche acts on the harbor and estuary through the Duluth Ship Canal and Superior Entry. When water piles up on the western shore of the lake, it is forced through these two inlets and into the harbor and river. The flow of the river reverses (water flows upstream) until the seiche in the lake reverses as the water moves to the east shore of the lake. When the seiche reverses, the river once again flows downstream to the lake. The seiche has the strength to reverse the flow of the St. Louis River up to the Oliver Bridge, 11 miles upstream. River currents which are 1-3 cm/sec under no or very low seiche conditions, can increase by a factor of 20 during high seiche conditions (15.0 cm seiche) (Stortz and Sydor, 1980). Table III.1 shows river flows under various seiche conditions.

In addition to the reversals in direction of river flow, the seiche also sets up oscillations in the harbor. Approximately every 2.1 hours the water flow in the two inlets changes direction. Water will flow out the inlets to Lake Superior for 2.1 hours and then reverse and flow into the harbor for 2.1 hours. The water in the harbor has its own "mini-seiche" event as water moves back and forth off the shores in the harbor (Jordan et al., 1981).

The Lake Superior seiches and their resultant river flow reversals and harbor oscillations have a significant impact on transport of resuspended particulates and pollutants. Currents in excess of 15 cm/sec are of interest in consideration of resuspension and transport of suspended solids (Stortz and Sydor, 1980). During seiche events it is not uncommon to have river currents in excess of 15 cm/sec (See Table III.1). The seiche also affects movement and dispersion of pollutants. For example, due to the reversal of river flow, a spill in the harbor could potentially move upstream. (See Section V.B.5. for more information on spills.) The general hydrodynamics of the river and harbor and the transport of particulates and pollutants are greatly affected by the Lake Superior seiches.

Table III.1 Effects of Lake Superior Seiches on St. Louis River Currents (Stortz and Sydor, 1980)

Location	Normal Current (cm/sec)	Current with 3.0 cm Seiche (cm/sec)			Current with 15.0 cm Seiche (cm/sec)		
		Max. Up+	Ave.	Max. Down+	Max. Up+	Ave.	Max. Down+
Superior Entry*	1.6	-7.9	2.0	11.5	-30.4	1.9	34.6
Duluth Entry*	2.0	-16.6	1.9	19.4	-41.9	2.5	45.8
Superior Front Channel*	0.6	-3.0	1.1	5.0	-11.8	1.2	14.1
Duluth Harbor Basin	0.3	-2.1	0.4	2.7	-5.3	0.5	6.1
Blatnik Bridge*	2.7	-17.1	3.4	22.3	-45.4	3.7	50.0
Sewage Plant	2.5	-15.6	3.2	20.5	-42.0	3.4	45.7
Coal Dock	1.2	-7.7	1.6	10.0	-20.6	1.6	22.1
Cross Channel	0.1	-0.9	-0.0	0.8	-1.9	0.0	1.8
North Channel*	1.5	-9.0	1.9	11.8	-24.2	2.0	25.7
South Channel	1.4	-5.1	2.1	8.8	-19.0	1.8	20.8
Arrowhead Bridge*	1.7	-8.4	2.7	12.6	-26.5	2.5	28.2
Drills*	2.0	-6.4	3.0	11.3	-23.2	2.6	24.7
Oliver Bridge	2.0	-1.5	2.7	6.5	-8.9	2.7	11.9
Fond du Lac	17.8	14.3++	15.6	16.7	11.9++	15.5	18.5

* Insitu current measurements made in channel
\+ Max. Up is when the water is piling up on the west shore of Lake Superior
Max. Down is when the water is piling up on the east shore of Lake Superior
A negative (-) value indicates flow is moving upstream
++ Flow does not reverse at this location

E. DEVELOPMENT OF AN "AREA OF CONCERN"

The Duluth-Superior Harbor has changed from a clean, large, shallow lower river area protected by the world's largest freshwater sand bar to a substantially polluted, dredged, developed and drilled harbor in little more than 100 years. Where depths had averaged 5 to 8 feet they are now as deep as 27 feet in dredged channels which extend for six miles or more upstream. Where vast shallow areas dotted with floating islands existed before, we now have vast areas of fill on which are situated a variety of facilities. It is estimated that since 1861, over 4,000 acres of shoreline and open water in the harbor have been filled (DeVore, 1978).

Archaeological finds of some projectile points give evidence that the region has been inhabited since at least 7000 B.C. These early seminomadic hunters and gatherers established permanent villages around 1000 B.C. as increasingly stable food supplies like wild rice eliminated the need for a nomadic way of life. When early European explorers arrived in the region in the 1600's, the area was inhabited by the Dakota (Sioux). By 1776, however, the Dakota had left the region for the plains as the Ojibwa (Chippewa) moved into the western Great Lakes region under pressure from the Iroquois groups in the east. Today the Ojibwa people are the predominant native people in the region (ARBC, 1976).

The European explorers, Radisson and Groseilliers arrived in this area less than 350 years ago, in 1659. Twenty years later Sieur Du Lhut, after whom Duluth is named, established a camp at Fond Du Lac near the end of the readily navigable waters.

The region was a major link in the early days of the trading posts. The Hudson Bay Company set up one of their earliest trading posts in 1689 on the Wisconsin side of the bay. This was one of the more important trading posts on the Great Lakes and was used in some capacity until the early 1800's when the goods were moved to Fond Du Lac (Flower, 1890). In 1793, the British North West Company established its fur trading post on the Wisconsin side of the bay and John Jacob Astor's American Fur Co. set up business in Fond Du Lac in 1816.

Ten years later the Council of 1826 produced a treaty permitting mining in the region, subsequently reaffirmed in greater detail by the LaPointe Treaty of 1854. Copper miners and prospectors immediately took advantage of the new mining rights since low grade copper oxide ore had been discovered along the Nemadji River and in the area that would become the city of Superior. The mining activities were crude and lasted only a decade or so due to the poor grade of the ore (Flower, 1890).

While the fur trade played a large role in the early days of the region, commercial trade and shipping provided the major impetus for the growth of Duluth and Superior. In 1855, the excavation of the Soo Canal around the rapids at Sault Ste. Marie was completed. This canal opened up Lake Superior and permitted waterborne shipment of freight and passenger traffic the length of the Great Lakes. With the promise of potential wealth from Great Lakes shipping, speculators from St. Paul traveled to the Superior area in 1853, plotted the city of Superior, and claimed ownership of Wisconsin Point so as to control the entrance to the harbor (Flower, 1890). From 1856 to 1859, a total of 11 townsites were plotted within the present city limits of Duluth. It wasn't until 1870, however, when the Lake Superior and Mississippi River Railroad from St. Paul to Duluth was completed, that Duluth could boast a sizable population (ARBC, 1976). Superior wasn't incorporated as a village until 1887 (Flower, 1890).

To support the expanding shipping industry, early improvements were made to the natural harbor and its entrance. In 1857, the federal government built a lighthouse at the entrance to the harbor at Wisconsin

Point. In 1867, the harbor entrance was stabilized and dredging was done to deepen the channel (Flower, 1890). In 1871, the City of Duluth excavated the Duluth Ship Canal to provide an alternate entrance to the harbor. In 1873, administration of the Ship Canal was taken over by the federal government. The canal was reconstructed with piers and rip-rapped (U.S. Army, 1940). Over the last 134 years, the Duluth-Superior harbor has continuously been modified to accommodate the increasingly larger ships using the Great Lakes.

Logging was underway by the 1800's when August Zachau constructed a mill to produce the lumber required to build Superior's Pioneer Hotel. Two years later Henry W. Wheeler built Duluth's first sawmill. By the late 1800's, Duluth was the hub of North America's premier white pine logging operation producing over 1 billion board feet/year of which about half was produced in Duluth's sawmills. It was really with the growth of the logging industry that the nature of the Duluth-Superior harbor began to change. While there is no exact count it is estimated that there were between 50 and 100 dams along the St. Louis River during the 1800's to serve the logging industry.

Northern Minnesota's mining industry had a short early flirtation with a gold rush in 1865-66. By 1873, Duluth had an iron-making capability; the Duluth Blast Furnace Co. had built a small operation on Rice's Point. In 1888, the Standard Iron Works and West Superior Iron and Steel Company foundries were established in Superior. In 1890, the Duluth Iron and Steel Co. created a plant which became the West Duluth Blast Furnace Co. and Zenith Furnace Co. This site would eventually become the Interlake Iron operation which is currently a Superfund site on and adjacent to property now operated as Hallett Dock #6. The Zenith blast furnace operation produced some 60,000 tons of pig iron and installed 65 coke ovens in 1904. Over the years, Duluth has had some 14 blast furnaces, foundries and steel mills.

The grain trade early on provided employment in the area. Duluth's first grain elevator, located at the foot of 5th Avenue East, was completed in 1871 at nearly the same moment the Duluth Ship Canal opened for ship passage. Subsequent elevators and accompanying grain milling operations were constructed in the harbor, the Duluth Imperial Mill having a capacity of up to 12,000 bushels a week. The first Superior grain elevators were the Great Northern Elevators and the Sawyer Elevator system established in 1886 and 1887, respectively (Flower, 1890).

Shipbuilding in one form or another has been occurring continuously in the harbor. In just one four-year period, 1888-1892, over thirty "whalebacks" were built by Captain Alexander McDougall for use on the Great Lakes. The first five whaleback steamers were constructed at the existing Robert Clark shipyard in Duluth. Requiring larger quarters for his shipbuilding, McDougall began construction of the American Steel Barge Company in Superior in 1889. The shipyard was built on a filled dry dock facility on adjoining property. At the time, this was the largest dry dock on the Great Lakes (Wright, 1969). During WWII, some 230 ships were built by eight different shipyards in the Duluth-Superior Harbor.

However, these were not the only industries in the Duluth-Superior area. Brewing had begun in 1857 and continued, except for the prohibition period, until 1972 when the last of the three Duluth breweries, Fitgers, closed. Railway cars were manufactured by Duluth Iron Car Company and its successors from 1888 until after WWI. Prior to the widespread use of electricity, it was common to use gas light fueled by acetylene produced locally by the American Carbolite Company. About 300 workers produced as much as 12 million cubic feet of acetylene gas/day during the early part of the century. Beginning in 1908, the Duluth Showcase Company, eventually to become the Coolerator Company, began building first, iceboxes, and eventually refrigerators. It was eventually closed in the mid-1950's. The area also produced flax, much of which was used by the Klearflax Looms Company to weave carpets, towels and other items.

At its peak, it employed over 300 workers. Duluth also boasted the Duluth Shoe Company, started in 1890, and its successors, which produced shoes, boots, figure and hockey skate shoes, and other items. While not competing with Cuba in producing "stogies," Duluth's H. Oswald Cigar Co. was in operation in 1869 and was followed by a number of cigar and cigarette makers the last of which operated until the late 1930's. The largest of these, the Ron-Fernandez Cigar company, employed as many as 125 persons.

Superior also supported a variety of industries. Fine quality coke produced by the Lehigh coal and Iron Company of Superior was shipped to Montana and other western destinations beginning in 1888. The coal was shipped to the Lehigh coal docks from mining regions around Lake Erie. This was the first enterprise of its kind in Wisconsin. Ironically, today, western coal is shipped east to Wisconsin and Minnesota. A thriving brick and tile industry flourished in Superior as early as 1882. In 1889, Standard Oil Company built a storage tank facility in Superior (Flower, 1890). This facility grew in size over the years. Eventually, it became a major petroleum refining site and for a number of years petroleum products were shipped from the Lakehead Terminal. The Murphy Oil refinery in the southern part of the city of Superior was constructed in the late 1950's and is the only active refinery in the city.

There were other industries in the area as well--candy, coffee, food, brooms, woolen fabrics and clothing, hardware manufacturing and wholesaling, bulk cargo import and export. By the 1940's, Superior had several powdered milk plants which were supplied by the dairy industry situated on farmlands around Superior (Superior Assoc. of Commerce, 1942).

All of these activities were a central ingredient in the growth of the area's population. The 1865 Duluth-Superior population is estimated at about 600. Within a half-dozen years, it had risen to over 4,000 only to drop precipitously with the failure of Jay Cooke's area investments. But by 1890, it had shot to 45,000 people, by 1900 to about 84,000, and by 1910 to nearly 120,000. The 1990 population of the Twin Ports was almost 113,000 (Superior - 27,134 and Duluth - 85,493). The St. Louis River watershed has a population just over 212,500. Forty-seven thousand of these residents live in rural areas. The population density of the watershed is 30 persons per square mile and the majority of the residents reside in the northwest and southeast sections of the watershed.

Duluth-Superior became, and has remained, a regional hub for a variety of transportation modes: highways, railroads, pipelines, aircraft, and waterborne shipping. Table III.1 summarizes the history of activities within the Area of Concern.

Table III.2	**History of Actions Influencing the Natural and Industrial Environment in the St. Louis River/Nemadji River Watersheds**
1800-1890	Transformation from marshy, island-filled estuary with Chippewa villages and Northwest Company trading posts to two cities each with a harbor, numerous shipping operations, blast furnaces, foundries, steel mills operating
1853	City of Superior platted
1856	City of Duluth platted
1861	St. Louis estuary charted

Table III.2 cont. History of Actions Influencing the Natural and Industrial Environment in the St. Louis River/ Nemadji River Watersheds

1867	Dredging of the Duluth Harbor
1868	Jetties constructed to confine river currents at Superior Entry
	Construction of the Lake Superior and Mississippi Railroad
1870-1871	Digging of the Duluth Ship Canal
1871	Dredging of the Superior Harbor
1871-1930	Introduction of railroads, 50 shipping docks, flour and lumber mills on Howards Bay and Rice's Point
1881	Initiation of coal shipping, primary docks east side of Rice's Point and along South Channel
1892	First shipment of iron ore out of Allouez Dock #1
1893	First shipment of iron ore out of DM & N Dock #1 in Duluth
1896	Dredging combined the Duluth-Superior Harbor
1899	Northwest Paper (Potlatch) Dam constructed
1900-1940's	Zenith Furnace Company, later reorganized into the Interlake Iron Company and Duluth Tar and Chemical operational at 59th Avenue peninsula area
1903-1904	USGS and Minnesota Department of Health investigation into the sources and nature of pollution
1907	Thomson Dam constructed
1909	Wild Rice Lake and Island Lake reservoirs constructed
1911	Fish Lake reservoir constructed
1915	U.S. Steel Duluth Works plant opens in West Duluth
1920	Boulder Lake reservoir constructed
1921	Knife Falls Dam constructed
1921-1970	Channel deepening, use of dredged materials for island building and land expansion, reduction in number of docks.

Table III.2 cont. History of Actions Influencing the Natural and Industrial Environment in the St. Louis River and Nemadji River Watersheds

1922	Interstate bridge constructed over St. Louis Bay to connect the cities of Duluth and Superior
1923	Scanlon Dam constructed
1923	Whiteface reservoir constructed
1924	Fond du Lac Dam constructed
1927	Harbor plus Minnesota Point available for industrial development
1928-1929	Minnesota Board of Health comprehensive pollution survey conducted in the St. Louis River, from Floodwood to Lake Superior; lower stretch of river was deemed "pollutional"
1947-48	Follow-up comprehensive pollution survey of the St. Louis River, by the Minnesota Board of Health, concluded that water quality had degraded in the past 20 years
1950	Harbor dredging included Duluth Harbor Basin, East Gate Basin, Superior Front
	Channel, Allouez Bay, Howards Bay, St. Louis Bay, and Minnesota Channel
1954	Pollution study conducted by the MN State Board of Health; fish kill reported in Silver Creek and attributed to phenols from Wrenshall Oil Refinery
1956	Fish kill reported at Thomson Dam; samples with high concentrations of sulphate ions and chlorides collected at Thomson Dam and Scanlon
1958	Recreational and natural environment concerns recognized; fish kill reported in the vicinity of Fond du Lac
1960s	Continued industrial development and natural environment concerns
1961	Minnesota Department of Health released a water quality report on the St. Louis River which deemed coliform bacteria and dissolved oxygen levels unacceptable; further study was recommended
	City of Superior Common Council adopted a resolution for the immediate need to eliminate pollution in adjacent waters
1962	Samples with high concentrations of sulphate ions and chlorides collected at Thomson Dam and Scanlon
1967	Federal Water Pollution Control Administration published a report recommending construction of secondary treatment plants to reduce nutrient loading

Table III.2 cont. **History of Actions Influencing the Natural and Industrial Environment in the St. Louis River/Nemadji River Watersheds**

1967	Minnesota Department of Natural Resources fisheries-potential investigation found the lower St. Louis River offered poor fisheries habitat
1969	Wisconsin Department of Natural Resources conducts walleye study documenting migratory habits of St. Louis River walleye
1971	Minnesota State Legislature approved the creation of the Western Lake Superior Sanitary district (WLSSD)
1975	Water quality field measurements taken by the Center for Lake Superior Environmental Studies, University of Wisconsin-Superior, determined numerous areas to be aesthetically unattractive and having degraded water quality
	U.S. EPA studies described St. Louis Bay as eutrophic and classified Duluth-Superior Harbor sediments as "polluted to marginally polluted to unpolluted"
	Wisconsin Department of Natural Resources conducted an inventory of the lower St. Louis River concluding that many areas were not meeting established water quality standards
1975-1980	The nonpoint source erosion study called the Red Clay Study was conducted for the Nemadji River Watershed
1976	Swimming not recommended in the Billings Park area
1977	U.S. EPA reclassified all harbor sediments as "polluted"
1975-1977	Sewer separation, construction of CSO treatment lagoons, City of Superior Wastewater Treatment plant upgrade
1978	Western Lake Superior Sanitary District operational
	Hearding Island in Superior Bay and Interstate Island in St. Louis Bay designated as wildlife management areas
1979	U.S. Steel Duluth Works steel mill operations closed
	Walleye first stocked in St. Louis River using eggs from existing river walleyes
1981	Smallmouth bass and bluegill first stocked in St. Louis River
1982	St. Louis River/Interlake/Duluth Tar Site was placed on the National Priorities List; Asbestos removed from U.S. Steel Duluth Works Site during demolition work
1983	U.S. Steel Duluth Works wire mill operations closed

Table III.2 cont. **History of Actions Influencing the Natural and Industrial Environment in the St. Louis River/Nemadji River Watersheds**

1983	U.S. Steel Duluth Works Site was placed on the National Priorities List
	Lake sturgeon, muskellunge, and black crappie first stocked in St. Louis River
1984	Investigation of Wisconsin Point landfill, site did not rate for placement on the Superfund National Priorities List
1985	Minnesota Department of Health issues fish consumption advisories based on mercury and PCB contamination
	Wisconsin issues fish consumption advisories
	U.S. Steel signs a MPCA agreement to clean up the Duluth Works Site; contaminated water from above- and below-ground tanks discharged into sanitary sewer for treatment
1986	Asbestos removed from U.S. Steel Duluth Works Site during demolition work
	Discovery of the White Perch (*Morone americana*), an exotic species
1987	Discovery of the ruffe (*Gymnocephalus cernua*), an exotic species to the St. Louis River (First observation of the ruffe in North America)
1989	Discovery of the zebra mussel, an exotic species to the St. Louis River
	Remedial Action Plan Citizens Advisory Committee initiated
	Federal Energy Regulatory Commission relicensing process for St. Louis River dams
1990	Remedial Investigation report complete from the St. Louis River/Interlake/Duluth Tar Site
1991	Ruffe most abundant fish species in St. Louis estuary

F. THE CUMULATIVE RESIDUE

There is no clear documentation on how the various constituent units of the Duluth-Superior area handled their solid and liquid wastes prior to the last two decades. It is evident from recent analyses of river and harbor sediments, water samples, and soils, that waste management was not a major concern. It is apparent from what we now know of the Interlake Iron-Duluth Tar and Chemical and the U.S. Steel sites that a great deal of waste was disposed of along the shore and directly in the river and harbor.

It has been established that a number of firms discharged directly and indirectly into the river or bay. U.S. Steel, Superwood, R.J. Reynolds, Minnesota Power, and Fitger Brewing are specifically identified, but periodic findings of others have been reported. In addition, a review of the wastewater treatment facilities in the early 1970's of the area revealed that Duluth's four main primary treatment plants had a design capacity of approximately 13.5 million gallons per day (mgd), but an average daily flow of 18.5 mgd. It is assumed that the overflow was discharged into the bay. Known upstream discharges include Northwest Paper, Conwed Corporation, Diamond National Corporation, Continental Oil Company, Conoco Refinery, and Nopeming Nursing Home (previously a tuberculosis sanitarium), as well as discharges from the municipal wastewater treatment plants (WWTP) at Cloquet, Carlton, Scanlon, Esko, and Wrenshall.

Despite the fact that since the mid-70's water quality of the river and harbor has improved, the cumulative effects of years of unbridled waste disposal in the river and bay area has earned us a ranking of one of the 43 "Areas of Concern" on the Great Lakes.

G. HISTORY OF INVESTIGATIONS, MANAGEMENT NEEDS, AND ACTIONS

The water quality of the St. Louis River watershed has followed a trend typical of development patterns. A commercial fishery was supported on the St. Louis River in the late 1800's during which time the marshy, island-filled estuary developed into a harbor area supporting shipping operations for both Duluth and Superior. The harbor was first dredged in 1867, the Superior Entry modified in 1868, and the Duluth Ship Canal completed in 1871. The late 1800's into the 1940's supported increased shipping and industrialization. Industrial activity reported in the Lake Superior region included five sawmills, a paper mill, two pulp mills (operated by Northwest Paper Company) all located in Cloquet along the St. Louis River. General industries listed for the area included breweries, gas works, paper mills, sawmills, tanneries and woolen mills. The lower St. Louis River has been developed for production of hydroelectric power since 1907. There are four public utility hydroplants and one industrial hydroplant on the river. Five storage reservoirs are used to regulate streamflow for the operation of the power dams.

The first series of water quality samples collected in the St. Louis River basin were taken in the winter of 1903 and continued seasonally through the winter of 1905 (USGS, 1906). The St. Louis River was sampled above major sources of pollution at Cloquet, just above the paper mill which was below the village, and at Scanlon three river miles below Cloquet. Comparison of the three samples showed them to be almost identical in organic content. The similarity was attributed to the water being full of logs along the entire sampling stretch. Notes on municipalities include:

> Carlton: No waterworks or sewage. Ice supply cut from a mill pond on Otter Creek and from Chub Lake. Garbage hauled to village dumping ground and burned.
>
> Cloquet: No public waterworks. Ice supply is cut from St. Louis River above the village. Sanitary sewerage discharges into the St. Louis River. Garbage is hauled to dumping grounds away from the village and burned.
>
> Duluth: Water supply is unfiltered Lake Superior water. Ice supply is obtained from Spirit Lake and Lake Superior. Separate sanitary and storm sewerage discharge into Lake Superior. Garbage formerly dumped on the bayfront, but a modern crematory was being installed.
>
> Proctorknott: On Kingsbury Creek which enters St. Louis Bay. No waterworks or sewerage. Ice supply cut from Kingsbury Creek.
>
> Scanlon: No waterworks or sewerage. Ice is shipped from Cloquet. Garbage is collected and deposited outside village limits.

A second series of studies was conducted by the Minnesota State Board of Health. The first comprehensive pollution survey of the St. Louis River, from Floodwood to Lake Superior, was conducted in 1928-29. The stretch of river from the Swan River tributary to Cloquet was considered to have "satisfactory" water quality levels, while the Cloquet to Oliver Bridge section was deemed "pollutional." Beach closings in St. Louis Bay due to high bacterial counts followed the publication of the survey results.

A follow-up study in 1947-48 was conducted by the Minnesota State Board of Health to assess changes over the 20-year period. The survey included chemical, biochemical, and bacteriological sampling. Treatment plants for sewage and industrial waste had been added to some communities along the St. Louis. The study concluded that the sanitary quality of the water had deteriorated in the past 20 years and that recreational use of the river had been curtailed. The section of river from Cloquet to Fond Du Lac had seen an increase in domestic and industrial use with no facilities for waste treatment installed in the last 20 years. An increase in sludge deposits and virtual depletion of oxygen in some areas was observed. The area below Fond Du Lac had been aided by installation of a sewage treatment plant in Duluth.

The next water quality survey was conducted approximately 20 years later in 1961. The Minnesota Department of Health observed the physical, bacteriological, chemical and biochemical status of the St. Louis River. Physical parameters noted included water that was both turbid and colored, oil slicks, and areas of emergent and submerged aquatic vegetation. Shoreline investigations showed no visible evidence of unsanitary conditions with sewage treatment plant outfalls appearing to be in satisfactory condition. Bacteriological studies showed the Billings Park area to have relatively low coliform counts; relatively high counts were collected just below the Arrowhead Bridge and at the sewage treatment outfalls. Dissolved oxygen levels measured in the lower St. Louis River above the Interstate Bridge were below the acceptable level of 4 mg/l for propagation of fish. Further studies were recommended.

A 1967 report published by the Federal Water Pollution Control Administration Great Lakes Region Office defining the water pollution needs of the St. Louis River basin cited construction of secondary sewage plants to reduce nutrient loading, e.g., nitrites and phosphates, as a critical need. Specific recommendations included:

- "The City of Superior eliminate...discharges of untreated sewage due to storm and clear water additions..."
- "The City of Duluth...effectively process untreated sewage that is now discharged..."
- "Separate storm and sanitary sewer systems be built for all communities requiring new or rebuilt systems..."
- "Industries treat wastes to such an extent as is necessary to maintain stream conditions suitable for limited contact recreational use and protection of aquatic life."

Problem areas identified were inadequate treatment of sanitary wastes in the upper St. Louis River basin and inadequate treatment of sanitary wastes, waterfront industrial discharges, combined sewer system in Duluth, and ship refuse and effluents in the lower St. Louis River basin.

A fisheries-potential investigation conducted in 1967 concluded that the lower St. Louis River offered poor fish habitat. The report also noted that "fish caught in the river reportedly have a very strong flavor and are scarcely edible without strong seasoning." A series of studies were conducted in 1975 by the Center for Lake Superior Environmental Studies (UWS, 1976) to provide background information regarding selected aspects of biota in the St. Louis River. The general conclusions based on the fish, benthic and macrophyte parameters studied were that the area ranged from aesthetically not attractive with degraded water quality, to areas with water quality which supported aquatic vascular plants and game fish.

An inventory of the lower St. Louis River was conducted in 1976 by the Wisconsin Department of Natural Resources. Areas which had not met established water quality standards (pH, dissolved oxygen, temperature, ammonia, fecal coliform) were identified. Lake Superior seiches, shipping, nonpoint runoff, atmospheric fallout, industrial discharges, wastewater treatment plants, and dredging were cited as factors affecting the water quality of St. Louis Bay and the St Louis River. Areas not meeting the standards included Pokegama Bay, Winter Street Drainageway, St. Louis River, St. Louis Bay, Superior Bay, Newton Creek, and Bear Creek as well as others that are out of the AOC. Several industries which were reported to have recently upgraded their wastewater treatment systems included Murphy Oil, Superior Fiber Products, Chicago and Northwestern, and Koppers Company, although it was noted that the 1973 limits for industrial dischargers were not based on the upcoming 1983 Best Available Technology (BAT) standards.

The Western Lake Superior Sanitary District (WLSSD) was created by the Minnesota legislature in 1971 with a mandate to reduce the pollution levels of the St. Louis River and subsequently Lake Superior. The WLSSD facility was constructed in the late 1970's and combined virtually all of the Minnesota industrial and municipal discharges in the area. The tertiary treatment plant treats wastes from seven cities, ten townships, and seven major industries. In the mid 1970's, the City of Superior underwent a sewer separation project and upgraded its wastewater treatment facilities.

Sampling by the WDNR for toxic contaminants in St. Louis River fish began in 1970. In December 1970 the Minnesota Department of Conservation advised limiting fish consumption to one meal per week on the St. Louis River from Cloquet to Lake Superior. Wisconsin fishermen were also advised to observe this consumption caution (WDNR, 1972).

In 1979-1981 the Wisconsin Department of Natural Resources conducted a systematic and comprehensive survey of 16 toxic substances in Wisconsin's coastal zone (Sheffy et al., 1981). "None of the fish samples [collected] from the Lake Superior basin [during the 1979-1980 study year] were found to contain excessive amounts of chlororganic compounds. PCB levels were slightly higher in the Superior Entry area...but these levels do not represent a problem." Samples collected in the 1980-1981 study year supported the previous claim that "no contamination problem exists" in the Lake Superior basin. Sediment samples from the Superior Harbor and the St. Louis River showed 0.12 (0.06-0.29) ppm PCB contamination.

A 1980 <u>Fins and Feathers</u> article discusses the "dramatic comeback" of the walleye fishery in 1979. The author remembers back to 1969 when the St. Louis was "dirty," the fish "usually stank" and had "yellow bellies." Recent walleyes caught have all been eaten and "taste fine" vouches the author. In the summer of 1979, walleye fishing season lasted well into August. At the conclusion of the article, the merits of fishing for northern pike in the Duluth Harbor Basin, Pokegama Bay and Kimball's Bay are pointed out.

The Minnesota Department of Health published fish consumption advisories in 1985 based on mercury and PCB contamination (MDH, 1985). The Minnesota Department of Transportation provided toxic sediment concentration data in their Draft Environmental Impact Statement for the Arrowhead Bridge (MDOT, 1979). Fish consumption advisories were also issued in 1985 by Wisconsin for the St. Louis River below Fond Du Lac.

The MPCA conducted a survey of the impact of WLSSD on the water quality of the St. Louis River (McCollor, 1990). Selected chemical water quality variables were compared for the periods prior to 1978 and following the implementation of WLSSD after 1978. Overall water quality parameters have improved. Trend analysis indicated that the change over time could be attributed to the combining of historical point discharges into the WLSSD. Frequencies of water quality standards violations decreased over the period.

The current status of the St. Louis River and Duluth-Superior harbor includes fish consumption advisories issued by Minnesota and Wisconsin based on mercury and PCBs, identification of two Superfund hazardous waste sites in various stages of study and remediation, and continued debate over the "contaminated" status of the sediments.

IV. DESCRIPTION OF THE PROBLEMS

A. IMPAIRED USES, CAUSES OF IMPAIRED USES

Chapter IV discusses each of the beneficial uses identified by IJC as listing/delisting criteria for Areas of Concern. The application of these criteria to the St. Louis River AOC is summarized in Table IV.1.

Table IV.1 IJC Impaired Use Criteria Summary for St. Louis AOC

Impairments Identified in AOC

IJC Criteria	Reason	Comments
Fish Consumption Advisories	Advisories issued by MN and WI	PCBs, Dioxin, Mercury
Degraded Fish Populations	Impact of ruffe (exotic fish species)	-
Degraded Wildlife Populations	Decline in threatened and endangered species	-
Fish Tumors and Other Deformities	Observations in 1991 (harbor) and 1985 (Crawford Creek)	Data on incidence of tumors and deformities needed
Degradation of Benthos	Documented at Stryker Bay and Hog Island/Newton Creek	Surveys are needed to document extent of problem in AOC
Restrictions on Dredging	Contaminated sediment	Data lacking for many parts of AOC
Excessive loading of sediments and nutrients to Lake Superior[1]	High sediment/nutrient load from AOC to Lake Superior	-
Beach Closings/Body Contact	Sewage bypasses	Probable site specific bacterial problems from bypasses, spills, etc.
Degradation of Aesthetics	Aesthetics of water degraded by oily materials at Styrker Bay/ Interlake and at Hog Island/ Newton Creek	Other areas may have aesthetic impairment
Loss of Fish and Wildlife Habitat	Documented loss of habitat at Styrker Bay and Hog Island due to contamination	Continuing loss of physical habitat limits populations

Table IV.1 cont. IJC Impaired Use Criteria Summary for St. Louis AOC

Impairment Not Clear

IJC Criteria	Reason	Comments
Fish Tainting	Historical problem, currently conflicting evidence	Clarify existence or extent of problem in Stage II
Bird or Animal Deformities or Reproductive Problems	Low reproductive success in common terns - reasons not clear. Potential factors include toxics, competition, physical habitat loss.	Additional data on toxics in terns and other species needed

Not Impaired Currently

IJC Criteria	Reason	Comments
Wildlife Consumption Advisories	No advisories issued	Limited data
Restrictions on Drinking Water Consumption	Drinking water not taken from AOC	Concerns for spills
Eutrophication or Undesirable Algae[2]	High nutrient levels but no evidence of eutrophication	High nutrient loading to Lake Superior is of concern
Added Costs to Agriculture or Industry	No impairment currently	Zebra mussel could cause problems
Degradation of Phytoplankton and Zooplankton	No evidence of impairment	Future impairment possible due to exotics (BC and zebra mussel)

[1] Adaptation of IJC eutrophication criteria to fit local conditions
[2] IJC eutrophication criterion not impaired, see "Excessive Loadings" criterion

B. FISH CONSUMPTION ADVISORIES

IJC Listing Criteria: When contaminant levels in fish or wildlife populations exceed current standards, objectives, 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.

Is the Beneficial Use Impaired? Yes

Fish samples taken from the St. Louis River and Lake Superior exceed standards established by Minnesota and Wisconsin for the unrestricted consumption of sport fish. Each of the two states issue consumption advisories for various population groups, based on fish species and size classes. Advisories are collectively issued for the presence of mercury and polychlorinated biphenyls. Fish tissue residues of mercury and polychlorinated biphenyls also exceed the .5 mg/kg and .1 mg/kg standards established in the 1978 Great Lakes Water Quality Agreement for the protection of aquatic life and fish consuming birds.

1. Tissue Contamination

Issuance of sport fishing consumption advisories on the St. Louis River represents a primary reason for its designation as an AOC. Sport fishing consumption advisories are not unique to this region; there are some 34 other AOCs which have also been listed by IJC for the existence of fish advisories or biological impacts (Environment Canada and U.S. EPA, 1987). A number of past sampling efforts carried out by Wisconsin and Minnesota document the presence of heavy metals and chlorinated organic compounds in fish tissue. Appendix B contains listings of the tissue analyses of fish collected from the AOC by the two states since 1978. Trace amounts of several metals and organic compounds were found in numerous instances but the main contaminants of concern for this area are mercury and polychlorinated biphenyls (PCBs).

All the fish species sampled and analyzed during this period contained some level of mercury. Values ranged from 0.02 mg/kg to 1.4 mg/kg. Higher levels of mercury are usually found in the larger predatory gamefish of an ecosystem, and indeed this is the case for the St. Louis River system. Walleye over 18 inches in length exhibited mercury concentrations ranging from 0.31 to 1.4 mg/kg. Mercury as a contaminant in fish tissue tends to be evenly distributed throughout the musculature of the fish.

PCBs and other organic contaminants in fish tissue tend to be concentrated in fatty tissue deposit areas of the fish. In general, larger fish have higher levels of organic contaminants than smaller fish. PCB concentrations in fish sampled from the AOC ranged from below lab detection level to a high of 3.6 mg/kg.

Dioxin contamination has also been documented in a number of fish collected from the AOC. In 1984 and 1986, fish sampled in Superior Bay contained dioxin at levels ranging from below lab detection level to 8.2 pg/g. Carp and a turtle taken from the Nemadji River in 1984 and 1985 also contained dioxin.

A number of inorganic and organic substances detected in St. Louis River AOC fish tissue exceed specific objectives of Annex 1 of the Great Lakes Water Quality Agreement of 1978. Annex 1 specifies that fish tissue residues of mercury should not exceed 0.5 mg/kg and residues of PCBs should not exceed a standard of 0.1 mg/kg. Larger walleyes from the AOC have routinely exhibited concentrations of mercury over the 0.5 mg/kg standard. One northern pike sample has also tested over this level; however, the smaller fish and non-predator fish generally contain mercury residues less than the 0.5 mg/kg standard. PCB levels have exceeded the .1 mg/kg Annex 1 standard consistently over the period of 1978 through 1986. Although the data (Appendix B) is not directly comparable, average fish tissue PCB concentrations in white sucker and shorthead redhorse were .45 mg/kg and .33 mg/kg. The average PCB tissue residues in walleye and northern pike (skin on fillets) were 1.34 mg/kg and .45 mg/kg respectively. Individual walleye and northern samples taken in 1982 exhibited PCB concentrations of 2.2 mg/kg and 3.6 mg/kg, respectively (although these are not indicative of typical concentrations). TCDD has also been detected in three fish tissue samples taken from the AOC. Annex 1 does not contain specific standards for TCDD.

2. Consumption Advisories

Minnesota and Wisconsin have each taken steps to manage health risks associated with consuming St. Louis River AOC fish. Minnesota issues a sport fish consumption advisory for western Lake Superior and the entire length of the St. Louis River (see Table IV.2). Minnesota's consumption advice for the St. Louis River becomes more stringent for the river reaches below the City of Cloquet. Wisconsin's advisory includes Lake Superior and the lower 23 river miles it shares with Minnesota. The Wisconsin advisory generally recommends that consumers restrict or limit their intake of fish based on individual sensitivity, species of fish consumed, and size class. The advice of both states are presented to the public in pamphlet form, through a series of codes and tables.

a. Minnesota

The detection of mercury and PCBs in St. Louis River and Lake Superior fish triggered Minnesota's issuance of a consumption advisory. The advisory itself is based on quantitive risk assessment procedures derived from laboratory studies of animals. These quantitative risk assessment procedures are augmented by policy decisions in cases where data are either inconclusive or insufficient. Fish tissue residues of PCBs and polychlorinated dibenzodioxins (PCDDs) represent two such cases. PCBs contain residues of congeners (Aroclors) other than commercial mixtures, for which toxicity data is derived. There is little known about the toxicity of these congeners or properties of bioaccumulation. PCDDs are another similar case. TCDD represents one of the few PCDD congeners whose toxicological properties have been documented. TCDD is described as "exquisitely toxic in both acute and chronic exposures to laboratory animals" (Schubat, 1989). The LD_{50} of 2,3,7,8 TCDD orally administered to guinea pigs is a little as 2 ug/kg bw (Smith et al., 1988). Ingesting fish contaminated with PCBs and TCDD remains a matter of considerable scientific and policy disagreement. As a result, the advisories are in a continual state of change as new scientific data becomes available or as risk management strategies are further refined.

As a consequence of industrial poisonings such as the Japanese incident at Minamata Bay, the toxicological and human health implications of mercury are well understood and documented. At Minamata Bay, a chemical factory that used mercury as a catalyst in the production of acetaldehyde was identified by the Japanese government as the source of an epidemic that ultimately resulted in the death of 50 people (Thurman, 1983). The form of mercury thought to be responsible for the Minamata Bay incident and of concern in inland waters is methylmercury. Methylmercury is a neurotoxin whose symptoms can include: a lack of coordination; a pins and needles feeling; numbness of lips and mouth; night blindness; an obscured field of vision; tremors; a general loss of taste or smell; and in extreme cases, debilitation and death (Ontario MOE, 1986). Minnesota and Wisconsin have developed consumption advice designed to prevent the onset of even the earliest stages of mercury poisoning. In the State of Minnesota, this consumption advisory provides guidance for three consumption patterns for specific species and size classes of fish. Guidance issued for the various fish species and corresponding consumption levels for the St. Louis River and Minnesota waters of Lake Superior are listed in Table IV.2.

Table IV.2 Minnesota Fish Consumption Advisories for the St. Louis River

Table IV.2 cont. Minnesota Fish Consumption Advisories for the Area of Concern

Note: A more complete discussion of considerations used in developing Minnesota's fish consumption advisory can be obtained by contacting the Minnesota Department of Health, the Minnesota Pollution Control Agency, or the Minnesota Department of Natural Resources. The Minnesota Fish Consumption Advisory itself is available to the public through a number of Minnesota agencies.

b. Wisconsin

Wisconsin issued its first fish advisory in the late 1960's when concentrations of mercury in Wisconsin River fish were found to exceed federal guidelines. About 1976, Wisconsin issued a PCB advisory for Lake Michigan trout and salmon. Currently, these two contaminants are responsible for nearly all of the consumption advisories issued on Wisconsin waters. Two agencies (Department of Health and Social Services (DHSS) and the Department of Natural Resources (DNR)) share responsibility for the development and implementation of the state's sport fish consumption advisories. The goal of the advisories is to reduce public exposure to toxic chemicals through voluntary compliance with prudent health advice. Continuity from year to year and consistency between the advisories for the Great Lakes and inland waters and between sport and commercial fish are stressed. The Wisconsin fish consumption advisories are listed in Table IV.3.

1) Structure of the Fish Consumption Advisory

Wisconsin's advisory is organized in two sections; 1) organic contaminants, and 2) mercury contamination. Fish that contain organic contamination (primarily PCBs) are placed in one of the three categories. Categorization is based upon the percentage of samples of a particular species that exceed the U.S. Food and Drug Administration (FDA) criteria. (See Table IV.3)

Where fish exceed FDA criteria in greater than 50% of the samples, DHSS recommend no consumption (Group 3). The "sensitive" group (i.e. women and children, etc.) are advised not to consume fish where 10%-50% of the samples exceed the criteria (Group 2). Fish that contain detectable levels of organic

Table IV.3 Wisconsin Fish Consumption Advisories for the Area of Concern

LOCATION	CONTAMINANT	FISH SPECIES	FISH LENGTH				
			<10"-18"	18"-22"	22"-26"	26"-30"	>30"
St. Louis River Including Superior Harbor	Mercury	Walleye	Group 1 Advisory	Group 2 Advisory	Group 3 Advisory	Group 4 Advisory	---
Lake Superior	PCBs	Lake Trout	Group 1 Advisory	Group 1 Advisory	Group 1 Advisory	Group 1 Advisory	Group 3 Advisory
	Chlordane	Siscowett	< 20" Group 1 Advisory		> 20" Group 3 Advisory		

KEY: Mercury

Group 1: Pregnant women should eat no more than 1 meal/month. Everyone else may eat unlimited amounts of these fish. Skin-on fillet samples average 0.5 ppm mercury or less.

Group 2: Pregnant or breastfeeding women, women who plan to have children, and children under 18 should not eat these fish. Everyone else should eat no more than 26 meals of Group 2 fish/year. Eat no more than 13 of these 26 meals in any one month. Space the remaining meals over the rest of the year at a rate of 1-2 meals/month. Skin-on fillet samples average 0.5 to 0.75 ppm mercury.

Group 3: Pregnant or breastfeeding women, women who plan to have children, and children under 18 should not eat these fish. Everyone else should eat no more than 13 meals of Group 3 fish/year. Eat no more than 7 of these 13 meals in any one month, and space the remaining 6 meals over the rest of the year at a rate of 1 meal/month. Skin-on fillet samples average 0.75 to 1.0 ppm mercury.

Group 4: No one should eat Group 4 fish. Skin-on fillet samples contain an average mercury level >1.0 ppm.

PCBs and pesticides

Group 1: Contaminant levels in 10% or less of tested fish are higher than one or more health standards. Eating Group 1 fish poses the lowest health risk. Trim fat and skin from fish before cooking and eating them.

Group 2: Contaminant levels in >10% but <50% of tested fish are higher than one or more health standards. Children under 15, nursing mothers, pregnant women, and women who anticipate bearing children should not eat these fish. Limit overall consumption of other Group 2 fish, and trim skin and fat from fish before cooking and eating them.

Group 3: Contaminant levels in 50% or more of these fish are higher than one or more health standards. No one should eat Group 3 fish.

Table IV.4 FDA and Wisconsin Standards for Sport Fish Contaminants

PCBs	2 parts per million (ppm)
DDT	5 ppm
Toxaphene	5 ppm
Chlordane	0.3 ppm
Dieldrin	0.3 ppm
Mercury	0.5 ppm
Dioxin	10 parts per trillion

contaminants but significantly below the criteria are listed in Group 1 with no specific consumption advice. This is the same approach that all states bordering Lake Michigan have adopted. Thus, Wisconsin has placed a strong effort in maintaining a relationship between the sport fish advisories covering the Great Lakes, rivers and inland waters, commercial fishery licensing requirements, and the standards developed by the FDA for fish shipped interstate.

DHSS agrees that it is difficult to accurately quantify the potential adverse health impacts from contaminants in sport fish and translate them into "safe" consumption rates. DHSS has interpreted the toxicological data to indicate that the lower the exposure, the lower the risk of an adverse effect. Therefore, Wisconsin advises sport fishermen who are concerned about potential risks associated with contaminants, to eat only Group 1 fish. Table IV.3 summarizes the health advice for PCB and pesticide contamination in fish.

The mercury advisory is based upon the risk assessment model developed by DHSS in 1986 (Anderson and Olson, 1986). Recommended meal frequencies are determined when mercury levels exceed 0.5 mg/kg. Table IV.3 summarizes the health advice for mercury-contaminated fish.

2) Fish Species Involved in the Wisconsin Fish Advisory

The St. Louis River is presently listed on the Wisconsin fish advisory for walleye. Fish over 18 inches have consistently tested over 0.5 mg/kg mercury. The St. Louis River Walleye fishery is characterized by an abundant spawning population in the Fond du Lac area in spring. After spawning, the adult walleye disperse downstream throughout the estuary. Dispersal takes place at an extremely variable rate with some walleye spending lengthy periods of time in the St. Louis estuary and others moving throughout Western Lake Superior.

The St. Louis River walleye population makes up the bulk of the Western Lake Superior walleye fishery. For this reason, and because of confirming test results, the Wisconsin fish advisory has been extended to include walleye in the Wisconsin portion of Lake Superior.

Since 1980, 53 walleye have been collected by the Wisconsin DNR from the St. Louis estuary for mercury analysis. An additional 17 walleye have been collected from the Western Lake Superior area. Figure IV.1 graphically depicts the length vs. mercury (Hg) concentration relationship of walleyes collected by the WDNR for the St. Louis River and western Lake Superior. Figure IV.2 displays length/mercury concentration relationships for walleye from five inland lakes in Douglas County, Wisconsin, within the

Lake Superior drainage basin. These lakes: Amnicon, Dowling, Lyman, Minnesuing, and Nebagamon have mercury advisories for walleye. A comparison of Figures IV.1 and IV.2 indicates that mercury levels in St. Louis River walleye are comparable to levels in fish taken from regional inland lakes that have fish advisories.

The only fish species from Lake Superior on the PCB and pesticide portion of the Wisconsin fish advisory is lake trout. Larger fish (> 30") of this species contain PCB levels over the 2.0 ppm level set by the U.S. Food and Drug Administration and utilized to generate the Wisconsin health advice categories. Siscowett ("fat lake trout") were added to the advisory list in 1990 because of concern over chlordane levels. This impairment is probably a lake-wide problem not related to source loading from the St. Louis River. Lake trout are not listed in the St. Louis River portion of the Wisconsin Fish Advisory because they are not usual residents of the estuary. Any lake trout incidently caught in the St. Louis River should be considered under the criteria of the Lake Superior Advisory. Figure IV.3 graphically shows the length/PCB concentration relationship of the lake trout population in Western Lake Superior.

Figure IV.1

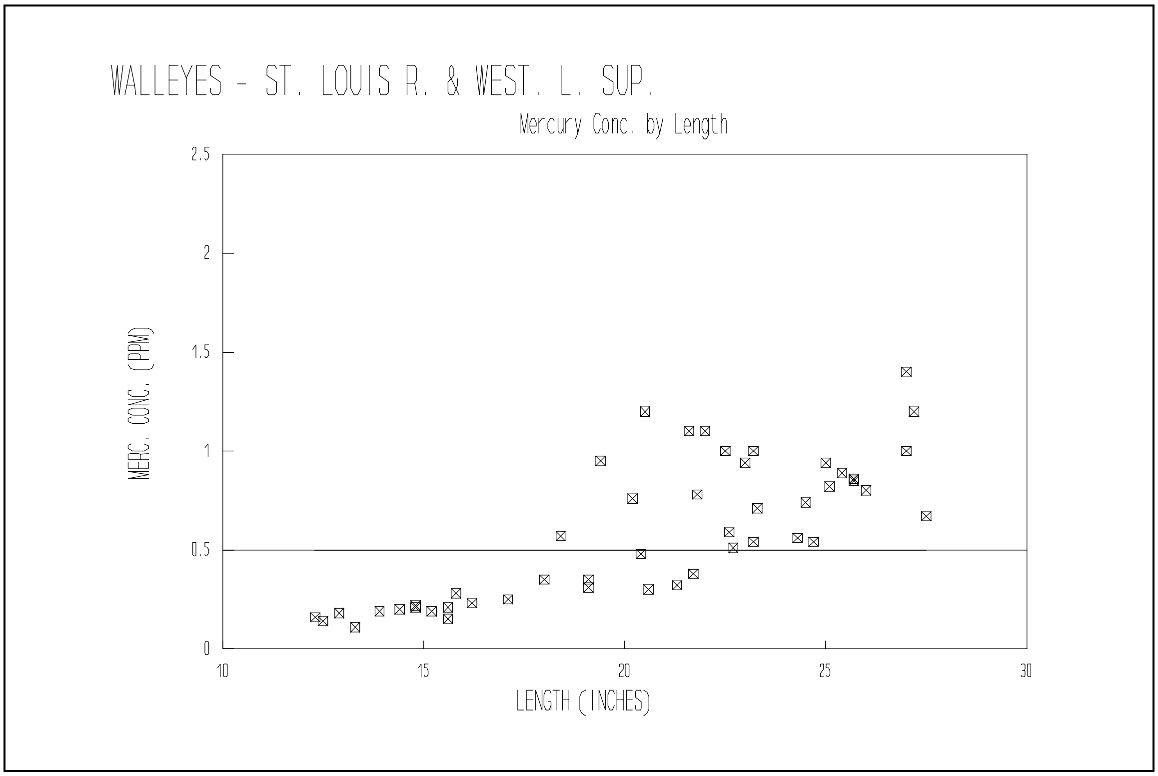


Figure IV.2

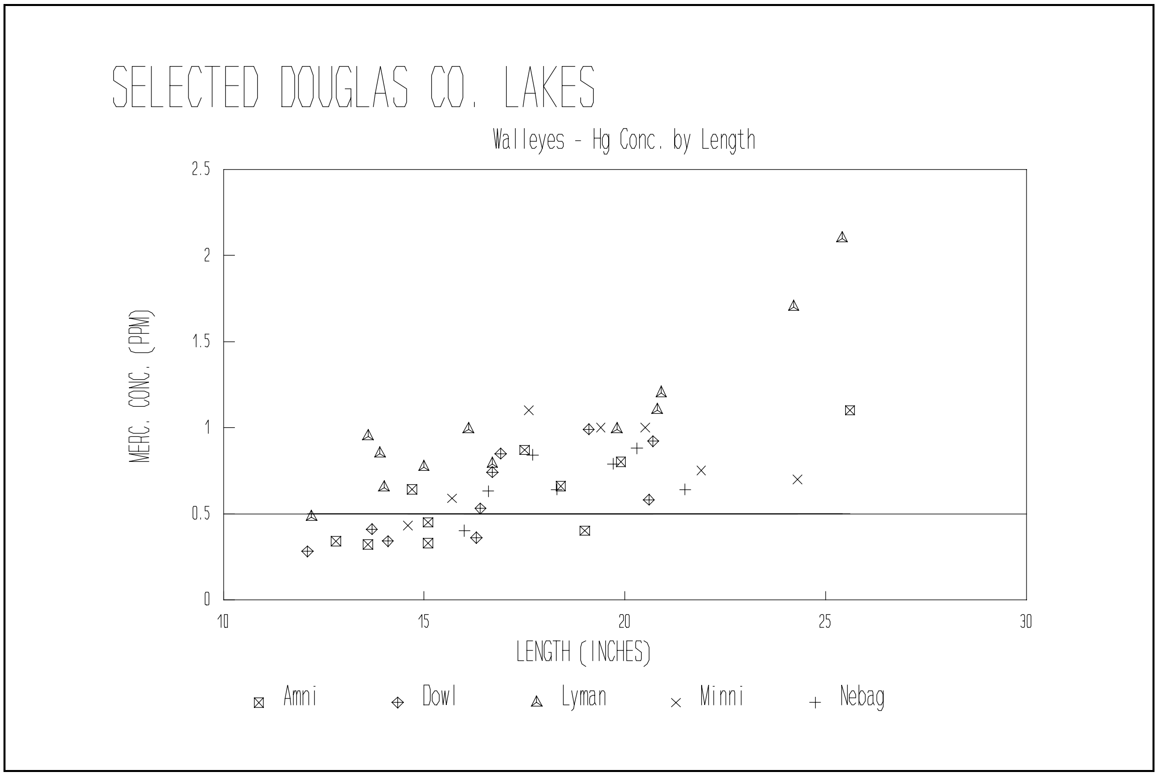
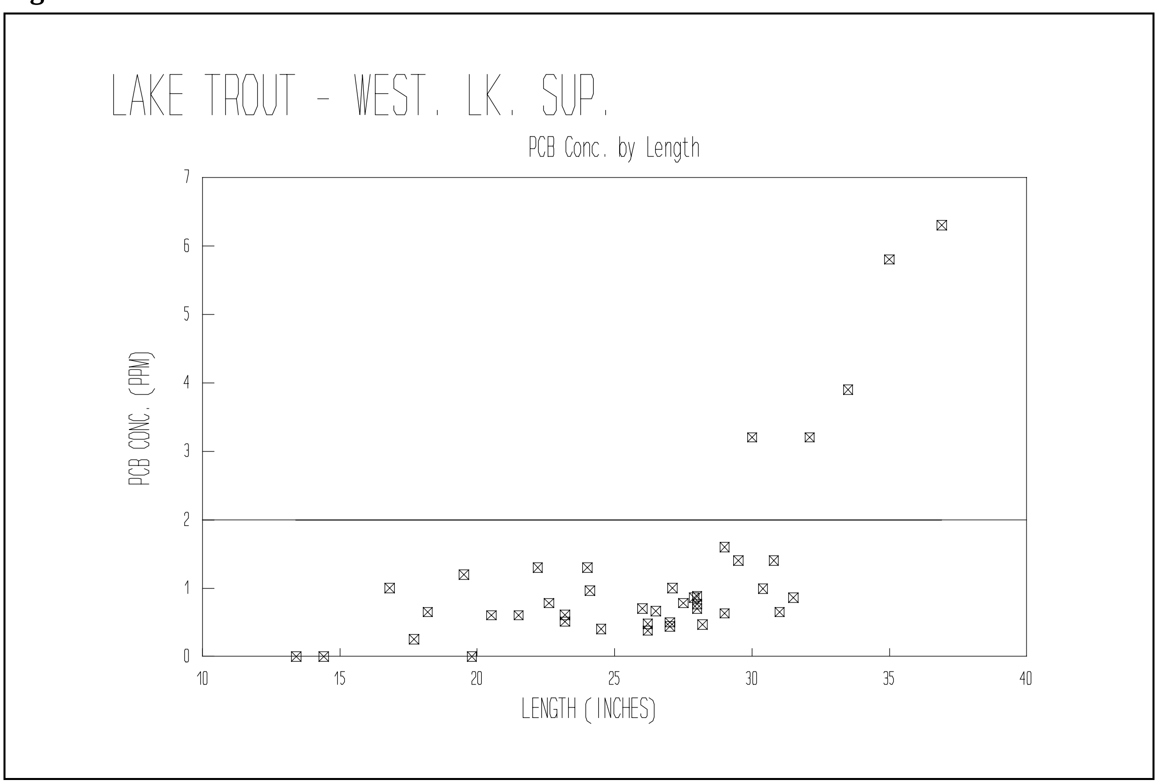


Figure IV.3



Since 1980, over 200 fish have been collected by the Wisconsin Department of Natural Resources from the St. Louis River estuary and analyzed for toxics contamination. Appendix B lists these fish and their corresponding tissue analyses.

c. Conflicting State Fish Consumption Advisories

Minnesota and Wisconsin share major boundary waters (St. Croix River, St. Louis River, Mississippi River, Lake Superior) in which many of the important commercial and sport fish contain toxic contaminants. Fish are regularly monitored by each state to assist in the evaluation of pollution control efforts and determine potential human health risks associated with fish consumption.

Public health consumption advisories are issued by both states for the Mississippi, St. Louis, and St. Croix Rivers and for Lake Superior, primarily due to PCB levels and mercury found in fish tissue. However, the two states issue different consumption advice to the public for those fish caught in boundary waters. Both states should make it a priority to develop uniform methodologies to assess health risks and issue uniform advisories.

C. WILDLIFE CONSUMPTION ADVISORIES

IJC Listing Criteria: When contaminant levels in fish or wildlife populations exceed current standards, objectives, 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.

Is the Beneficial Use Impaired? No

No wildlife consumption advisories are in effect or under consideration for any portion of the St. Louis River AOC. Concern exists, nonetheless, that wildlife are exposed to and may be accumulating the same range of toxic substances commonly found in area sediments or fish. There are few, if any, studies that document the dynamics of wildlife populations common to the St. Louis River AOC environment and/or the impacts of toxic substances on those species.

There are no wildlife consumption advisories in effect or under consideration for any portion of the St. Louis River AOC. Studies or surveys of contaminant concentrations in mammals and waterfowl in even the industrialized areas of the Duluth-Superior Harbor are almost nonexistent. The only information available on contaminant levels in area wildlife will come as a part of a two year project supported by Legislative Commission on Minnesota Resources (LCMR). This two year project, carried out under the auspices of the MPCA, examines the accumulation of contaminants in a variety of Minnesota's popular game and non-game wildlife species. The intent of this study was solely to survey toxic substances in wildlife; the study itself was never intended as a consumption study. A number of wing clipped mallards or sentinel ducks were released as a part of this study into an embayment area adjacent to the Interlake Steel Superfund Site and within a diked area at the Erie Pier dredge disposal facility. Surviving birds were collected in October of 1990 for tissue analyses. The results of these tissue analyses have not been made available as of this report's publication.

D. FISH AND WILDLIFE TAINTING

IJC Listing Criteria: When ambient water quality standards, objectives, or guidelines, for the anthropogenic substance(s) known to cause tainting, are being exceeded or when survey results have identified tainting of fish or wildlife flavor.

Is the Beneficial Use Impaired? Inconclusive

Informal surveys of fish and wildlife personnel, area game wardens, and recreational users, suggest that fish tainting problems in the St. Louis River are no longer pervasive or widespread problems. However, a fish tasting study and survey conducted in the 1980s raises questions as to whether this problem was simply transferred from upper river sites, where paper mill wastes were formerly discharged, to areas near the mixing zone of the WLSSD. This study correlated water column chloroform levels as indicators of fish tainting problems and of the total loading of chlororganics released into the St. Louis River.
The existence and extent of fish tainting should be investigated further in Stage II.

Tainting of fish flesh was a historical problem in the lower reaches of the St. Louis River. The major reason for the existence of this problem was that numerous industrial and municipal sources discharged effluents directly to river and bay areas over a long period of time. Effluent discharged from the Northwest Paper/Potlach mill contained a variety of phenolic compounds identified as largely responsible for the tainting and odor problems associated with river fish (SAIC, 1988). Jerome A. Blazevic, a life long resident of the City of Duluth, provides a vivid reminder of the river's pollution and fish tainting problems when he discusses fishing memories. In Blazevic's words, "walleyes are almost uneatable after five days in the upper waters." Surveys of area fisheries personnel and game wardens make it clear that fish flavor or tainting problems are no longer as severe or pervasive as Blazevic recalls. A 1980s study by the Chemistry Department of the University of Minnesota-Duluth indicates that fish tainting problems have been alleviated and relocated with the establishment of WLSSD, but not eliminated (UM-Duluth, 1980).

Area resource managers, fish and wildlife enforcement personnel, and members of the St. Louis River Recreation and Flowage Lakes associations, were asked about their awareness of any flavor or odor problems associated with fish or wildlife taken from the St. Louis River AOC. The uniform response was that fish tainting is no longer of concern. Minnesota Department of Natural Resources (MDNR) fisheries manager, John Spurrier, asked St. Louis River Recreation Association members about fish tainting in 1990. Only one man indicated that fish taken during the fall had an unusual taste. A call to an officer of the Flowage Lakes Association elicited a similar response. MDNR conservation officer, Beatrix Ransfer, canvassed officers responsible for the St. Louis River. None of these officers were aware of any problems/complaints. Wisconsin Warden, Joe Davidowski, who has 27 years of experience working the St. Louis River and Lake Superior, has not received a single fish tainting report in the last five years. Davidowski had numerous complaints prior to 1979. Wisconsin Department of Natural Resources fisheries manager, Dennis Pratt and fisheries technician, Bill Blust, also believe fish tainting is no longer a problem. Pratt and Blust have a long history of working the St. Louis River, are in contact with numerous recreation groups, and are, themselves, avid sportsmen.

The 1980 study by the University of Minnesota-Duluth Chemistry Department raises questions unanswered by the informal survey discussed above. The study focuses on the success of the new WLSSD facility in treating paper mill effluents thought to be responsible for historical fish tainting problems. In this study, nine participants were asked to taste cooked walleye fillets taken from fish in the river reach at Fond du Lac, near the former Arrowhead Bridge, and at the outfall of WLSSD. The Arrowhead Bridge site represented fish exposed to WLSSD effluent and given a five day recovery period. The conclusions of the study were as follows: Fond du Lac fish were selected over either WLSSD or recovered fish; and there was no clear preference for recovered fish over WLSSD fish. "The results thus demonstrate the improvement in fish taste in the upstream areas of the St. Louis River because of the initiation of wastewater treatment by the WLSSD. The results may also suggest that if fish for some reason, become tainted from the WLSSD discharge that the recovery period might be prolonged". (Carlson and Caple, 1980). Since the results of the 1980 study conflict with recent opinions of fishery managers, it may be necessary to conduct another fish tainting study.

In Carlson and Caple (1980), chloroform was used as an indicator chemical to qualitatively associate discharges of chlororganic compounds to the river from pulp mill effluents or the chlorination of waste water. The use of chloroform as an indicator species was based on the feasibility of analyzing water samples and the belief that such discharges were an indication of the total chlororganic loadings, including phenolic compounds which are responsible for undesirable odors and flavors in waters. Chloroform concentrations in the St. Louis River before and after the start up of WLSSD are shown in Table IV.5. The results of this monitoring show that chloroform concentrations have dropped significantly in upper river sites. Table IV.6 and Chapter VI on Pollutant Loadings indicate that levels of chloroform have been reduced, but not eliminated by the WLSSD (Carlson and Caple, 1980).

Table IV.5 Water Column Levels of Chloroform for Select St. Louis River Sites 1979-1980 [from Carlson and Caple, 1980]

Location	Spring 1978 (ug/kg)	Spring 1979 (ug/kg)	Spring 1980 (ug/kg)
Scanlon Dam	19.1	.7	.8
Fond du Lac	7.5	1.0	.7
Oliver Bridge	5.1	1.0	.4
Arrowhead Bridge	3.3	1.0	.7
Rail Road Bridge	1.9	-	3.7
Duluth Influent	4.3	-	5.6
Treatment Plant Effluent	18.9	-	138.8*

* Effluent from the Western Lake Superior Sanitary District waste water treatment plant.

Table IV.6 Water Column Levels of Chloroform for Select St. Louis River Sites - Spring and Summer 1980 [from Carlson and Caple, 1980]	
Sample Location	**Chloroform Concentrations (ug/L)**
WLSSD	22.3
North Star Steel	4.2
Rail Road Bridge	3.7
Blatnik Bridge	2.9
Connors Point	2.9
Airport	1.8
Duluth Entry	.6
Arrowhead Bridge	.7
Oliver Bridge	.4
Fond du Lac	.7
Jay Cooke Park	.7
Thompson Dam	.7
Scanlon Dam	.8

* Average of three samples taken between 4/28/80 and 6/18/80.

E. DEGRADED FISH AND WILDLIFE POPULATIONS

IJC Listing Criteria: 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.

Is the Beneficial Use Impaired? Yes

During the period of severe organic pollution before 1979, fish populations were degraded and fish kills were common. Fish populations have been recovering from that era because of improvements in wastewater treatment. However, fish populations are now adversely affected by the proliferation of the ruffe, an exotic species first found in the AOC in 1987. Other exotics threaten fish populations. The potential effects of toxic substances on fish population health in the AOC is largely unknown. Continuing loss of physical habitat also threatens populations. The loss of wetland habitat and the infestation of the exotic plant, purple loosestrife, have the potential to cause declining fish and wildlife populations. Little population data is available for wildlife with the exception of colonial nesting birds in the AOC.

Populations of the common tern and the piping plover (threatened and endangered species) have declined probably due to a combination of local and regional factors.

1. Fish Populations

The St. Louis River estuary supports a large and diverse warmwater fish community of approximately 54 species, which include walleye, yellow perch, northern pike, burbot, black crappie, emerald shiner, spottail shiner, and white sucker. Rainbow trout, brown trout, and chinook salmon are also found in the St. Louis, Nemadji, and their tributaries. Many species are seasonally abundant, using the river and estuary to spawn and return to Lake Superior. The Fond du Lac Dam restricts fish movement further up the St. Louis River, but fish are free to migrate up the Nemadji River and other tributaries. In recent years, populations of many resident species have been increasing. Because of recent dramatic improvements in the water quality of the estuary, fish populations have been changing rapidly. The St. Louis River estuary is important for the fishery of western Lake Superior.

a. Historical perspective

Historical accounts of the fishery of the St. Louis River describe abundant catches of a variety of species which continue to live in the estuary, as well as whitefish and lake sturgeon, both of which disappeared from the river during the last century. The Ojibwa subsistence fishery depended primarily on three species of river-spawning lake fish: walleye, lake sturgeon, and whitefish. The walleye and whitefish spawned near the first rapids of the river, located approximately one and one half miles above the village of Fond du Lac (Kaups, 1984). The lake sturgeon spawning area was located from the Fond du Lac vicinity downstream to Bear Island, as well as at the lower rapids (Kaups, 1984). Commercial fishing began in the area in the 1830's. Lake sturgeon, walleye, and northern pike were commonly harvested. Published accounts describe large harvests of walleye or "pickerel" during their spring run at the lower falls of the river upstream from Fond du Lac in the 1850's and 1860's. Commercial fishing of western Lake Superior was also based in Superior and Duluth. By 1869 and 1870, a scarcity of fish was reported for the St. Louis River and the western part of the Lake (Kaups, 1978).

Overall water quality had declined by the turn of the century. By the 1920's and 1930's, industrial wastes and the effects of municipal sewage inputs lead to the general characterization of the river as "polluted." The character of the river was changed also by the construction of the hydroelectric dams in the early twentieth century. The St. Louis River estuary was historically quite shallow and included large areas of submerged and emergent vegetation (DeVore, 1978). Natural historical channels ranged from about 10 to 30 feet for many areas (Meade, 1861). Over 4,000 acres of the estuary have been dredged to provide deeper shipping channels and anchorage areas for the port activities of Duluth and Superior. DeVore (1978) calculated the surface area of the estuary to be more than 11,500 acres of water.

The aquatic resources of the St. Louis River estuary have had a long history of degradation by water quality problems, shoreline and watershed development and other disruptive land-use practices. Fish populations were adversely affected by poor water quality prior to the implementation of the Western Lake Superior Sanitary District treatment plant in 1978. Generally, fish species that were resident to the St. Louis River estuary and could not migrate out to the lake during periods of low flow and greater water pollution, declined to very low numbers. Migratory species were better able to maintain their use of the estuary. Fish kills were reported in several years in the late 1940's through the early 1970's. In most cases, these fish kills were attributed to dissolved oxygen deficiencies caused by oxygen-consuming industrial and municipal wastes. In some cases fish kills were attributed to dramatically fluctuating water levels caused by the Fond du Lac dam. Tainted flavor was also a feature of fish caught from the St. Louis River during this time.

With the improved wastewater treatment brought about in the late 1970’s, water quality problems and dissolved oxygen levels began to improve. Populations of many fishes began to increase at this time. The fish community is currently in a phase of recovery from degraded water quality.

b. Monitoring

Before the 1970’s, little specific data existed on the fish populations of the St. Louis River Estuary. Between 1970 and 1979 investigations generally were carried out in response to development projects proposed for the lower estuary and port area. A WDNR 1976 survey report of the lower St. Louis River indicated that there were no records of fish stocking or other active fish management activities in the St. Louis River before that time. DeVore (1978) reported on the status of the estuarine fishery based on surveys conducted in the 1970’s. Thirty-six species of fish were identified during these surveys (Table IV.8a). Problems with dissolved oxygen and fish kills continued through the 1970’s, exacerbated by periods of low river flow. The survey work conducted from 1973-1978 suggested that yellow perch was the most abundant fish species in the estuary area, excluding minnows. Yellow perch were followed by black bullheads and white suckers in large fish species abundance. Walleye and northern pike were the most commonly observed game fish. Walleye was at that time, and continues to be, the most sought after game fish in the estuary. Northern pike, another important game fish, was found to have fairly abundant weedbed type habitat, but tended to utilize much of the open water portions of the estuary, an observation DeVore (1978) suggests may have been related to low dissolved oxygen. The forage base was comprised of juvenile yellow perch, trout-perch, log perch, smelt, emerald shiners and spottail shiners.

Index monitoring in the St. Louis River estuary by the Wisconsin DNR began in 1978 and was expanded in 1980. Improved water quality and subsequent increased fishing interest prompted the establishment of this program to acquire baseline data on fish communities inhabiting the river. Sampling locations and results for several species are shown in Appendix C.

Results from the index monitoring indicate that emerald and spottail shiners make up the highest percent of the forage fish population in the estuary. In total, they comprised approximately 66% of the total catch from 1978 to 1990. Yellow perch was the most abundant species sampled in 1980 in the limited amount of sampling done. Yellow perch remained the most common large fish encountered in the index seining and in other survey work through 1986 (MDNR, 1980,1981,1983,1984,1986, EA Engineering, Science, and Technology, 1987). Subsequently, black crappie, ruffe, and white perch have surpassed yellow perch in abundance.

Table IV.7a lists fish species observed in surveys conducted in the 1970’s before WLSSD became operational, and fish species observed subsequently. Several species were collected in the estuary since 1979 that were not collected before that time. In the case of some species, the pre-1979 surveys were either not conducted in areas where these fish were present at the times of sampling, or were not conducted with appropriate sampling gear. The increasing survey efforts and expansion of scope to more areas of the estuary could explain some additional species collected. Other species may be Lake Superior residents that were incidental to samples taken near the entrances to the harbor. Still others are newly established or reestablished in the estuary.

Table IV.7a Fishes Sampled in the St. Louis Estuary Between 1970-1978 and 1979-1988

Family	Common Name	Scientific Name	1970-78	1979-88
Amiidae	*Bowfin	*Amia calva*		X
Acipenseridae	Lake sturgeon	*Acipenser fulvescens*		X
Petromyzontidae	Silver lamprey	*Ichthyomyzon unicuspis*		X
	Sea lamprey	*Petromyzon marinus*		X
Anguillidae	American eel	*Anguilla rostrata*	X	X
Clupeidae	Alewife	*Alosa pseudoharengus*	X	X
Salmonidae	Lake herring	*Coregonus artedii*		X
	Pink salmon	*Oncorhynchus gorbuscha*		X
	Chinook salmon	*Oncorhynchus tshawytscha*	X	X
	Coho salmon	*Oncorhynchus kitsuch*		X
	Rainbow trout	*Oncorhynchus mykiss*	X	X
	Brown trout	*Salmo trutta*	X	X
	Lake trout	*Salvelinus namaycush*		X
	Brook trout	*Salvelinus fontinalis*	X	X
	Splake			X
Osmeridae	Rainbow smelt	*Osmerus mordax*	X	X
Cottidae	Spoonhead sculpin	*Cottus ricei*		X
	Slimy sculpin	*Cottus cognatus*		X
	Mottled sculpin	*Cottus bairdi*		X
Umbridae	Central mudminnow	*Unbra limi*	X	X
Esocidae	Northern pike	*Esox lucius*	X	X
	Muskellunge	*Esox masquinongy*	X	X
Cyprinidae	Lake chub	*Couesis plumbeus*	X	X
	Carp	*Cyprinus carpio*	X	X
	Golden shiner	*Notemigonus crysoleucas*	X	X
	Emerald shiner	*Notropis atherinoides*	X	X
	Common shiner	*Notropis cornutus*	X	X
	Spottail shiner	*Notropis hudsonius*	X	X
	Mimic shiner	*Notropis volucellus*		X
	Bluntnose minnow	*Pimephales notatus*		X
	Fathead minnow	*Pimephales promelas*	X	X
	Blacknose dace	*Rhinichthys atratulus*		X
	Longnose dace	*Rhinichthys cataractae*		X
	Creek chub	*Semotilus atromaculatus*	X	X
	Longnose sucker	*Catostomus catostomus*	X	X
	White sucker	*Catostomus commersoni*	X	X
	Silver redhorse	*Moxostoma anisurum*	X	X
	Shorthead redhorse	*Moxostoma macrolepidotum*	X	X
Ictaluridae	Black bullhead	*Ictalurus melas*		X
	Yellow bullhead	*Ictalurus natalis*		X
	Brown bullhead	*Ictalurus nebulosus*		X
	Channel catfish	*Ictalurus punctatus*	X	X
	Stonecat	*Noturus flavus*		X

Table IV.7a continued **Fishes Sampled in the St. Louis Estuary Between 1970-78 and 1979-1988**

Family	Common Name	Scientific Name	1970-78	1979-88
	Tadpole madtom	*Noturus gyrinus*	X	X
	Trout-perch	*Percopis omiscomaycus*	X	X
Percopsidae	Burbot	*Lota lota*	X	X
Gadidae	Ninespine stickleback	*Pungitius pungitius*		X
Gasterosteidae	Brook stickleback	*Culea inconstans*	X	
	White Bass	*Morone chrysops*	X	X
Percichthyidae	White perch	*Morone americana*		X
	Rock bass	*Ambloplites rupestris*	X	X
Centrarchidae	Pumpkinseed	*Lepomis gibbosus*	X	X
	Bluegill	*Lepomis macrochirus*	X	X
	Smallmouth bass	*Micropterus dolomieui*		X
	Largemouth bass	*Micropterus salmoides*		X
	Black crappie	*Pomoxis nigromaculatus*	X	X
	Johnny darter	*Etheostoma nigrum*	X	X
Percidae	Yellow perch	*Perca flavescens*	X	X
	Logperch	*Percina caprodes*	X	X
	Walleye	*Stizostedion vitreum v.*	X	X
	Ruffe	*Gymnocephalus cernuum*		X
	Freshwater drum	*Aplodinotus grunniens*	X	X
Sciaenidae				

* Identification has not been verified.

1) Walleye

The walleye that inhabit the St. Louis estuary and western Lake Superior west of the Apostle Islands utilize the one-mile stretch of river below the Fond du Lac dam almost exclusively for their spawning needs. A walleye tagging study was conducted by the WDNR from 1967 to 1969, adding to the understanding of the distribution and abundance of walleye in western Lake Superior. Studies initiated in 1977 (UWS and WDNR) and in 1980 (WDNR and MDNR) have served to further describe the St. Louis River walleye population. Walleye spawn in the St. Louis River below the Fond du Lac Dam in the one mile stretch of riffle areas extending to the Highway 23 bridge. Tagging results strongly suggest that the major portion of western Lake Superior walleyes are from the St. Louis River, Fond du Lac spawning area (DeVore, 1978: WDNR, 1982). In 1989 the Wisconsin DNR purchased 60 acres of Wisconsin shoreline in this critical spawning area, placing it in public ownership. Walleye also spawn in the Pokegama River, but this population is relatively small compared with the St. Louis River spawning population (DeVore, 1978). Walleye enter the St. Louis from Lake Superior to spawn in the spring. In the 1970's, during the period of seriously degraded water quality conditions, most walleye returned to Lake Superior by mid to late July (DeVore, 1978). Walleye fry moved downstream and were found to be most abundant in shallow, sandy areas with scattered weedbeds or rocks and sunken logs. This is not a common type of habitat in the estuary: most of this type is found from Pokegama Bay downstream (DeVore, 1978).

Walleyes from the estuary have exhibited slow growth, late maturity, a complex age structure, and greater longevity than have been observed in other walleye populations. These characteristics have been attributed to their residency in the cool waters of Lake Superior for part of the year which is thought to cause slow metabolic rates and growth rates, and result in a longer life span. The lack of significant exploitation of this population in the past was regarded as one reason why these older ages could be reached (WDNR, 1982). In the post-WLSSD era, walleye have tended to spend more time in the estuary than previously. This change may be directly due to improved water quality, or may relate to increased forage fish densities that may have resulted from better environmental conditions.

Operation of the Fond du Lac dam on the St. Louis River can affect walleye spawning success. Stranding and mortality of spawning adults and eggs has been observed under erratic flow conditions. Stranding of both adults and eggs before hatching can occur when walleyes spawn under high flow conditions followed by a drop in water level. This situation has been documented on at least two occasions during spring spawning (D. Pratt, WDNR, 1989). This situation can affect year class strengths. Specific flow requirements for the St. Louis River species of interest are not adequately defined. Studies undertaken as part of the Federal Energy Regulatory Commission dam relicensing process should help provide some information regarding a desirable flow maintenance scheme.

2) Northern Pike

Northern pike provide one of the major sport fisheries in the St. Louis River estuary. Schram (1983) studied northern pike in the estuary in 1978 and 1979 to document spawning areas, determine movement patterns, and acquire data on age, growth and mortality of the population. Allouez Bay and Grassy Point were identified as the two primary spawning areas in the lower estuary. Other minor spawning areas include Hog Island, Barkers Island and Clough Island. Habitat suitable for northern pike spawning is also found in the estuary upstream from Clough Island, although that area was not included in the study. Both Allouez Bay and Grassy Point are undeveloped areas containing shallow water and emergent vegetation. Schram concluded that habitat preservation was the most important management goal for northern pike in the St. Louis River estuary.

3) Lake Sturgeon

Historical accounts indicate that lake sturgeon were abundant in the estuary in the late 1800's (Kaups, 1978). Loss of the lake sturgeon populations may have been influenced by several factors. Historically, water quality problems due to organic loading in the St. Louis River and overharvest by commercial fisheries may have reduced populations to a level where they were incapable of recovery. Lake sturgeon are a very long-lived species (> 50 yrs) and may be affected by toxic contaminants accumulated through the food chain over long periods. Efforts to reestablish the lake sturgeon in the St. Louis River began in the 1980's with a program of stocking by WDNR and MDNR and maintaining a closed fishery to allow for recovery of a spawning stock. The results of this effort will be important for the fishery of western Lake Superior. MDNR has found lake sturgeon in the course of their gillnetting surveys since 1983. However, it will be difficult to assess the success of these reestablishment efforts since individuals stocked will require up to 25 years before reaching maturity.

4) Centrarchids

Black crappies were incidental in surveys conducted in the 1970's, although discussions with local residents revealed that there was a fishable population 30-50 years ago (Dennis Pratt (WDNR), pers. comm.). DeVore and Hargis (1982) observed densities of young black crappies in 1981 that were orders of magnitude higher than were seen in previous years. The population continued to increase due to water quality improvements and possibly to the stocking of adult fish by the MDNR in 1983. In WDNR index seining, highest concentrations of black crappie are found at the three upstream stations (Clough Island, Dwight's Point, and Reiss's Coal Dock), which are close to winter holding areas and spawning areas. Black crappies have become well established, and in 1990 were the fifth most abundant species sampled during index seining (WDNR, 1990).

Bluegill young in 1981 trawling catches were also notably increased in comparison to densities found in previous years (DeVore and Hargis, 1982). Adult bluegills were stocked by WDNR in 1989 and 1990, producing year classes. Smallmouth bass had not been observed in any surveys before 1981. WDNR has stocked smallmouth bass to promote growth of this population. The successful growth of this population has prompted WDNR to cease the stocking operation. Largemouth bass, although not abundant, have been increasing as well.

5) Exotics

Undesirable exotic species can degrade native fish populations and are a major concern in the St. Louis River estuary. Undesirable exotic species of most recent concern, including the ruffe, zebra mussel, and spiny zooplankton (*Bythotrephes cederstroemi*), have entered the Great Lakes via ship ballast water. Previous introductions of the undesirable exotic sea lamprey, white perch, rainbow smelt, and alewife to the Great Lakes have been through the canals created for shipping, and by stocking directly into the basin. The spiny zooplankton and zebra mussel are of concern for fish populations because of their capacity to impact zooplankton communities on which the fry of many fish species depend. The exotic plant, purple loosestrife (*Lythum salicaria*) has spread throughout the St. Louis River estuary and has the potential to degrade fish and wildlife populations through loss of habitat.

Alewife was first sampled in the harbor during 1973 (Swenson, 1978) and was the fifth most abundant species sampled during 1981-1988 (WDNR, 1989). Most alewife are found at the four lower-most index stations (Allouez Bay, Wisconsin Entry, Hog Island, and Minnesota Point). This pattern may be associated with preferred spawning habitat close to Lake Superior, which the adults inhabit most of the year.

Rainbow smelt, an exotic species introduced to the Great Lakes in the late 1920's, became abundant in the St. Louis estuary during the early 1950's (Anderson and Smith, 1971). Smelt spawn in the estuary in the spring and then return to the shallower areas of Lake Superior (Swenson and Heist, 1980). Evidence collected over the years illustrate how this exotic species has impacted the system. The warm waters of the estuary promote rapid growth and high survival of young smelt (Schaefer et al. 1981), stimulating rapid population growth in western Lake Superior. Large die-offs of smelt fouled beaches during the 1970's and early 1980's, the period of peak abundance. These die-offs rendered the beaches on Wisconsin and Minnesota points almost unusable. The postspawning mortality has been attributed to temperature gradients and dissolved solid levels to which the new species was not adapted. Studies by Anderson and Smith (1971), Swenson (1978), and Heist and Swenson (1983) have linked smelt to the declines of the commercially important Lake Herring (*Coregonus artedii*) in Lake Superior. Smelt concentrate in the warm near-shore waters prior to and after spawning (Heist and Swenson, 1983) where a combination of spawning habits and currents tend to concentrate larval lake herring (Swenson and Heist, 1980). Predation by smelt on larval herring during the late 1970's appeared to be a major source of mortality (Swenson and Heist, 1980). Thus, although only spawning adults and some young smelt inhabit the estuary, conditions in the estuary which promoted rapid expansion of the population appear to have had major negative effects on native fish production in western Lake Superior.

Ruffe were found for the first time in North America at the Minnesota Point index station in July, 1987 (Pratt, 1988). The ruffe (*Gymnocephalus cernuum*) is a European member of the perch family and is believed to have entered the harbor as fry via the ballast water of foreign grain ships. Ruffe have the capacity to create large stunted populations. Another exotic species recently found in the St. Louis is the white perch. White perch were sampled for the first time in September, 1986 in Allouez Bay. White perch are believed to have entered the harbor via ballast water of iron ore carriers from Lake Erie. White perch were first found in the lower Great Lakes in the early 1950's and were considered abundant by the late 1970's to early 1980's. They were first found in Green Bay in Lake Michigan in 1988.

During their short history in the St. Louis estuary, the ruffe and white perch have experienced rapid population growth. In 1990, ruffe was the eighth most abundant species in index seining and white perch was the third most abundant (WDNR, 1990). U.S. Fish and Wildlife Service trawls of the St. Louis estuary found ruffe to be the seventh most abundant species sampled in 1989 and the second most abundant in 1990 (Table IV.7b). The population of ruffe in the St. Louis estuary in 1990 was estimated to be 1.9 million (Selgeby and Ogle, 1991). White perch ranked as number 12 and 13 in abundance in 1989 and 1990 in USFWS trawls. These exotics are a serious problem for the fishery. As of 1991, ruffe have been the most abundant species in trawls and other species have been declining (D. Pratt, WDNR, pers. comm.).

Table IV.7b U.S. Fish and Wildlife Service Total Catch Summary of 360 Trawl Tows in the St. Louis River Estuary. Most Abundant Species by Mean Number per Hectare

1989		**1990**	
1. emerald shiner	854.07	1. emerald shiner	266.59
2. spottail shiner	643.18	2. ruffe	257.44
3. trout perch	375.88	3. spottail shiner	236.43
4. rainbow smelt	224.46	4. trout perch	174.59
5. black crappie	145.09	5. yellow perch	46.00
6. yellow perch	91.48	6. black crappie	41.23
7. ruffe	80.53	7. log perch	32.84
8. black bullhead	42.89	8. johnny darter	29.88
9. log perch	37.45	9. channel catfish	29.37
10. white sucker	34.51	10. black bullhead	27.83
11. johnny darter	25.76	11. rainbow smelt	24.11
12. white perch	17.92	12. white sucker	22.23
13. channel catfish	13.32	13. white perch	21.98
14. walleye	12.16	14. walleye	11.88
15. freshwater drum	11.22	15. freshwater drum	7.90

As water quality conditions in the St. Louis River and estuary improve, conditions may develop which promote reproductive success of the sea lamprey. Riffle areas of good water quality are required for lamprey spawning. Riffle areas below the Fond du Lac Dam could be utilized for spawning by sea lamprey. Limited surveys conducted since the early 1960's by the U.S. Fish and Wildlife Service did not establish the presence of ammocoetes (larval lamprey) in the St. Louis River until the fall of 1979 (P. Rugen, USFWS, pers. comm.). So far, adult sea lamprey are not found concentrated in the reach below the Fond du Lac Dam as would be expected if they were using that area of the river for spawning (D. Pratt, WDNR, pers. comm.). Utilization of the St. Louis for sea lamprey spawning would represent a threat to the Lake Superior salmonid fishery recovery program and would pose a significant management challenge.

Each of these new introductions has the potential to degrade the biotic community of the estuary and Great Lakes to the extent that sea lamprey and smelt have. A wide array of case histories demonstrate that the process of natural selection through which most species must adapt to change, is not very effective in equipping native species populations to cope with the rapid rates of changes that an exotic species can bring about. This is particularly true for the longer-lived species, because of their lower reproductive potential. As with lake trout and lake herring, we can expect other populations of native species, which natural selection has trained to make good use of the resources a system has to offer, to crash under the new conditions brought about by the recently introduced exotic. Lacking the "education" which must be acquired through extended periods under natural selection, these new species are not equipped to take the place of the natives. Therefore, we can expect a system characterized by population instability and die-offs over an extended period of time.

Purple loosestrife, an exotic plant introduced from Europe, has infested the estuary and has the potential to degrade fish populations. Purple loosestrife is a prolific, hardy plant that aggressively crowds out native vegetation. The root system of the loosestrife consists of a dense, woody mat that is difficult to remove. Thick growths of loosestrife can choke off or eliminate access to fish spawning habitat. Loosestrife is presently growing among native vegetation with no noticeable decline in fish populations, however; if it continues to spread, northern pike and other fish which have major spawning areas in the estuary, could be adversely affected. (See Section IV.P. Loss of Fish and Wildlife Habitat for more information on purple loosestrife.)

2. Current Status

It is difficult to completely characterize the present state of a fishery of such a diverse and dynamic nature as the St. Louis River system. The fish community of the St. Louis River estuary has exhibited a pattern of increasing abundance and diversity in the 1980's. Compared with the era of obvious degraded water conditions (pre-1979), the populations have been recovering. Comparisons with the pre-degraded period (nineteenth century) are difficult since the fishery has changed in many respects from the original fishery of the St. Louis estuary. Dams, dredging, habitat loss through waterfront development, overharvest, and degraded water quality have substantially altered the system. Important species which were historically present, such as lake sturgeon, have been lost and can be considered to be impaired. Rehabilitation efforts for the lake sturgeon population are underway.

Threats to the fishery include undesirable exotic species, physical habitat loss, and the long-term effects of exposure to toxic substances on population health. Fish populations and community stability are seriously threatened by exotic species. The establishment and huge population growth of the ruffe since 1987, is beginning to impair the fish populations in the estuary. Exotics will continue to result in population instability and reduced productivity of the estuary and Lake Superior. Special measures may be needed to protect crucial gene pools during a period dominated by stress from recent exotic introductions. Physical habitat loss is another threat to the recovery of the fish community. The recovery of the fishery will not be sustained with further habitat loss. Impairment to the fishery can occur gradually due to consecutive habitat loss over time. Near-shore, shallow-water habitats which may be important spawning or nursery areas should be protected to support healthy self-sustaining populations. In addition, exposure of fish populations to toxic contaminants through the food chain has the potential to influence the incidence of disease and reproductive success.

3. Wildlife Populations

a. Birds

Populations of colonial nesting bird species: the common tern, piping plover, ring-billed gull, herring gull, black tern, and great blue heron have been monitored since 1977 as part of the St. Louis River Estuary Colonial Bird Program, a cooperative project between the two states, other governmental agencies, and private groups (Penning and Cuthbert, 1990; S. Matteson, WDNR, pers. comm.). Extensive management efforts have been directed toward the common tern and piping plover by both the Minnesota and Wisconsin DNRs. More is known about the population and reproductive success of common terns than any other bird species in the estuary.

The piping plover, a federally endangered species, has not nested in the St. Louis River Estuary from 1985 onward (Penning and Cuthbert, 1990). Suitable nesting habitat for the piping plover has declined in the past 20 years. Minnesota and Wisconsin Points and dredge disposal areas have historically been used as nest sites for the piping plover as well as the common tern. Several factors have contributed to the loss of suitable breeding habitat in the estuary including human development of historical nesting sites, natural succession of vegetation (e.g. growth of shrubs and trees), rapid increase of competing colonial species, such as the ring-billed gull, and human disturbance. Return of breeding piping plovers to the estuary will probably rely on development of more suitable nesting habitat and a supply of birds from a regional population. The regional population is also down, limiting the possibility of pioneering (F. Strand, WDNR, pers. comm.). Ideal nesting areas would be broad sparsely vegetated sand and gravel beaches on islands or peninsulas, relatively isolated from humans and free of mammalian predators (S. Matteson, WDNR, pers. comm.).

The common tern, a species of concern in Minnesota and an endangered species in Wisconsin has had low reproductive success in the St. Louis River Estuary since the mid-1970's (Davis and Niemi, 1980; Niemi et al., 1986; Penning and Cuthbert, 1990). Several factors may be contributing to this low reproductive success including a lack of suitable nesting and rearing habitat, chemical contamination, human disturbance, predation, inclement weather including storms and wave action which has destroyed nests and young birds, and competition with the ring-billed gull for breeding habitat.

The population of ring-billed gulls in the harbor has increased dramatically in the last few decades. The ring-billed gull competes with common terns and piping plovers for nesting habitat in the harbor. The gulls return earlier, begin to nest earlier in the year, and tend to make use of a greater range of habitats. This species is more terrestrial than the herring gulls. The herring gulls have had a low stable population in the harbor area. The first record of ring-billed gull nesting in the harbor was in 1958 (F. Strand, WDNR, pers. comm). Currently, approximately 8,000 pairs nest in the harbor. The dramatic increase in numbers of ring-billed gulls in the estuary may relate to their food supply. Numbers of smelt were increasing in this area while the numbers of alewife were decreasing in the lower Great Lakes.

A great blue heron rookery is currently located near the Billings Park area on the Wisconsin shore. The number of active nests in this rookery has been monitored, and appears to be declining in recent years (F. Strand, WDNR, pers. comm.). Human disturbance from a nearby housing development could be a factor in the colony's decline. Heron rookeries are by nature ephemeral. Suitable potential sites for nesting need to be maintained so that the colony can relocate when the herons abandon the present site (Collins, 1992).

Waterfowl and marsh birds that nest and feed in the estuary have the potential to be detrimentally impacted by the purple loosestrife infestation in the estuary. Purple loosestrife, an exotic plant species that has little or no wildlife value, crowds out native marsh vegetation. Waterfowl, especially ducks, shun wetlands that have become dominated by loosestrife since the plant does not provide the necessary feeding or nesting habitat. While there has not yet been a noticeable decline in waterfowl and marsh bird populations due to the loosestrife, the potential exists due to the prolific nature of the plant. (See Section IV.P. Loss of Fish and Wildlife Habitat for more information on purple loosestrife.)

Reproductive success of species that breed in the harbor and river and rely on an aquatic based food sources may be affected by the presence of toxic contaminants in the aquatic environment. Populations of shorebirds and other groups which use the St. Louis River estuary could be affected by a degraded aquatic insect or benthic community. Several species of breeding birds associated with wetlands in the estuary feed their young aquatic macroinvertebrates. There is evidence to suggest that a contaminated food source or depressed populations of aquatic insects inhibit growth of nestlings (Beaver et al., 1988; Rothstein et al., 1989; Hanowski et al., 1989). However, there are no data to show that bird populations have been impacted by an affected food supply or by toxic contamination in the St. Louis River estuary.

Over the last ten years die-offs of immature ring-billed gulls and adult mallards in the harbor have been reported. Minnesota DNR has had samples of these birds analyzed by the U.S. Fish and Wildlife Service disease laboratory, but nothing conclusive has been found. Investigations into the extent and causes of these periodic die-offs is needed (Staffon, 1992).

Historical (pre-WLSSD) use of the harbor by migrating waterbirds was documented by Niemi et al. (1979). This work could serve as baseline data to indicate changes in migratory waterbird populations and preferred stop-over sites in the estuary. Currently, migratory waterbirds (shorebirds, swans, geese and ducks) use the Erie Pier dredge disposal site as a migration stop-over spot. There is concern that these individuals may be picking up aquatic insects that have been exposed to contaminated dredge spoils or water used to clean dredge spoils. Migratory birds consume large amounts of food during migrations. Organic toxic contaminants found in the food will be stored in the birds' fat. Previous studies have indicated that as birds metabolize fat during migration; toxins can be released that may be fatal if present in high concentrations. Contaminants can also cause reproductive problems.

b. Raptors

The area of the St. Louis River estuary lies within the hawk migration route along Lake Superior. "Hawk Ridge" along the Skyline Drive area in Duluth is an excellent location to view migrating raptors. There is some information on the use of the St. Louis River estuary and upstream areas by raptors, but no sense of what the populations should be or have been in the past. During the spring migration, bald eagles concentrate at Fond du Lac since this is the first part of the river with open water. There is a concern over the effects from eagles eating contaminated fish from the river during this stressful period of the year since this is a potential route for exposing the regional eagle population to contaminants from the estuary (Collins, 1992). The estuary appears to have habitat suitable for osprey, but there is no historical or present record. Two active eagle nests are located along the Wisconsin shore of the upper estuary. Recent activity has also been noted at a historical eagle nest site further upstream near the Thomson reservoir in Minnesota (F. Strand, WDNR, pers. comm.).

The St. Louis River and harbor are also used by wintering raptors that are attracted to the area by an abundant prey associated with grain storage and shipping (e.g. rock doves and rats). Raptors naturally migrate south during the winter months when food becomes scarce further north and are naturally drawn to the harbor because of its rat and rock dove population. These species, including gyrfalcon, snowy owl, and peregrine falcon may ingest dead or weakened prey that have been affected by the pesticides used to control rock doves and rats in grain areas. There is concern that these pesticides are being accumulated by raptors and that they may be ingested at dangerously high levels when prey killed by these pesticides is consumed. No information is available that identifies the incidence of raptor poisoning.

c. Mammals, Reptiles, Amphibians

There is little or no information on the current status of reptile, amphibian, or non-game mammal populations in the area of concern. Wetland and riparian habitat important to these groups has been lost through development, but it is not known how populations may have been affected by this since historical information on these populations does not exist. It is probable that fish-eating mammals such as mink and otter are bioaccumulating contaminants from fish they eat. Littoral feeders such as raccoons and skunks may ingest contaminants through food sources such as clams or other invertebrates of the water's edge. Small mammals like the water shrew or the star-nosed mole could encounter contaminants while feeding on oligochaetes or aquatic insects (Habitat and Biota TAC, 1990). Although there is no evidence of degraded mammal, reptile, or amphibian populations, the potential exists for wildlife populations to be affected through exposure to toxic contaminants through the aquatic food chain and through loss of habitat due to the purple loosestrife infestation.

F. FISH TUMORS AND DEFORMITIES

IJC Listing Criteria: 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.

Is the Beneficial Use Impaired? Yes

Observations suggest that fish tumors and deformities represent an impaired use in the St. Louis River estuary. However, at present, there are no studies which document the incidence rates of tumors in fish. Additional work is needed to fully determine the incidence of fish tumors and deformities in the Area of Concern.

No published research or studies document the incidence of tumors in fish or wildlife taken from the St. Louis River AOC. There have also been no documented reports from area citizens of any unusual or tumorous fish or wildlife relayed to game wardens in either Minnesota or Wisconsin. An unpublished U.S. Fish and Wildlife Service study of 32 black bullheads (*Ictalurus melas*) taken from the shipping channel of Allouez Bay did not reveal a high incidence of abnormalities. External lesions were discovered on two of the fish. One fish liver "showed a small suspicious lesion reminiscent of incipient neoplasm" (Smith, 1991).

A number of fish collected from Crawford Creek on August 2, 1985 by WDNR Fisheries Manager, Dennis

Pratt and John Sullivan, WDNR, appeared to have spinal deformities and possibly tumors. None of these fish, however, were reviewed histopathologically. The sediments in Crawford Creek are known to contain detectable levels of phenanthrene, pyrene, and other polynuclear aromatic hydrocarbons (PAHs). Crawford Creek receives drainage from a contaminated wetland area below Koppers Co. near Superior, Wisconsin. "Fish tumor incidences are known to be higher in areas of high PAH contamination..." (Denny, 1990).

Tumor incidence in Great Lakes fish has ben shown to increase near areas contaminated by chemical compounds such as PAHs and PCBs (Baumann, 1984). Appendix D, Table PAH-7 lists sites around the Great Lakes and elsewhere in the U.S. where a high incidence of abnormalities (epizootics of neoplasia) in fish have been found in association with sediments contaminated with PAH compounds. There are sites in the St. Louis River Area of Concern where PAH levels have been found at levels comparable to areas with fish tumors (Appendix D, Table PAH-8). These sites in the AOC include sediments in the vicinity of the Interlake and U.S. Steel Superfund sites, the Crawford Creek wetland, and Newton Creek.

In July, 1991, participants from the Envirovet Program at the Lake Superior Research Institute of the University of Wisconsin, Superior, conducted field sampling trips in the St. Louis River Harbor and Apostle Islands area of Lake Superior. The Envirovet Program is a four-week summer course for veterinarians, which involves training in diseases and toxicoses of aquatic animals. On July 5 and 6, trawling was conducted near Stockton Island in the Apostle Islands. The catches consisted of small (150-350 mm) whitefish and herring. On July 12, trawling efforts in the Duluth-Superior Harbor main channel between the Port Terminal and Arena, yielded samples of suckers and burbot. Approximately 30-40 fish were netted with sizes ranging from 1-30 inches.

Necropsies of the Apostle Island fish showed normal tissues with no gross signs of pathology. Serum proteins showed only minor alterations between individual fish. However, a majority (approximately 80%) of the fish taken from the harbor showed significant lesions, fibrosis, hemorrhagic liver tissue, clubbing in the gill lamellae with noticeable hemorrhaging, and alterations in serum proteins that are consistent with a stress - induced acute phase response. A majority of the harbor fish had poor mucus production which could cause them to be more susceptible to parasites. These preliminary observations suggest that fish from the Duluth-Superior Harbor have significant pathologic alterations in blood proteins and organ structures when compared with fish taken from the Apostle Islands which exhibited normal organ structures and minimal or no signs of stress. No firm conclusions can be drawn from this information because different species were captured at the sites making comparisons difficult, stress caused by capture could not be evaluated, and there was an absence of control fish. This preliminary information suggests that there may be a problem with fish tumors and deformities in the harbor. The 1991 observations made by the Envirovet program point to the need for a full and formal study (T. Eurel, University of Illinois, pers. comm.).

G. BIRD OR ANIMAL DEFORMITIES OR REPRODUCTIVE PROBLEMS

IJC Listing Criteria: 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.

Is the Beneficial Use Impaired? Potential impairment - more information is needed.

With the exception of colonial nesting birds, there is little population data available to characterize *wildlife in the Area of Concern. The common tern, whose populations have been extensively monitoring in the harbor, have experienced less than desirable reproductive success. At this time, however, there is no evidence to tie the population decline to toxic contaminants or a degraded food supply. Additional study of wildlife populations, with a particular emphasis on eagles and terns, is needed along with information on toxic substance residues in species with aquatic based diets.*

There are no obvious abnormal occurrences of deformities in birds or other animals and little is known about the reproductive success of many species which could be affected by toxic contaminants in the environment. The common tern is one species which has been followed extensively because of the joint state management effort. Consequently, information on their populations and reproductive success is available.

The number of common tern breeding pairs fluctuated around 200 in the estuary from 1977 to 1981. Numbers decreased between 1981 and 1986 to around 100 breeding pairs. From 1987 to 1989, the number of breeding pairs had been steady at 81 to 88. (Penning and Cuthbert, 1990). In 1989, common terns nested at Wisconsin Point and Interstate Island, and fledged from Interstate Island. Storms washed away nests at Wisconsin Point. For the first time since 1984, a substantial number of chicks hatched: 193 hatched, at least 64 survived to fledgling. Reproductive success of common terns at Interstate Island in 1989 was 0.79 fledgling/pair. At the Ashland pier colony in Ashland, Wisconsin, on the south shore of Lake Superior, the reproductive success rate was 0.58 fledgling/pair. The Ashland pier site had 176 breeding pairs in 1989, but was subject to great horned owl predation (S. Matteson, WDNR, pers. comm.).

Occasional cross-billed chicks have been observed among the common terns at Interstate Island and Ashland pier. In 1990, one cross-billed chick was observed among approximately 100 fledged at Interstate Island (B. Penning, University of MN; F. Strand, WDNR, pers. comm.). One cross-billed chick was found in 1990 out of 400-500 total chicks at Ashland pier. At Ashland pier, four cross-billed chicks have been observed over the last 10 years of fairly intensive surveillance of the colony. The incidence of cross-bill syndrome and other deformities should continue to be monitored. Common terns would be a logical species on which to perform residue analysis to determine uptake of toxic substances, because of the information available on their populations and reproductive success, and because of their aquatic based diet of small fish and aquatic invertebrates.

Niemi et al. (1986) studied organochlorine residues in ring-billed and herring gulls from western Lake Superior and common terns from the estuary in the late 1970's. The concentrations of organochlorine residues were found to increase from the pre-fledge to post-fledge stage. The residue levels for common tern eggs was lower than for the gull eggs. However, levels in common terns increased relative to gulls in pre- and post-fledge stage. Niemi et al. (1986) concluded that residue levels cannot be eliminated as a potential contributing factor to the low reproductive success of the common tern in the estuary.

Toxic contaminants in common tern eggs were studied by the U.S. Fish and Wildlife Service (USFWS) in 1984 throughout the Great Lakes. Sampling locations included common tern colonies at Duluth-Superior, Ashland, Wisconsin, and Lake of the Woods, Minnesota; all of the tern eggs analyzed from these sites contained quantifiable levels of mercury, selenium, total PCBs, DDE, and dieldrin (Table IV.8). The levels of these contaminants were generally highest in eggs from the Duluth-Superior colony (Lake Superior), followed by the Ashland colony, and lowest at the Lake of the Woods colony (non-Great Lakes).

The levels of DDE found were below those associated with egg shell thinning in common terns (Fox, 1976). Levels of PCBs in these common tern eggs in 1984 were in a similar range to those reported for herring gull eggs in lake Superior colonies for that time period. These levels are below the high concentrations associated with reproductive failure found in the 1970's in herring gulls in the eastern Great Lakes (Bishop and Weseloh, 1990). The contaminant concentrations reported by Niemi et al. (1986) for common tern eggs sampled in the Duluth-Superior Harbor in 1977 were slightly higher than those found by the USFWS sampling in 1984. Niemi reported that the level of contaminants found in common terns in 1977 was below those affecting reproduction in gull species. However, the potential for impairment to common tern reproduction could not be ruled out. Niemi et al. (1986) also found that, although residue levels for common tern eggs were lower than for ring-billed gulls or herring gulls in their study, their results suggest that common terns accumulated organochlorine residues within western Lake Superior, and at a rate faster than gull species.

Reproductive success of the eagles nesting along the St. Louis River and estuary should also be investigated. It has been documented that eagles nesting along the shores of Lake Superior experience lower reproductive success than those nesting inland (Kozie and Anderson, 1991). Reproductive success of the eagles nesting in the St. Louis River area should be evaluated in the context of the St. Louis River watershed as well as in the context of the Lake Superior region.

Table IV.8 Contaminants in Common Tern Eggs - 1984+
[G. Smith, U.S. Fish and Wildlife Service, pers. comm.]

	Duluth\ Superior			Ashland Pier			Lake of the Woods		
Substance	**Mean (mg/kg)**	**Range (mg/kg)**	**No.**	**Mean (mg/kg)**	**Range (mg/kg)**	**No.**	**Mean (mg/kg)**	**Range (mg/kg)**	**No.**
Mercury	0.49	0.26 - 1.1	8	0.31	0.019 - 0.53	7	0.27	.17 - 0.42	8
Selenium	0.37	0.31 - 0.52	8	0.59	0.37 - 0.80	7	0.11	ND - 0.25	6
PCBs (total)	4.9	3.0 - 13.0	8	2.0	1.3 - 3.4	7	1.2	0.53 - 2.6	8
pp^1-DDE	1.0	0.72 - 2.0	8	0.52	0.23 - 0.88	7	0.46	0.14 - 1.4	8
pp^1-DDD		ND			ND*			ND	
pp^1-DDT		ND			ND			ND	
Dieldrin	0.10	ND - 0.17	6	0.09	ND - 0.18	5		ND - 0.12	1
Heptachlor epoxide		ND			ND			ND	
Oxychlorodane		ND			ND			ND	
Chlorodane		ND			ND			ND	
Nonachlor		ND			ND			ND	
Toxaphene		ND - 0.12*	1		ND - 0.15	1		ND	

+ All concentrations are wet weight and are corrected for moisture loss. Geometric means, concentration ranges, and the number of samples with quantifiable residues are given.

ND* = not detected at the lower limit of quantification

Lower limit of quantification = .02 mg/kg for mercury, .05 mg/kg for selenium, .5 mg/kg for PCBs, and .1 mg/kg for pesticides.

H. DEGRADATION OF BENTHOS

IJC Listing Criteria: 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.

Is the Beneficial Use Impaired? Yes

The limited data available suggest that there has been some improvement in the benthic community in areas impaired in the past from organic pollutant loading. No system-wide benthic studies have been conducted in the estuary. Current studies show that benthic communities in certain locations are impaired due to contaminated sediments. Work conducted in 1989-1991 indicates degraded benthos at the Interlake Site or Stryker Embayment and at the Newton Creek/Hog Island Inlet of Superior Bay.

Reduced benthic invertebrate density, diversity, and species richness have been reported within portions of the St. Louis River estuary in areas subjected to physical disturbance or in close proximity to known discharges or hazardous waste sites. Historically, much of the estuary and harbor were severely degraded by anoxic conditions created by untreated wastes entering the river from municipal and industrial sources as far upstream as Cloquet (MSBH, 1929). Problems with dissolved oxygen depletion persisted through the 1970's. Several factors complicate any effort to characterize the extent of degradation to the benthic community. Benthic sampling typically has been conducted sporadically in a limited geographical area and with limited objectives. The St. Louis River estuary is a large and diverse system to study and characterize. It is expected that benthic communities would be affected by the distribution of toxic contaminants in sediments. The St. Louis estuary is known to have contaminated sediments, but the distribution of contamination has not been determined, and existing information has not yet been compiled in a manner that could facilitate ecological interpretation. The spatial extent to which known deposits of contaminated materials affect benthic parameters is largely unknown. Focused studies that separate the differences between habitat-related influences on benthic process and toxic effects are needed in conjunction with sediment contaminant surveys.

1. Sampling in 1970's

In the 1970's, benthic sampling in the St. Louis River between the Pokegama River and the Blatnik Bridge revealed decreased diversity in the downstream locations (Koch et al., 1976). The highest benthic invertebrate diversity indices were seen at the mouth of Pokegama Bay. Samples at this site included *Hexagenia sp*. (burrowing mayfly) and various species of *Trichoptera* (caddis flies). Samples in the Grassy Point area showed an intermediate diversity index. The downstream sites: adjacent and downstream from the former Duluth Sewage Treatment Plant demonstrated the lowest diversity indices and lowest number of organisms for this study. Samples from the channel near the treatment plant discharge area contained 97% nematodes.

In the 1970's, bioassays of sediment from the Duluth and Superior Harbor basins indicated the presence of sediments that were toxic to benthic organisms (Prater and Anderson, 1977). Sediments from eight locations were tested. Ninety-six hour tests were conducted with *Daphnia magna, Hexagenia limbata, Asellus communis*, and *Pimephales promelas* and chemical analyses of the sediment were performed for inorganics and metals. The two locations in the Superior Harbor basin and one of the six locations in the Duluth Harbor basin showed the greatest toxicity to test organisms of the eight samples. The Superior

Harbor Basin Sites were off Wisconsin Point inside the Superior entry and off the Elevator O Slip. The Duluth Harbor Basin site which showed the greatest toxicity was located in the Northern Section off the Superwood Corp. and Cargill Elevator B Slips. In sediment from the two Superior Harbor locations, *D. magna* demonstrated mortality of 45-70% and 15-45%. Mortality of *H. limbata* was 10-20% and 10-30%. No death occurred among the fathead minnows. In the Duluth Harbor tests, sediment from the Superwood-Cargill location produced 50-75% mortality in *D. magna*, 40-50% mortality in *H. limbata*, 30% in *A. communis,* and 10% in *P. promelas*. The other five locations in the northern and southern sections of the Duluth Harbor Basin demonstrated relatively little mortality. Evaluation of the chemistry data for these three most toxic locations did not show any one parameter to be excessively high compared to the other stations. Heavy metals and not organics were measured in these samples. The concentrations varied between stations and did not always appear highest at those stations where mortality was greatest. The authors offer that synergistic or antagonistic effects as well as chemical parameters which were not measured (organics) may have contributed to the results.

2. Sampling in 1980's

A few benthic surveys have been conducted in the post-WLSSD era of the 1980's. Roush (1982) sampled the benthic invertebrate community in the vicinity of the WLSSD plant outfall and in two upstream bays near the Minnesota Power Hibbard electric generating plant (See Table IV.9a). Overall, 93.4% of the organisms sampled in the study were oligochaetes and chironomids, groups which are relatively tolerant of organic pollution. The upstream bays had the fewest number of oligochaetes and the largest number of taxa. In the vicinity of the WLSSD discharge, the most common group sampled were oligochaetes (numbers included some freshwater polychaetes), followed by chironomids. The burrowing mayfly *Hexagenia sp*. was not found in the WLSSD discharge area. Roush (1982) reports noticeable differences between the WLSSD discharge bay and the two bays sampled upstream. Compared to the sampling by Koch et al. (1976) in the region of what is now the WLSSD discharge bay, a somewhat more diverse community was found by Roush in 1982, although the area was still dominated by oligochaetes and chironomids, which are generally considered to be tolerant of organic pollution.

Benthic invertebrate community sampling in the post-WLSSD era has been carried out in the harbor dredged channels and in a few shallow areas upstream to the bays around the Minnesota Power Hibbard electrical generating plant. Two general benthic surveys from the 1980's are available. These were conducted by contractors for the U.S. Army Corps of Engineers and mainly cover the dredged channel areas throughout the harbor. Envirodyne Engineers sampled in the fall of 1982 and spring of 1983; Limno-Tech Inc. (LTI) sampled in August of 1984. Data are grouped into geographical regions in the harbor in Table IV.9a. Data on the macroinvertebrate community of Stryker Bay are also included from the Superfund Remedial Investigation for the Interlake Iron site (MPCA, 1990). Table IV.9a shows total numbers of organisms and percent oligochaetes and chironomids for these various regions sampled. Major areas for which no macroinvertebrate data have been found include Allouez Bay, and areas upstream of the Hibbard Plant (for recent decades). No information is available on the uptake of contaminants by macroinvertebrates in the St. Louis River and bays.

Overall, the benthic community throughout the harbor and in the few shallow bays sampled, appears to be dominated by oligochaetes. However, variation between samples is wide: some contained no oligochaetes while some were comprised entirely of members of this group. Freshwater polychaetes were found in large numbers in some samples. Chironomids were also found consistently in high numbers throughout the sampled areas, but they were generally found in fewer numbers than the oligochaetes. Other groups frequently sampled were sphaerid clams, *Hexagenia sp.* (burrowing mayfly), Trichoptera, amphipods, gastropods, isopods, Hirudinea, and nematodes. The regions where *Hexagenia sp*. were found in at least half of the samples are the Superior Harbor basin (Envirodyne Engineering, 1983), the area of St. Louis Bay near the old Berwind dock (LTI, 1984), and the bay south of the Minnesota Power Hibbard plant which was sampled by Roush (1982) and Envirodyne Engineering (1983). Otherwise the

Table IV.9a Benthos

Location	No. Samples	Study [1]	Total Organisms Number per Sq. Meter Mean	Range	Percent % Oligochaetes	Percent % Chironomids	Fraction Samples w/ Hexagenia
Superior Entry	16	ENV	452	0 - 2081	0 - 96	0 - 100	7/16
Superior Harbor Basin	14	ENV	4775	100 - 19135	38 - 98	0 - 21	10/14
Hearding Island	4	ENV	919	667 - 1247	83 - 96	0 - 14	1/4
Hearding Hole	5	LTI	2475	805 - 3329	25 - 67	8 - 25	1/5
East Gate Basin	15	LTI/ENV	3524	14 - 16000[2]	1 - 100	0 - 15	0
Duluth Harbor Basin	16	ENV	1189	91 - 4558	46 - 91	4 - 23	1/16
Duluth Entry	4	ENV	0	0	0	0	0
Interstate Island	21	LTI/ENV	2351	301 - 5547	30 - 100	0 - 23	3/21
Erie Pier	8	ENV	1872	39 - 6112	0 - 77	19 - 80	1/8
WLSSD Outfall	6	ROU	1604	538 - 2086	55 - 81	17 - 37	1/6
St. Louis Bay, South	4	ENV	439	77 - 764	25 - 77	17 - 50	0
St. Louis Bay, So. Channel	4	ENV	819	258 - 2330	25 - 89	6 - 50	0
St. Louis Cross Channel	4	ENV	1136	467 - 2752	86 - 93	0 - 9	1/4
Berwind	8	LTI	1238	579 - 3387	25 - 70	0 - 31	8/8
Hibbard South	15	ROU/ENV	635	45 - 1531	0 - 85	5 - 100	8/15
Hibbard North	3	ROU	571	464 - 785	28 - 44	44 - 49	3/3
Stryker Bay	13	MPCA	19	0 - 114	0	0 - 100	3/13

[1] ENV = Envirodyne Engineering, 1983
LTI = Limno-Tech, 1984
ROU = Roush, 1982 (samples are composite for 3 dates)
MPCA = Minnesota Pollution Control Agency, 1990

presence of Ephemeroptera (mayflies) and Trichoptera (caddis flies), which are relatively intolerant of organic pollution, was fairly sporadic.

The only regions where samples were taken that contained no macroinvertebrates were the Duluth entry, Superior entry, and Stryker Bay adjacent to the Interlake Iron Superfund site. One area of marked paucity is the Duluth entry where no organisms were found in four samples. Unsuitable substrate (coarse sand, gravel, and cobble) and physical disturbance are probably the causal factors here (Envirodyne Engineering, 1983). Likewise, some of the Superior entry samples contained no organisms, for probably the same reasons. The two superfund sites on the river in Duluth have sediment contaminant levels known to be toxic to benthic organisms. No benthic invertebrate sampling has been done in connection with the U.S. Steel Superfund site. Benthic sampling in July, 1989 in Stryker Bay, adjacent to the Interlake Iron Superfund site, indicate very low benthic density and diversity (MPCA, 1990). Of thirteen samples taken in the embayment, seven contained no macroinvertebrates. Those samples that contained organisms were dominated by Chironomids. Very small numbers of the burrowing mayfly *Hexagenia limbata*, leeches, and sphaerid clams were also collected. No Oligochaetes were present in the samples. Total densities ranged from 0-114/sq. meter (see Table IV.9a). The results of this sampling in Stryker Bay are suggestive of toxicity. Visual inspection of Eckman dredge sediment samples taken in Hog Island Inlet in July, 1990 showed an absence of benthic invertebrates. Fifteen dredge samples were inspected, one per 200 ft x 200 ft grid covering the inlet. An occasional chironomid was present in a sample (Koshere, 1990).

The Superior Harbor basin and Duluth Harbor basin were covered by 14 and 16 samples respectively (Envirodyne Engineering, 1983). These areas showed relatively high number of organisms, with some samples dominated by large numbers of polychaetes. Percent oligochaetes and chironomids ranged from 39-98% and 0-21% respectively in the Superior Harbor basin and from 46-91% and 4-23% respectively in the Duluth Harbor basin. The Superior Harbor basin samples contained *Hexagenia sp*. in 10 out of 14 samples. No clear cut differences are apparent between total densities in shipping channel or harbor basins vs. shallow regions. Throughout the harbor, some samples contained very few organisms. Further analysis of these data would be necessary to discern more subtle trends or to correlate macroinvertebrate distributions to sediment contamination or other environmental factors.

3. Recent Bioassays

One area where recent investigations on sediment toxicity to benthic invertebrates have taken place is Hog Island Inlet of Superior Bay and Newton Creek, which flows into the inlet. Newton Creek is the receiving water for wastewater discharge from the Murphy Oil USA refinery in Superior, Wisconsin.

In August 1990, the WDNR conducted bioassays on sediment collected from three sites in Hog Island inlet, from Newton Creek at 21st Street, and from the Nemadji River at Highway C (upstream from the City of Superior) as a reference. Acute (48 hour) and chronic (10 day) static tests were performed using *Chironomus tentans*, a burrowing midge larva, and *Daphnia magna*, an epi-benthic cladoceran (Masnado, 1990).

Because the Newton Creek sediments produced acute and chronic toxicity to benthic organisms, the benthic community can be considered to be impaired at this location. Some test organism mortality was observed at the Hog Island Inlet sites closest to Newton Creek, but this mortality did not exceed acute or chronic criteria used by Wisconsin. Also, significant chronic impacts were not seen in tests on the Hog Island Inlet sediments. However, field observations revealed an absence of benthic invertebrates (Koshere, 1990).

The criterion used to determine acute toxicity was 50% mortality in a 48-hour test. The chronic toxicity criterion was a statistically significant difference in survival between test and reference sites during the 10-day test. Additional chronic toxicity criteria include significant differences in larval length and weight for *C. tentans* and in adult reproduction for *D. magna*. Test results are summarized in Table IV.9b.

Acute toxicity of the Newton Creek sediments was demonstrated in the *D. magna* test. The *C. tentans* test experienced dissolved oxygen depletion which invalidates the test results. The chronic toxicity test for *C. tentans* demonstrated significant impacts on larval weight and length at the Newton Creek site, indicating an effect of chronic toxicity.

The Hog Island inlet sediments did not exceed the 50% mortality criterion for acute toxicity. However some mortality was observed for both organisms in the acute tests. Chronic toxicity was not observed for either test organism in the Hog Island inlet sediments.

Table IV.9b Summary of WDNR Toxicity Test Data for Hog Island/Newton Creek

Site	Test Type	Species	Endpoint	Toxic/Non-Toxic
Laboratory Control	48-h Acute	*Chironomus tentans*	Survival	-
	48-h Acute	*Daphnia magna*	Survival	-
	10-d Chronic	*Chironomus tentans*	Survival/Weight/Length	-
	10-d Chronic	*Daphnia magna*	Survival/Reproduction	-
Nemadji River (Ref)	48-h Acute	*Chironomus tentans*	Survival	-
	48-h Acute	*Daphnia magna*	Survival	-
	10-d Chronic	*Chironomus tentans*	Survival/Weight/Length	-
	10-d Chronic	*Daphnia magna*	Survival/Reproduction	-
Hog Island Z 1-2/2	48-h Acute	*Chironomus tentans*	Survival	-
	48-h Acute	*Daphnia magna*	Survival	-
	10-d Chronic	*Chironomus tentans*	Survival/Weight/Length	-
	10-d Chronic	*Daphnia magna*	Survival/Reproduction	-
Hog Island Z 1-3/2	48-h Acute	*Chironomus tentans*	Survival	-
	48-h Acute	*Daphnia magna*	Survival	-
	10-d Chronic	*Chironomus tentans*	Survival/Weight/Length	-
	10-d Chronic	*Daphnia magna*	Survival/Reproduction	-
Hog Island Z 3-2/6	48-h Acute	*Chironomus tentans*	Survival	-
	48-h Acute	*Daphnia magna*	Survival	-
	10-d Chronic	*Chironomus tentans*	Survival/Weight/Length	-
	10-d Chronic	*Daphnia magna*	Survival/Reproduction	-
Newton Creek @ 21st	48-h Acute	*Chironomus tentans*	Survival	NA[1]
	48-h Acute	*Daphnia magna*	Survival	+
	10-d Chronic	*Chironomus tentans*	Survival/Weight/Length	+
	10-d Chronic	*Daphnia magna*	Survival/Reproduction	+

[1] = Invalid test due to unacceptably low dissolved oxygen concentration in test chambers.

Note: A toxic response is denoted by a plus sign (+), while a non-toxic response is denoted by a minus sign (-). All tests were initiated on 31 July 1990.

The U.S. EPA Environmental Research Laboratory in Duluth conducted bioassays on sediments from Hog Island Inlet in 1991. Sediments for the tests were collected from the inlet, approximately 50 feet from the mouth of Newton Creek. Sediments were collected for the tests four times: December 1990, January, May, and September 1991. Acute toxicity was observed for a variety of species (Schubauer-Berigan et al., unpubl. data). Results of these toxicity tests are shown in Table IV.9c. For bulk sediments, the percent mortality is reported for each test. For the tests with interstitial and overlying water, the toxicity value reported is the concentration at which 50% of the test organisms died during the test (LC50). The lower the LC50 value, the greater the toxicity of the sediments. These data indicate adverse toxic impacts upon the benthic and fish communities in this area.

Table IV.9c Summary of U.S. EPA Sediment Bioassays - Toxicity of Hog Island Sediment, Interstitial Water, and Overlying Water to Several Pelagic and Benthic Species. Tests were conducted for 96 h with fathead minnows, *Hyalella azteca* for 48 h with *Ceriodaphnia dubia*. Numbers in parentheses are 95% confidence intervals. (From M. Schubaer-Berigan, ASCI Corp., Unpubl. data)

			Toxicity		
Date Sampled	Date Tested	Species	Bulk Sediments (% Mortality)	Interstitial Water* (LC50)	Overlying Water* (LC50)
12/04/90	12/07/90	Fathead Minnow	--[1]	18 (14-22) 53 (41-68)	-- --
		C. dubia	--	57 (47-70)	--
01/29/90	01/31/90	Fathead minnow	--	29 (24-35)	23 (17-32)
		C. dubia	--	44 (31-61)	41 (NC)
		H. azteca	50	89 (NC)[2]	--
05/28/91	06/07/91	Fathead minnow	80	54 (43-66)	42 (26-68)
	06/07/91	*C. dubia*	--	20 (17-24)	NT[3] (0.1)
	05/29/91	*H. azteca*	70	50 (39-64)	NT (20%)
09/04/91	09/13/91	Fathead minnow	65	TIP[4]	TIP
	09/16/91	*C. dubia*	--	54 (43-66)	TIP
	09/13/91	*H. azteca*	60	TIP	TIP

* Concentration of test water resulting in 50% mortality
1 --; Not tested.
2 NC; confidence intervals not calculable because of lack of partial mortality in test concentrations.
3 NT; Not toxic, percent mortality at high concentration in parentheses.
4 TIP; Tests in progress.

The Wisconsin DNR tests with *C. tentans* and *D. magna* showed acute and chronic toxicity effects for sediments from Newton Creek impoundment. The DNR tests did not show toxicity effects (LC50) for sediments from Hog Island Inlet. U.S. EPA tests with fathead minnows, *Ceriodaphni dubia*, and *Hyalella azteca* did demonstrate acute toxicity effects from the Hog Island Inlet sediments, the interstitial water of the sediments, and the overlying water in Hog Island Inlet.

I. RESTRICTIONS ON DREDGING

IJC Listing Criteria: When contaminants in sediments exceed standards, criteria, or guidelines such that there are restrictions on dredging or disposal activities.

Is the Beneficial Use Impaired? Yes

Restrictions on dredging is a use that can be clearly identified as impaired in the St. Louis River AOC. Sediments in many parts of the AOC exceed guidelines developed by regulatory agencies to characterize in-place sediments and contain a variety of toxic, bio-accumulative contaminants which have been shown to cause adverse effects to aquatic and terrestrial organisms. Serious economic and social consequences are also imposed upon some resource users through special dredging requirements and obligations for long term sediment containment.

1. The Significance of Sediments

Restrictions on dredging represent one of the principal reasons for designation of 42 of 43 Great Lakes Areas of Concern (AOC). In terms of significance to AOC communities, few issues elicit more debate or interest than the disposal/management of dredged materials. Dredging involves a variety of complex and inseparable economic, social, and environmental issues. The maintenance of commercial navigation in the Great Lakes, for instance, requires dredging and a place for the disposal of dredged material. In the past, disposal of dredged materials simply involved casting the spoils aside or dumping them into the bottom of Lake Superior. These practices are no longer as simple or as acceptable. Sediments are now recognized as pollutant sinks and reservoirs of contaminants that can be mobilized and bio-accumulated by aquatic organisms. Contaminants can attach to sediment particles which are then ingested by organisms. The contaminants on sediment can also partition or leach into surrounding waters. This release of contaminants can be exacerbated by dredging, large streamflow events, ship traffic, and the effect of Lake Superior seiches.

2. Evaluation of Ecosystem Effects

Sediments are significant from an ecological perspective because of their roles as pollutant sources to the water column, to bottom dwelling organisms, and to aquatic and terrestrial consumers at various steps of the food chain. Organic chemical compounds and some heavy metals are known to bio-accumulate in fish, plants, and other aquatic organisms. The consequences of this bio-accumulation on animal populations is aptly described in IJC's Fifth Biennial Report on Great Lakes Water Quality. This report found that "sixteen Great Lakes wildlife species near the top of the food web have experienced reproductive problems or declines in populations at one time or another since 1950. In each case, high concentrations of contaminants have been found in animal tissue" (IJC, 1990). The key factors that determine biological effects of contaminants are the bioavailability of the contaminants and the sensitivity of the organisms to a particular contaminant once exposed (as determined by size, sex, age, reproductive cycle, lipid content, and detoxification mechanisms). Measurement of the contaminants in sediments (bulk chemistry) alone is not a good measure of the relevant toxicity of the contaminant or its availability to biota.

A lack of clear guidelines has made the evaluation of contaminated sediments and their linkages to biological impacts and human health difficult to ascertain. The first attempts at developing dredge disposal guidelines resulted in U.S. EPA's issuance of dredge disposal guidelines in 1977. Such guidelines, however, were never intended to serve as long term references and do not take into account background levels of metals characteristically present in watershed soils or the significance of in-place sediment contamination on aquatic organisms. At present, there are approximately a dozen approaches to assessing the quality of sediments including field-based, laboratory, and calculation-based methods. These methods are in various stages of development and application by researchers and regulatory agencies. Current approaches for characterizing sediment quality include the Equilibrium Partitioning approach (EQP) and the Screening Level Concentration approach.

The U.S. EPA is using the Equilibrium Partitioning approach to develop draft sediment quality criteria for some nonpolar organic compounds (unionized and undissociated compounds). A basic assumption of this approach is that there is an equilibrium between the level of the contaminant on the sediment and the level in the surrounding waters. Under the EQP approach, levels of an organic compound are established for the sediment such that the contaminant will not be found in the surrounding waters in concentrations exceeding water quality criteria. This approach only takes into account the partitioning or leaching of contaminants from undisturbed sediment. However, disturbance and resuspension of sediment may increase the amount of contaminants that are released from the sediment into surrounding waters. These sediment quality criteria establish acceptable water concentrations based on bioaccumulation from water and food uptake into biota, and risks associated with consumption of the biota.

The Screening Level Concentration approach is used in the Ontario Ministry of the Environment's (MOE) Sediment Quality Guidelines. The guidelines are developed around the assumption that bottom dwelling or benthic organisms are integrators of the physical, biological, and chemical conditions present in the environment. The MOE Sediment Quality Guidelines have biological thresholds which are defined as no effect level, lowest effect level, and limit of tolerance. The no effect level is a level of contamination where no toxic effects have been observed. The no effect level for nonpolar compounds is driven by tissue-water concentration levels. That is, the concentration of a contaminant in the water must not exceed a certain level in order that the contaminant level in the organism's tissue does not cause a toxic effect. The lowest effect level is a level of sediment contamination that can be tolerated by the majority of benthic organisms. The limit of tolerance is the level of contamination that could potentially eliminate most of the benthic organisms from a site (Appendix D: Janisch, 1991). The MOE Sediment Quality Guidelines are listed in Tables I-1 and I-2 in Appendix D.

3. Sediment Evaluation for the St. Louis AOC

Data from a number of sources and studies were used to assess sediment quality of the St. Louis AOC. The spatial and temporal variability in data collection and the varying sampling designs and procedures had to be considered in evaluating and comparing the data. Consolidation of the available bulk chemistry data into a database was begun by the Arrowhead Regional Development Commission and continued by the Wisconsin DNR, Lake Superior Research Institute, and the Minnesota PCA.

The Toxics TAC Sediment subcommittee conducted an examination of criteria and assessment methods for sediment evaluation for the St. Louis AOC (See Appendix F). The subcommittee recommended a set of categories to graphically represent the degree of contamination in St. Louis AOC sediments for this initial assessment. The categories were based on the Ontario Ministry of Environment's Sediment Quality Guidelines for no effect level, lowest effect level, and limit of tolerance. Descriptive labels used to correspond to these categories are 1) no effect/clean, 2) marginally polluted (greater than no effect level but less than lowest effect level), 3) significantly polluted (greater than lowest effect level but less than limit of tolerance, and 4) limit of tolerance. MPCA staff mapped the bulk sediment data for those compounds of greatest concern, based on recommendations of the Toxics TAC. These contaminants: mercury, PCBs, dioxins, and PAHs are highlighted because of their connection to the fish consumption advisories and/or to biological effects in the AOC. The maps are presented in Figures IV.4 - IV.7 along with further discussion of these contaminants. [Note: Figures V.4, V.5, and V.7 were based on data from 500 sediment samples at 123 locations. Seventy four percent of the 500 samples were samples taken a varying depths at a location. At locations with multiple depth sampling, the highest concentration of the pollutant found at the location is displayed on the maps. The sediment data is not directly comparable because of variability in detection limits and quality assurance/control programs.]

Further analysis of the sediment data was conducted by Tom Janisch, WDNR (Appendix D). Several sediment quality assessment approaches were used in Appendix D to evaluate the St. Louis AOC sediments. These approaches provided a preliminary assessment and served as a screening step to help identify existing and potential problem areas that need to be addressed and fully characterized through appropriately designed sampling plans and application of selected toxicity testing and in-field studies. Sediment bulk chemistry data are available for only certain areas within the AOC, mainly the navigation channels. Laboratory toxicity testing and in-field biological studies related to sediment contamination have been conducted for only a very limited number of sites within the AOC. Overall, further chemical and biological characterization of the sites where some sediment data are available is needed. Characterization of sediment quality is also needed for large areas within the estuary, particularly in shallow biologically productive areas, and in reservoirs behind the dams, where little or no data are available.

The available data show that contaminants present in the AOC include:

a. Nutrient or conventional pollutants (e.g. BOD, oil and grease, ammonia-nitrogen, phosphorous);

b. Inorganic or metal pollutants and cyanide;

c. Synthetic or xenobiotic organic compounds (e.g. polychlorinated biphenyls, polycyclic aromatic hydrocarbons).

Evaluation of available sediment data indicates that there are five distinct locales within the St. Louis River AOC that have clearly elevated levels of contaminants. Studies at some of these sites have related the sediment contamination to potential adverse effects on biota. The contamination sites are:

1. St. Louis River adjacent to the settling pond and unnamed creek from the U.S. Steel site in the Duluth neighborhood of Morgan Park

2. Stryker Embayment, Hallet Boat Slip, and an area in the river at the foot of the 54th Avenue Peninsula (Interlake/Duluth Tar site) in West Duluth

3. Newton Creek and Hog Island Inlet of Superior Bay

4. The embayment of St. Louis Bay into which the wastewater effluent from the Western Lake Superior Sanitary District wastewater treatment plant is discharged

5. The wetlands of Crawford Creek (a tributary of the Nemadji River) associated with the Koppers Company wood treatment facility in Superior

The five sites listed above represent locales of known sediment contamination within the AOC but not a complete inventory of all sites because comprehensive sampling has not been performed throughout the sediment depositional areas of the AOC. The existing data show sample sites at dispersed locations within the AOC that have elevated levels of PCBs, mercury, and some metals. Additional sampling is needed at these sites to determine the areal and vertical extent of contamination. Even the five locales listed above need further characterization and biological-effect studies before remediation planning can be started. All were characterized based on studies that had different sampling designs.

A common feature with all of the sites, except WLSSD, is sediment known to be contaminated by polycyclic aromatic hydrocarbon (PAH) compounds originating from a number of different sources (including coal tars, petroleum, creosote). Other contaminants such as metals, mercury, and PCBs are also found at one or more of these sites. Based on the high concentrations of PAHs at some of these sites and the potential for dispersion and transport away from the sites, future efforts to characterize sediment contamination at other locations within the AOC should include sampling and analysis for PAH compounds. Based on the association made between PAH concentrations in sediments and fish neoplasms at other AOCs in the Great Lakes, further efforts to characterize the St. Louis AOC should attempt to identify if the presence of PAHs is impairing fish health.

a. Mercury

The presence of mercury in AOC surface waters and sediment is of concern because of its toxicity and ability to bio-accumulate in aquatic organisms. Mercury in fish of the St. Louis River is one of the reasons for the fish consumption advisories. Of the mercury forms commonly found in natural waters, the most hazardous is methylmercury; methylmercury is stable and binds to protein thus it can be well distributed throughout muscle tissue and can penetrate membranes of living organisms such as fish. (Appendix D: Janisch, 1991). The prevailing evidence suggests that sediments are the principal source areas for the methylation of mercury. Micro-organisms living in sediments ingest inorganic mercury in their food supply and excrete methylmercury as a means of detoxification. This methylation of mercury is part of a natural cycling process. "Man made sources of mercury in sediments can result in methyl-mercury concentrations above natural cycle steady-state conditions" (Appendix D: Janisch, 1991). This condition, while controlled largely by such variables as biological activity, pH, temperature, and sediment organic contents, can result in elevated mercury water column concentrations and consequently levels in aquatic organisms. Even though 90-99% of mercury in sediments remains unavailable, its persistence creates a long term concern. The conversion of mercury to methylmercury is estimated to be less than 0.1% in natural aquatic systems (undisturbed). Unless accumulated mercury in sediments is removed or rendered unavailable, its persistence makes it available for conversion to methylmercury for years to come (Appendix D: Janisch, 1991).

The eco-toxic properties and human health implications of mercury contamination are reasonably well documented and understood. Studies have shown that mercury is the most toxic of metals to aquatic organisms. This toxicity is reflected in stringent standards adopted by the states of Minnesota and Wisconsin. Wisconsin Administrative Code, N.R. 105, specifies that surface waters not exceed a limit of Hg^{+2} 1.53 ug/l for the protection of acute effects to aquatic organisms; a limit of .002 ug/l for consumption by wild and domestic animals; and a level of .079 ug/l for the protection of human health. Minnesota Rules, Chapter 7050, specifies that total mercury water column concentrations not exceed 2.4 ug/l for the class of waters designated for fisheries or recreational use (Appendix D: Janisch, 1991). This class of waters includes the St. Louis River. Sediment classification guidelines developed by the Ontario Ministry of the Environment specify that discernable impacts to benthic organisms are observed at mercury sediment concentrations of 200 ug/kg (See Table I-1, Appendix D). Areas known to contain sediment mercury levels in this category are identified in Figures IV.4a and IV.4b and include the Interlake site, sites adjacent to WLSSD and the Superior Midwest Energy Terminal, and in predominantly off channel areas of Superior Bay. From the perspective of human health, mercury is also recognized as a potent neurotoxin. Long term exposure to either inorganic or organic mercury in adults can result in shakiness, memory loss, and damage to the brain and/or kidneys (MPCA, 1990). The states of Minnesota and Wisconsin have both issued fish consumption advisories for mercury on the St. Louis River. These advisories, which are explained in Chapter IV, recommend strategies for limiting exposure to mercury contaminated fish based on consumption patterns and demographics.

Figure IV.4a

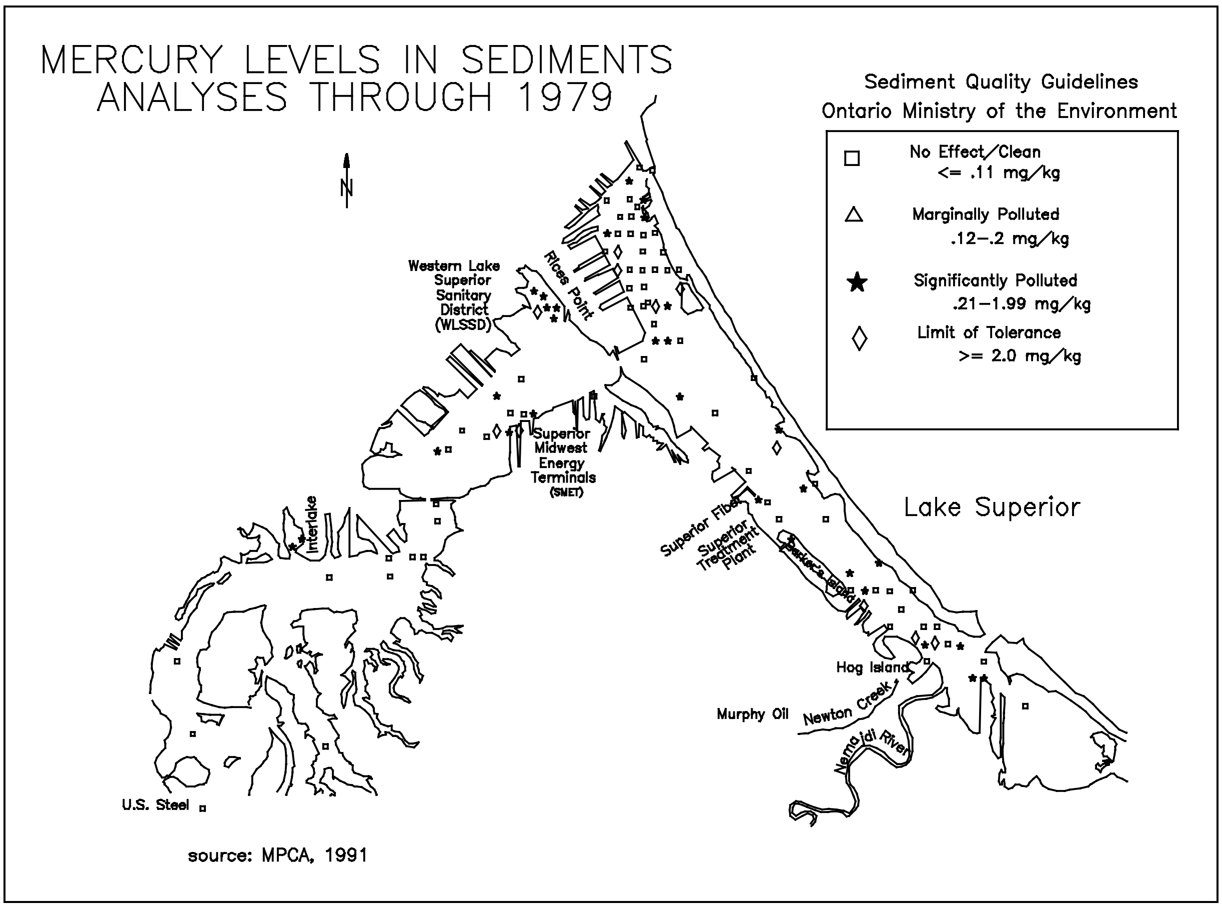
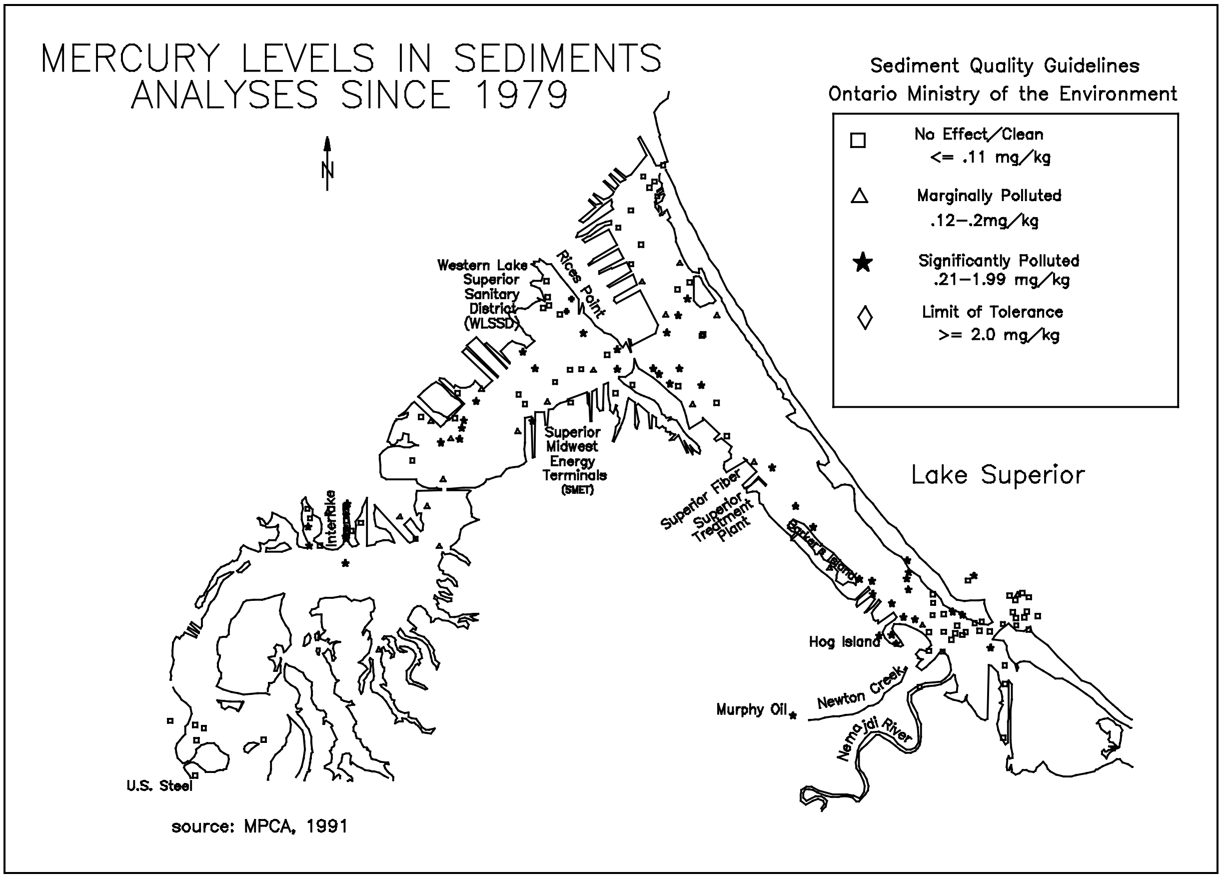


Figure IV.4b



The characteristics and distribution of mercury contamination in the St. Louis River were examined recently in a study conducted by Glass et al. (1990). As a part of this study, mercury concentrations were measured in sediments, suspended solids, plankton, and in the water column. Some of the conclusions reached by this study are as follows: 1) historical usage of mercury by the paper industry above the community of Fond du Lac contributed to contamination of the lower St. Louis River; 2) the use of mercury for iron analysis by a steel mill (U.S. Steel Duluth Works Mill) may have contributed to the sediment accumulation of mercury; and 3) the highest sediment concentrations of mercury were detected near the WLSSD discharge outfall (See Table IV.10). This study indicated that WLSSD represented the major source of elevated mercury levels to the water column and sediments adjacent to the plant's outfall. Mercury levels in sediment ranged from 1,000 to 5000 ug/kg around the outfall. (Glass et al., 1990). Figures IV.4a and IV.4b illustrate the relationship of these samples to others in the estuary and harbor area of the St. Louis River AOC. The figures also show sediment contamination conditions prior to and after start-up of the WLSSD facility in 1979. It should be noted that the area
adjacent to WLSSD's outfall also served as a site where wastes were historically discharged with little or no treatment and that WLSSD has initiated a program focused at reducing mercury discharges to St. Louis Bay. Prior to any reduction initiatives, the average daily loading of mercury from WLSSD to the St. Louis River consisted of about 60 g/day. Average daily mercury loadings from the Superior Waste Water Treatment Plant consist of approximately .4 g/day (Glass et al., 1990).

Table IV.10 Mercury Concentrations in Lower St. Louis River Sediments - 1988 [from Glass et. al, 1990]

Sampling Locations	Concentration (ug/kg)
Highway 33	23-28[d]
USG	59-117[d,e]
Northwest Paper Dam - Potlatch	40-161[e]
Scanlon Dam	60-484[e]
Thomson Reservoir	112-134
Thomson Dam	861-962[d]
Forbay Lake	94-121
Fond du Lac Dam	52-211
Kimball’s Bay	148-168
WLSSD Point	1070-5070[d]
Superior Bay-19th Avenue	106-137

d = Composite sample from MPCA, others samples used Hongrve corer.

e = Above Knife Falls Dam.

b. Polychlorinated Biphenyls (PCBs)

Polychlorinated Biphenyls (PCBs) and chlorinated insecticides represent a large class of organo-chlorine compounds used or produced in the United States since 1929. "As a group, they are the most persistent anthropogenic organic compounds introduced into the environment since the lead and arsenic pesticides of the early 1900s" (Smith et al., 1988). The physical and chemical properties of PCBs resulted in their widespread application as plasticizers, hydraulic lubricants and cutting oils, and dielectric fluids. PCBs have also been used in fungicidal applications, paints, copying paper, printing inks, adhesives, and sealants (Smith et al., 1988). The toxicity and persistence of PCBs in the environment led to their commercial regulation under provisions of the 1976 Toxic Substances Control Act. The production, sale, and distribution of PCBs was prohibited in 1979. Despite cessation of production, an estimated 2.8 million capacitors and 2 million transformers still in use today contain PCBs. (Smith et al., 1988).

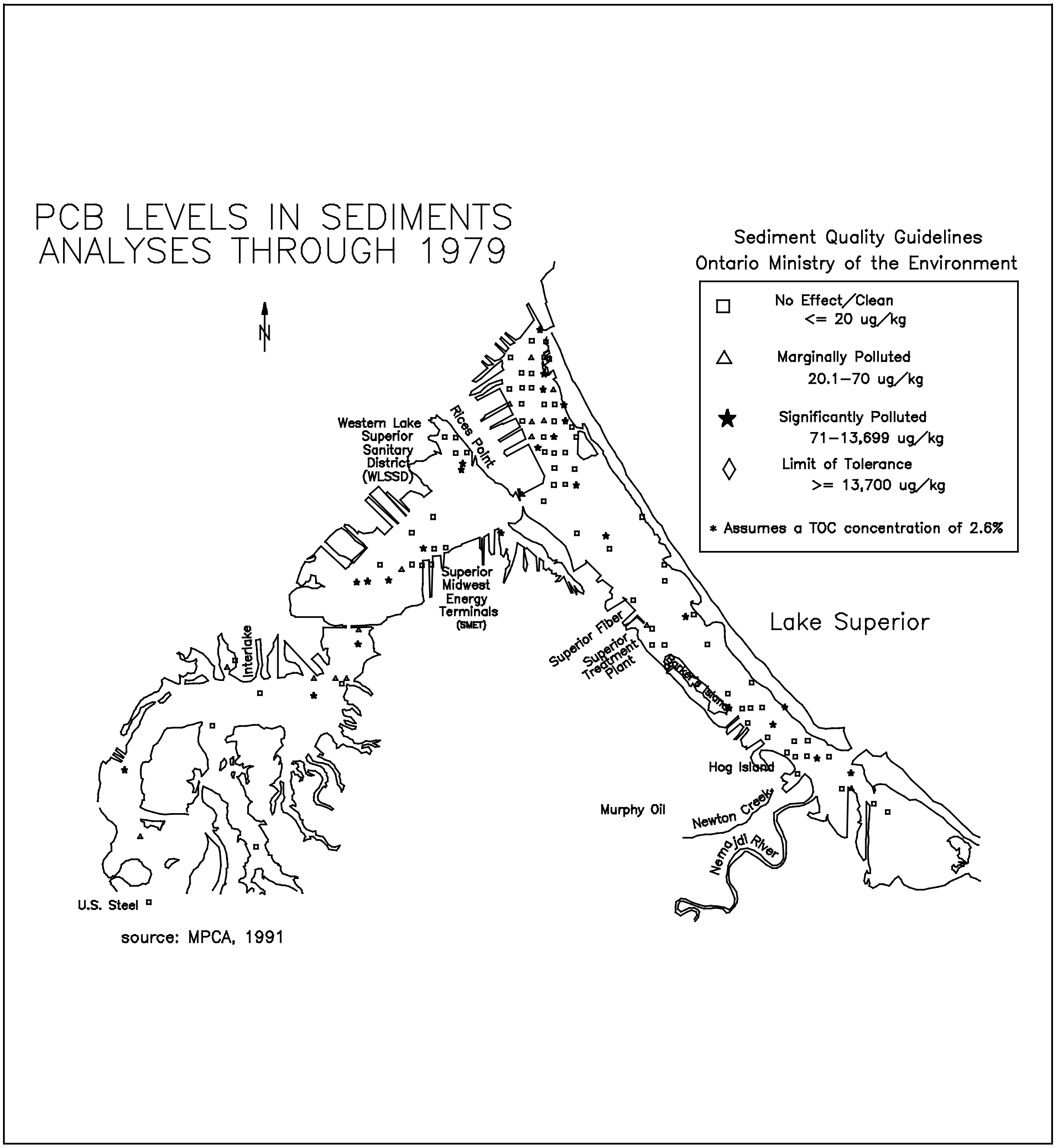
Low water solubilities and an affinity to partition to lipid (fat) reservoirs of aquatic organisms and sediments high in organic matter are distinguishing characteristics of PCBs. A New York study found aqueous concentrations of 3.0 ug/l over sediments known to contain PCBs levels of approximately 3,000,000 ug/kg. The level of PCBs in sediment was six orders of magnitude (10^6) greater than the level of PCBs found in the water column. Even low aqueous concentrations of PCBs can bio-accumulate significantly in aquatic organisms and fish. Bio-concentration factors experimentally derived for four PCB congeners ranged from 200 to 12,000 times its aqueous concentration (Smith et al., 1988). The bio-concentration of PCBs are of significance in the St. Louis River AOC because of known sediment sources.

Sampled areas of the St. Louis River contain sediment concentrations of PCBs ranging from non-detectable to over 2000 ug/kg. These samples were taken from a few select areas and do not necessarily reflect sediment concentrations in biologically productive backwater areas or upstream sites. Young-of-year spottail shiners sampled from the St. Louis River in 1983 contained PCB levels of .28 ug/g (+/- .063). These fish tissue levels were the highest observed in this particular sampling effort and exceeded levels detected in three AOCs along the Canadian shoreline of Lake Superior (IJC, Undated).

PCBs are significant from a human health and toxicological perspective. Animal studies have demonstrated the ability of PCBs to cause liver damage, alter immune and reproductive system functions, and to cause cancer. A study of children born to Michigan women, who for sixteen years consumed a steady diet of Lake Michigan fish contaminated with PCBs, revealed a higher than normal incidence of children with below normal birth weights, small head circumferences, and developmental disabilities that lingered for approximately four years. The findings of this study also corroborate well with research conducted later in North Carolina (Shubat, 1990). Minnesota and Wisconsin have each taken steps to minimize human health or environmental risks associated with PCBs. These efforts include the issuance of water quality criteria and, where necessary, fish consumption advisories. Wisconsin Administrative Code, N.R. 105, specifies a water quality criteria of 0.15 ng/l (Total PCBs) for the protection of fish communities in the Great Lakes. Minnesota has established water quality criteria for the protection of fisheries and recreational waters of 0.029 ng/l, 1000 ng/l, and 2000 ng/l, for chronic, maximum, and acute categories (Minnesota Rules, Chapter 7050). Consumption advisories based on fish tissue residues of PCBs are issued by both Minnesota for the St. Louis River and Lake Superior and by Wisconsin for Lake Superior.

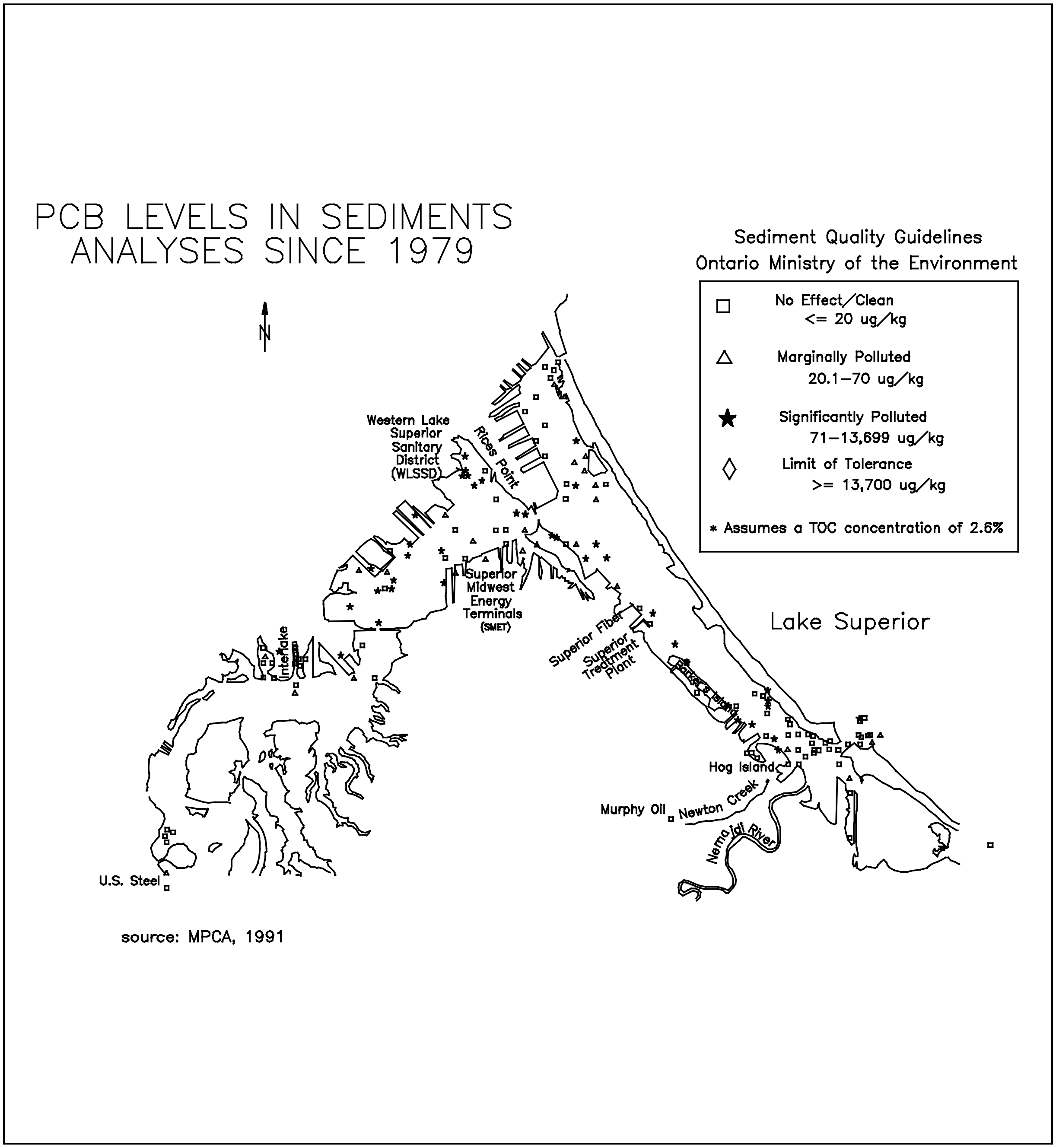
The distribution of PCB-contaminated sediments and their associated concentrations vary considerably from Lake Superior to the St. Louis River AOC. Mean sediment concentrations of PCBs in Lake Superior were identified in Appendix D: Janisch (1991) to be 3.3 ug/kg for the lake as a whole, 3.9 ug/kg for non-depositional areas, and 4.8 ug/kg for depositional areas. The highest levels of PCBs in Lake Superior were observed in the western arm, near the cities of Duluth, Minnesota and Superior, Wisconsin. These higher sediment concentrations were attributed to being downwind and/or in close proximity to the Duluth-Superior urban area. A number of sampling programs carried out on the St. Louis River detected sediment levels of PCBs far in excess of those reported in Lake Superior. Figures IV.5a and IV.5b show PCB levels in sediment prior to and after the 1979 start-up of the WLSSD facility. For instance, the highest concentrations of PCBs detected in sediments from a 1979 MPCA system-wide sampling effort program were near WLSSD and above the Scanlon Dam. Sediment levels of 280 and 2500 ug/kg were reported in two sites adjacent to WLSSD; sediment concentrations of 240 ug/kg were detected at the Scanlon Dam site (Appendix D: Janisch, 1991). Similar results were found in a subsequent sediment sampling effort carried out by the University of Minnesota-Duluth and MPCA in 1988. Bahnick and Markee (1985) also observed sediment levels of PCBs ranging from 67 to 222 ug/kg for four lower river sites. Of these sites, the highest sediment concentrations were detected near WLSSD’s outfall. Bahnick and Markee (1985) identified the major sources of PCBs to the St. Louis river as atmospheric emissions, wastewater effluent, and various industrial activities. Annual mass loadings estimated from samples of WLSSD effluent were calculated to be 9 kg/yr. PCBs are undetectable in WLSSD effluent at present. The total discharge of PCBs to Lake Superior from St. Louis river sources was estimated to be 23 kg/yr (Bahnick and Markee, 1985).

Figure IV.5a



PCB LEVELS IN SEDIMENTS
ANALYSES THROUGH 1979
N
Sediment Quality Guidelines
Ontario Ministry of the Environment
No Effect/Clean
<= 20 ug/kg
Marginally Polluted
20.1-70 ug/kg
Significantly Polluted
71-13,699 ug/kg
Limit of Tolerance
>= 13,700 ug/kg
* Assumes a TOC concentration of 2.6%
Western Lake Superior Sanitary District (WLSSD)
Rices Point
Superior Midwest Energy Terminals (SMET)
Interlake
Superior Fiber
Superior Treatment Plant
Barker's Island
Hog Island
Murphy Oil
Newton Creek
Nemadji River
Lake Superior
U.S. Steel
source: MPCA, 1991

Figure IV.5b


PCB LEVELS IN SEDIMENTS
ANALYSES SINCE 1979
N
Sediment Quality Guidelines
Ontario Ministry of the Environment
No Effect/Clean
<= 20 ug/kg
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71–13,699 ug/kg
Limit of Tolerance
>= 13,700 ug/kg
* Assumes a TOC concentration of 2.6%
Lake Superior
Western Lake
Superior
Sanitary
District
(WLSSD)
Rices Point
Superior
Midwest
Energy
Terminals
(SMET)
Superior Fiber
Superior
Treatment
Plant
Interlake
Hog Island
Murphy Oil
Newton Creek
Nemadji River
U.S. Steel
source: MPCA, 1991

c. Polychlorinated Dibenzo-p-dioxins

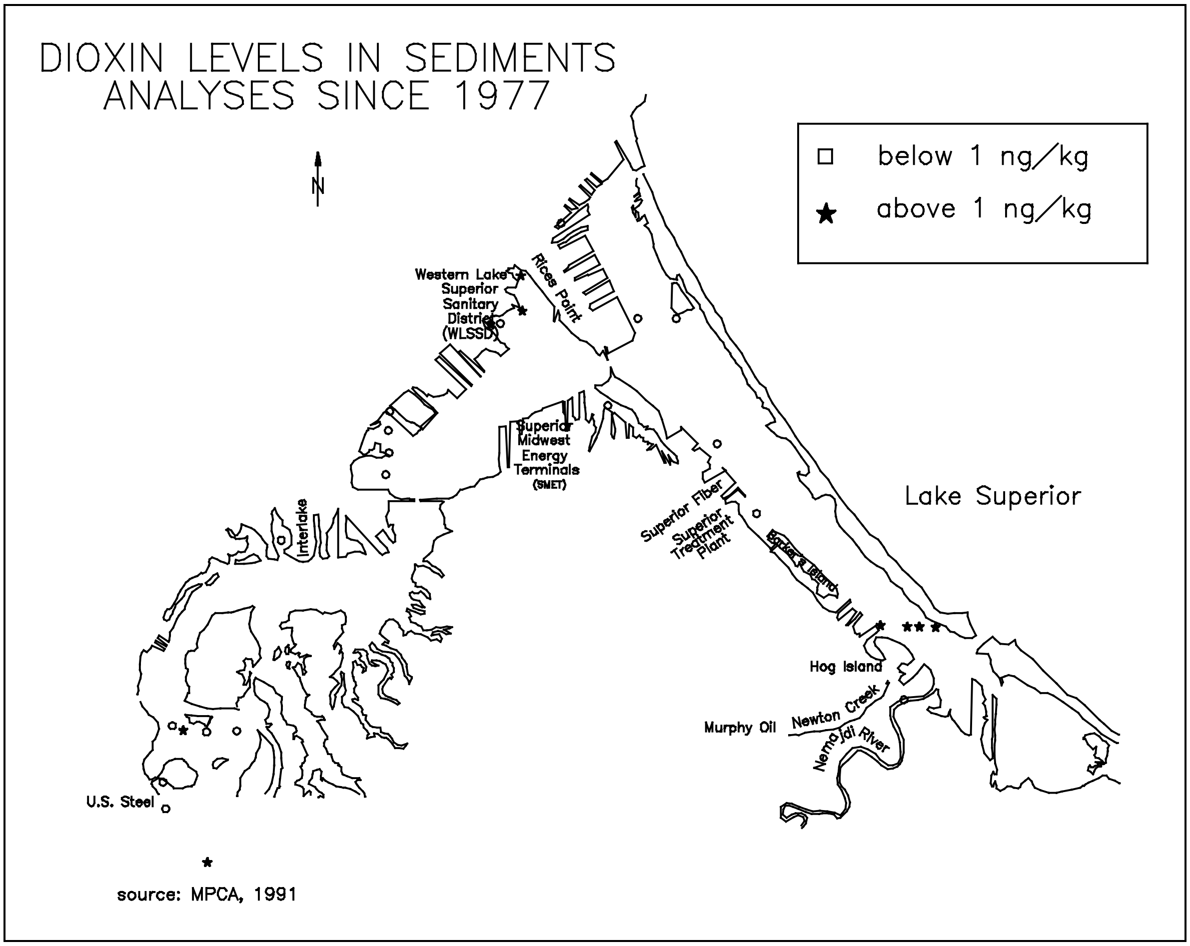
Polychlorinated Dibenzo-p-dioxins (dioxins) are compounds that strongly partition to lipid reservoirs of aquatic organisms and sediments high in organic matter. Unlike PCBs and chlorinated insecticides, dioxins have no commercial applications and are not intentionally produced. Major sources of dioxin to the environment include incineration, paper mills using chlorine bleaching processes, commercial chemicals, and spills or fires involving PCBs. Dioxin is also found in a variety of commercially produced pesticides and herbicides. Samples taken in 1968 from a manufacturer of the herbicide 2,4,5-T contained on average 10 mg/kg of 2,3,7,8-tetrachlorodibenzo-p-dioxin. Later 2,4,5-T samples contained dioxin residues of less than .1 mg/kg. Herbicides such as 2,4,5,-T have been used extensively in forests throughout the United States. A number of studies have shown that dioxins associated with herbicide applications will not leach out significantly from the soil. The principal mode of transport for dioxin associated with the application of 2,4,5,-T was found to be soil erosion (Smith et al., 1988).

The characteristics and fate of polychlorinated dibenzo-p-dioxins (PCDD) in the environment closely mimic that of chlorinated insecticides and PCBs. The maximum solubility of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) in natural waters is only 3 to 5 ng/l. As a consequence of this low solubility, significant concentrations of dioxins are likely to be found in sediments and lipid reservoirs of aquatic organisms. Studies have documented that low aqueous concentrations of dioxin can still result in significant bio-accumulation factors by aquatic organisms. One study reported that mosquito larva accumulated dioxin levels from 2,800 to 9,200 times the aqueous concentration. Catfish with an exposure time of six days had bio-concentration factors which ranged from 2,000 to 27,900 times the aqueous solution (Smith et al., 1988).

The compound 2,3,7,8-tetrachlorodibenzo-p-dioxin is of concern from an environmental and human health perspective. "In animals, death results from exposure to amounts ranging from less than one microgram to a few kilograms of body weight" (Canadian Environmental Protection Act, 1990). Birds and fish are more sensitive than mammals to short term exposure. Experimentally determined lethal doses of TCDD given to bluegills, carp, yellow perch, trout, and other species ranged from 2 to 23 ug/kg/body weight. Considerable disagreement still remains about the linkage between dioxin exposure and its carcinogenic properties in humans. The International Agency for Research on Cancer (IARC) concludes that "there is inadequate human data but sufficient animal data to conclude that this compound is possibly carcinogenic to humans" (Canadian Environmental Protection Act, 1990). As part of the U.S. EPA Great Lakes Water Quality Initiative, water quality criteria are being proposed for the protection of humans and wildlife from the effects of dioxin.

There are a number of instances where detectable levels of dioxin have been found in St. Louis River AOC fish or sediments. Thirteen fish samples and one turtle were found to contain dioxin (See Appendix B). The fish include carp, walleye, and northern pike. The tissue residues of the carp ranged from 5.2 to 15.0 pg/g. TCDD tissue residues found in the northern pike and walleye were 0.5 pg/g in an MPCA study and 5.2 and 1.0-4.0 pg/g respectively in a WDNR study. Areas of the lower St. Louis River AOC with detectable TCDD sediment concentrations are identified in Figure IV.6. In samples testing positive, the highest sediment levels were located near WLSSD's discharge outfall. WLSSD presently receives 4.48 x 10^{-7} pounds/day of dioxin from the Potlatch plant (MPCA, 1991). The sediment concentrations near WLSSD's outfall ranged from 10.5 to 13.7 pg/g. Sampled areas upstream of Fond du Lac community with detectable levels of TCDD in sediment include Fond du Lac, the Thomson Dam, and the Knife Falls Dam. TCDD levels identified in these sediments range from 1.9 to 3.4 pg/g (UMD, 1990).

Figure IV.6



d. Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic or polynuclear aromatic hydrocarbons (PAHs) represent a large class of chemical compounds characterized by two or more fused ring compounds based on benzene. PAHs are generated as a result of the incomplete combustion of wood, oils, coal, forest fires, vehicle emissions, and from incinerators. Residues of PAHs are present in gasoline, crude oils, diesel fuels, coal, and motor oils. Vehicle sources delivered from asphalt and tire wear are considered additional sources. On a global basis, combustion is believed to represent the principal source of PAHs to the atmosphere and consequently surface waters. Atmospheric emissions of benzo(a)pyrene in the United States, for instance, were estimated to be approximately 1,700,000 kg/yr in 1983 (Smith et. al, 1988). Benzo(a)pyrene is a constituent of fuels such as gasoline and is considered a potent carcinogen. The variety of pathways into the environment makes it difficult to find surface waters/sediments without detectable levels of PAHs. It is common to find sediments in urban streams with PAH levels in the range of 1000 to 5000 ug/kg (Appendix D: Janish, 1991). In contrast, sediment levels at the Interlake Steel/Duluth Tar and Chemical Company Superfund Site exhibited concentrations from 27,000 ug/kg to 6,090,000 ug/kg.

PAHs are characterized by a strong propensity to partition to lipid reservoirs of aquatic organisms and/or to sediments high in organic matter. "Fish and some invertebrates have enzyme systems capable of oxidizing PAHs, resulting in low bio-concentration factors. Invertebrates and some fish that lack a system capable of biotransformation of PAHs may bio-concentrate PAH compounds" (Appendix D: Janisch, 1991). These traits mean that concentrations can remain at low aqueous levels while sediments and aquatic organisms are on the order of a magnitude higher. Researchers in New Jersey found concentrations of PAHs ranging from 2 to 20 ug/l in bottom waters downstream from a chemical company's effluent discharge. Aqueous concentrations of PAHs in another study were undetectable downstream of a chemical company's discharge, despite the existence of pyrene and other substances in sediments at levels ranging from 200 to 75,000 ug/kg (Smith et al., 1988). Low aqueous concentrations of PAHs can still result in significant bio-concentration of PAHs by aquatic organisms. Experimentally determined bio-concentration factors for a variety of aquatic organisms are documented in Table IV.11.

Table IV.11 Bio-concentration Factors (BCFs) for Selected Polycyclic Aromatic Hydrocarbons. **[from Smith et al., 1988]**

Compound	Organism	Exposure Time - Days	BCF	Reference
Naphthalene	Daphnia pulex	1	131	1
Naphthalene	S. capricornutum	1	12,500	2
Naphthalene	Fish	-	427	3
Chloronaphthalenes	Grass Shrimp	3	50-300	4
Acenapthene	Fish	-	389	3
Phenanthrene	Daphnia pulex	1	325	1
Phenanthrene	S. capricornutum	1	23,800	2
Phenanthrene	Fish	-	2,630	3
2-Chlorophenanthrene	Fish	-	4,266	3
2-Methylphenanthrene	Fish	-	3,020	3
Anthracene	Daphnia pulex	1	917	1
Anthracene	Fish	-	912	3
9-Methylanthracene	Daphnia pulex	1	4,583	1
9-Methylanthracene	Fish	1	4,571	3
Pyrene	Daphnia pulex	1	2,702	1
Pyrene	S. capricornutum	1	36,300	2
Pyrene	Fish	-	2,692	3
Flourene	Fish	-	1,288	3
Benzo(a)anthracene	Daphnia pulex	1	10,109	1
Benzo(a)anthracene	Fish	-	10,000	3
Benzo(a)pyrene	Fish	-	22	4
Benzo(a)pyrene	Snail	-	3,000	4
Perylene	Daphnia pulex	1	7,191	1

1. Southworth and others (1978b)
2. Casserly and others (1983)
3. Mackay (1982a)
4. Biddinger and Gloss (1984)

The effects of PAHs on aquatic organisms and human health are not well understood. Of this large class of compounds, only a few have been reviewed and are recognized as carcinogenic. Wisconsin Administrative Code, N.R.105. (1989), lists these compounds as: 1) benzo(a)pyrene,
2) benzo(a)anthracene, 3) 3,4 - benzofluoranthene, 4) benzo(k)fluoranthene, 5) benzo[ghi]perylene, 6) chrysene, 7)dibenzo[a,h]anthracene, 8) ideno(1,2,3-cd)pyrene, 9) phenanthrene, and 10) pyrene. In the Great Lakes, tumor incidence in fish increases near areas contaminated with carcinogenic compounds such as PAHs (Baumann, 1984). The following generalizations about the impacts of PAHs on aquatic organisms were taken from Appendix D: Janisch (1991): "1) many PAHs are acutely toxic at water column concentrations ranging between 50 and 1000 ug/l; 2) deleterious sublethal responses are sometimes observed at water column concentrations ranging from 1 to 5 ug/l; and 3) uptake of PAHs can be substantial, but depuration is usually rapid, with the exception of certain invertebrates."

Areas within the St. Louis River with detectable sediment concentrations of PAHs are generally associated with historical dischargers and/or operations using large quantities of fossil fuels and/or their derivatives. Although some sampling has occurred for PAHs in specific areas, major regions of the lower St. Louis River from the City of Cloquet to Lake Superior have never been adequately examined. Areas of known PAH sediment contamination are associated with the Interlake and U.S. Steel-Duluth Works Superfund sites, Newton Creek/Hog Island Inlet, and the Crawford Creek wetland. Samples taken off-shore of a settling basin located on the U.S. Steel property was found to contain PAH levels ranging from 20,800 to 860,000 ug/kg. Sediments surrounding a major portion of the former Interlake site contain sediment PAH levels ranging from 27,000 to 6,090,000 ug/kg. An underwater tar deposit also emanates from this site at the location of a former 48" discharge pipe. Previous wastewater discharge from the Koppers Company, a wood preserving facility, contaminated an adjacent wetland and the sediments of Crawford Creek with creosote constituents. This creek, in turn, flows into the Nemadji River. Elevated PAHs have also been found in the vicinity of stormwater outfalls at the facility. Newton Creek, which receives wastewater discharges from the Murphy Oil facility drains to Hog Island Inlet of Superior Bay. Sediment concentrations of PAHs at Newton Creek and Hog Island Inlet include values such as 4,000 ug/kg and 80,000 ug/kg, respectively. Shipping channels are the only other areas of the lower St. Louis River AOC extensively sampled. PAH levels found in sediments from U.S. COE sampling efforts have ranged from undetectable to 2,800 ug/kg (Appendix D: Janisch, 1991). Known sample sites in the estuary/harbor and their associated sediment values are displayed in Figures IV.7a(pre-WLSSD) and IV.7b (post-WLSSD). Comparison of data between sites is difficult because the values listed are sums of the various PAH compounds and the same compounds were not necessarily measured at each site.

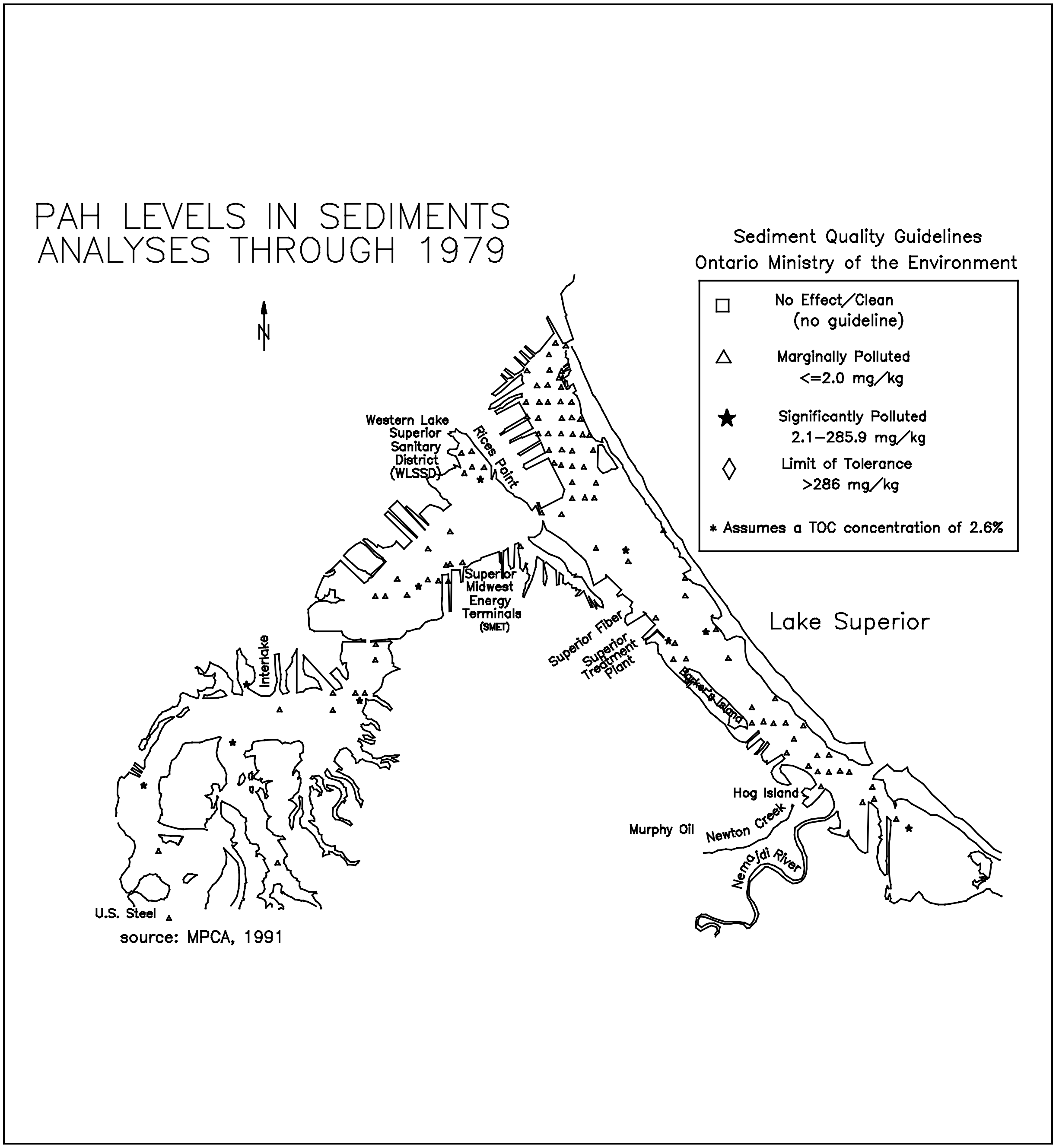
e. Other Pollutants

There are many pollutants capable of affecting the aquatic ecosystem of the St. Louis River AOC. These pollutants include lead, copper, arsenic, chromium, oil and grease, chlorinated insecticides, and many other substances. A more comprehensive treatment of sediments and a discussion of various chemical parameters are included in Appendix D.

f. Upstream Sediments

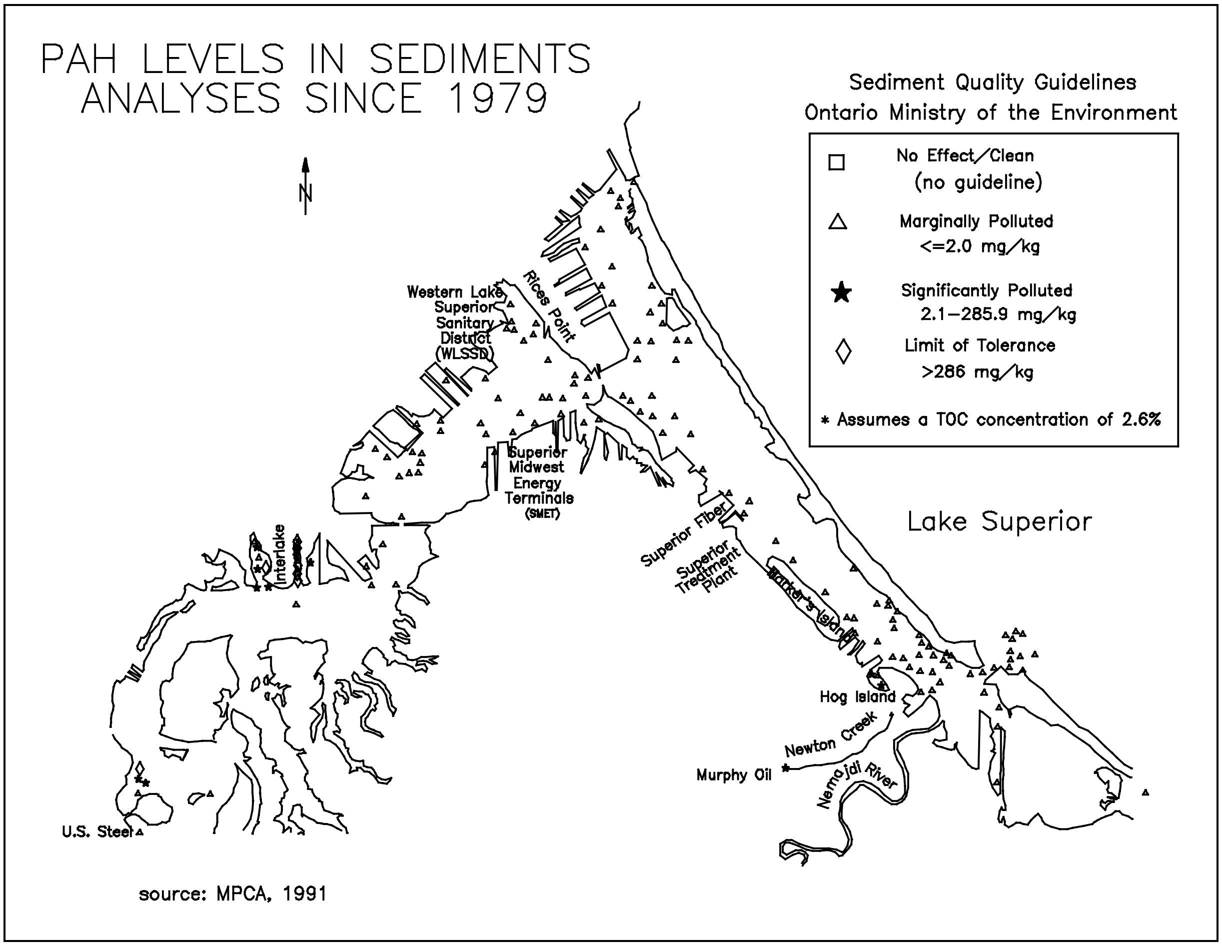
Little is known about the nature of sediments deposited in pools behind the five dams located on the lower St. Louis River. What is known is that dams generally trap sediment; and, these dams are located downstream of sites that discharged a variety of wastes directly into the St. Louis River for some 70-90 years. A U.S. Army Corps of Engineers (COE) study published in 1974 estimates that there are 4.6

Figure IV.7a



Note: Values represented on this map are the sums of the various PAH compounds; the same compounds were not necessarily measured at each site.

Figure IV.7b



Note: Values represented on this map are the sums of various PAH compounds; the same compounds were not necessarily measured at each site.

million yds^3 of sediments/sludges trapped behind these dams. These sediments or deposits were characterized as fibrous, organic sludges. Depths of these deposits were estimated to range from five to ten feet near the base of most dams (U.S. COE, 1974). A study by Quirk and Eder (1970) found an average sludge/sediment depth of 3.5 feet within Forbay Lake. With this level of sediments, there are approximately 2.6 million cubic yards of sludge/sediments within Forbay Lake. As a part of their Federal Energy Regulatory Commission (FERC) relicensing application for the St. Louis River hydroelectric facilities, Minnesota Power Company conducted a series of sediment and water quality investigations. The sediment investigations included a transport analysis and the characterization of surface sediments. A question unanswered by this effort, however, concerns the volume and characteristics of sediment accumulated behind these dams. This information is important in light of historical accounts of sediment quality and its potential to impact downstream sediments or remediation efforts.

The history of waste discharges upstream of these dams and the existing sediment data make the quality of these dam sediments suspect. Glass et al. (1990) examined mercury concentrations in sediment and biota from a variety of upstream St. Louis River locations. The sample results, which are displayed in

Table IV.10, indicate the presence of mercury sediment levels approaching 1 mg/kg in Thompson Reservoir. This level exceeds the Ontario Ministry of the Environment's SQG lowest effect criterion for impacts to benthic organisms and may exceed an unimpacted reference site level by ten times or more. Glass et al. (1990) concludes that the historical use of mercury as slimicides by the paper industry contributed to the contamination of sediments in the lower St. Louis River. A survey conducted by the Minnesota Department of Health (MDH) in 1948 stated that the "greatest pollution problem in the river basin was the discharge of upriver municipal sewage, paper mill waste, wash water and other industrial waste" (Appendix D: Janisch, 1991). Extensive oxygen demanding bottom sludges were found behind all of the dams in this 1948 study, as they were in the later 1974 U.S. COE study. Additional sources of contamination for this sediment may include landfill sites in Cloquet (i.e. Potlatch, USG, etc.) and/or spill events that have occurred adjacent to the river in the past (see Appendix J).

Information detailing accumulated sediments and their associated chemical characteristics are of importance to future downstream sediment remediation efforts. There are number of reasons for this concern. One issue pertains to the future removal of sediments to provide increased storage capacity at dam pools. The second issue addresses the resuspension of sediments from pool areas through dam operations or high flow storm events. A likely outcome of either scenario is that sediments will be transported downstream to settle out in slack water areas of the estuary and harbor. This transport of sediments and any associated pollutants not only poses a threat to the aquatic ecosystem, but may erase any successes achieved through remediation of estuary or harbor sediments. For this reason, the order of sediment characterization and\or remediation should generally progress from upstream areas to the estuary and harbor area.

4. Management of Dredged Materials

a. Dredging Regulations

Minnesota and Wisconsin legally and categorically define dredged materials as pollutants. As a consequence, the disposal of dredged materials into the open waters of either state are generally prohibited. Wisconsin recognizes dredged material as a recyclable commodity and has a policy of encouraging beneficial reuse over other disposal options. In a limited number of instances each state allows for the in water placement of dredged materials. Wisconsin, as an example, may allow the use of clean dredge material for fill within established bulkhead lines (WDNR, 1986). Minnesota evaluates dredging projects on a case-by-case basis and has the option of providing a disposal variance if the circumstances warrant it. The states generally use U.S. EPA's "Guidelines for the Classification of Great Lakes Harbor Sediments" as a mechanism to characterize St. Louis River AOC sediments. These guidelines are also augmented in Wisconsin by reference to the 1989 proposed "Interim Guidelines for Open Water Disposal of Dredged Materials". Specific chemical parameters and their associated values for each of the two classification schemes are located in Appendices D and F of this document.

The disposal or management of dredged materials and the act of dredging are activities that must be carried out in accordance with applicable local, federal, and state laws. Of these laws, Section 401 of the Federal Clean Water Act represents the principal mechanism used to regulate water quality impacts associated with dredging. Section 401 delegates authority to states to certify the quality of any discharge to navigable waters that occurs as a consequence of any action that requires a federal license or permit. This authority is binding on the federal agency issuing the permit, with the exception of written waivers or inaction that can be interpreted as implied consent (WPCF, 1987). Authority to certify that water quality will be maintained or minimally impacted is delegated to MPCA in Minnesota and WDNR in

Wisconsin. The U.S. COE, under the Rivers and Harbors Act of 1899, retains responsibility for maintaining the federally authorized shipping channels (LaValley, 1991). The regulation of the act of dredging at the state level is the purview of the WDNR in Wisconsin and the MDNR in Minnesota). Minnesota Statutes, Section 105.42, specifies that "any person proposing to change the course, current, or cross-section of Minnesota's public waters or wetlands must obtain a permit from the Department of Natural Resources" (MDNR, 1988). Wisconsin Statutes, Section 30.20, "specifies that removal of bed materials from a navigable lake or stream requires a contract with, or permit from the Wisconsin Department of Natural Resources" (LaValley, 1991).

b. Disposal or Containment of Dredged Materials

Management of dredged materials taken from the lower St. Louis River is of importance to the economic vitality of the Duluth-Superior Harbor. Dredging operations of the U.S. COE are responsible for maintaining 30 miles of shipping channels for about 1300 ships that enter the harbor on annual basis. The volume of sediment removed from these channels to accommodate ship traffic is about 150,000 yds^3 annually. For the most part, these dredged materials are transported to the Erie Pier containment facility. Erie Pier represents the Duluth-Superior Harbor's sole sediment containment facility. The facility itself was constructed in 1979 and the initial dredge material deposited on-site in 1980. Erie Pier consists of a diked storage area which encompasses 12 acres of existing land and 70 acres of former shallow water habitat. Design storage at 4.5' elevation above Lake Superior low water datum is 1,000,000 yds^3; capacity at design stage was expected to serve maintenance dredging needs in the Duluth-Superior Harbor for ten years (MIC, 1989). Actual storage capacity has been extended somewhat through compaction of Erie Pier's bottom materials and the initiation of a dredge material recycling program (recycling of granular materials for use as off-site fill). Erie Pier's storage capacity is expected to be fully exhausted between 1991-1993 (A. Klein, U.S. COE, pers. comm.).

Rapidly approaching limits to sediment storage at Erie Pier have inspired renewed calls to find cost effective solutions to the long term disposal or management of dredged materials. Without an alternative sediment disposal/management strategy, concern exists that dredging in the Duluth-Superior Harbor could come to a complete standstill. A number of local groups, including the Duluth Area Chamber of Commerce, have asked that planning for this contingency begin immediately. In a letter dated May 4, 1990 to the Chamber, Commissioner Gerald Willet, said that "the Minnesota Pollution Agency has not received a specific proposal in the form of a permit application for an alternative site. As such, there has been no approval or disapproval by state or federal environmental regulators of any of the dredge disposal options mentioned in your letter". The states of Wisconsin and Minnesota are supportive of current efforts to recycle granular material for off-site fill and as a mechanism to extend the useful storage capacity of Erie Pier. It is unclear, however, to what extent storage capacity can be enhanced by recycling or through raising the storage dikes. Keith Yetter of Zenith Dredge said in a letter dated April 11, 1990, that "while recycling of granular material has been done in the past, it cannot be considered as cost effective when comparing it to beach nourishment or bottom dumping". Interest in the most cost effective and environmentally sound disposal method has generated a number of disposal recommendations for the replacement of Erie Pier. These proposals are outlined in the Metropolitan Interstate Committee's Maintenance Dredged Material Disposal Recommendations and Implementation Report for the Duluth-Superior Harbor.

J. EUTROPHICATION - LOADINGS OF NUTRIENTS AND SEDIMENT

IJC Listing Criteria: 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.

Is the Beneficial Use Impaired? Not by a literal interpretation of the IJC criterion.

Adaptation of IJC Eutrophication Criterion to Fit Local Conditions: High nutrient and sediment levels in the St. Louis River estuary lead to excessive loadings to Lake Superior, although these high nutrient levels do not seem to be expressed as eutrophication in the Area of Concern.

Is the Beneficial Use Impaired? Yes

Prior to the improvements in wastewater treatment in the late 1970's in this area, water quality and biological investigations characterized the St. Louis estuary as eutrophic. At this time, the Western Lake Superior Sanitary District (WLSSD) treatment plant was built and the Superior wastewater treatment plant was upgraded. Since that time, many indicators of trophic status have shown improvements. For instance, concentrations of total phosphorus, ammonia, and organic nitrogen have decreased in the St. Louis Bay. The loading of phosphorus to the estuary from point sources has been reduced substantially. Further work is needed to ascertain the effects of nonpoint source loadings to the system and to Lake Superior. Despite the reductions in point source loadings, phosphorus concentrations in the estuary remain at levels where eutrophic conditions might be expected. However, algal biomass has been lower than would be expected given these high phosphorus concentrations. Chlorophyll a concentrations measured in the estuary have been similar to levels found in mesotrophic or oligotrophic waters. Several investigators have proposed that reduced light penetration due to turbidity and color may be a limiting factor for algal growth in the estuary. Although persistent water quality problems associated with eutrophication are not observed currently in the estuary, the high levels of nutrients and sediments being delivered to Lake Superior is an important concern. Therefore, the RAP will use a modification of the IJC eutrophication criterion to reflect local conditions.

1. Background on the Process of Eutrophication

Eutrophication refers to the process of nutrient enrichment of surface waters. An increased supply of available nutrients encourages growth of algae and other plants. Larger biomasses result in larger quantities of dead plant material. This matter is then oxidized by aerobic bacteria which can induce a state of oxygen depletion. This course can lead to water quality degradation and diminished aesthetic values. The natural "aging" process for water bodies normally occurs over centuries, but has been accelerated in many waters during the last several decades as a result of human activities. These activities contribute nutrients in the form of nitrogen and phosphorous found in detergents, treated/untreated waste products, urban and rural runoff.

The U.S. Environmental Protection Agency (1975) describes conditions of eutrophication as follows: decreasing hypolimnetic dissolved oxygen concentrations, increasing nutrient concentrations, increasing suspended solids (especially organic matter), progression from a diatom population to a dominant population of blue-green and/or green algae, decreasing light penetration and increasing phosphorus concentrations in the sediments (Henderson-Sellers and Markland, 1987). Other characteristics associated with eutrophic conditions include algae blooms and the spread of aquatic weeds. In cases where the biomass is dense, a fluctuation of dissolved oxygen may occur. An environment of oxygen supersaturation, as a result of photosynthesis during the day, may shift to depletion at night. This often kills fish and other organisms. A shift in variety of species, including fish, may also occur (Henderson-Sellers and Markland, 1987).

Water quality and biological parameters that can be used to evaluate the trophic status of a body of water include concentrations of phosphorus, nitrogen, chlorophyll a, dissolved oxygen content and algal variety. Phosphorus is an important indicator because it is often the limiting factor in algal production.

2. St. Louis Estuary Water Quality Improvements

Investigations prior to 1978 when WLSSD, began operation, characterized the Duluth-Superior Harbor as eutrophic (US EPA, 1975; Maschwitz et al., 1976). The studies revealed relatively high nutrient levels and low water transparency, but chlorophyll concentrations were relatively low.

To evaluate the extent of eutrophication in a body of water, comparisons of water quality and biological parameters can be made over time or with similar areas that are considered relatively unaffected. Temporal and spacial fluctuations of these parameters make trophic status difficult to assess. In addition, examination of different parameters may suggest different trophic conditions in the same water. Therefore, conclusions can not accurately be drawn on the basis of one parameter (Heiskary and Wilson, 1990). The St. Louis estuary is a very complex system with regard to its bathymetry and the flow of water between the bay and Lake Superior, which makes the result of point sampling a function of many variables (Hargis, 1983). While keeping this in mind, a review can be made of available data for the St. Louis estuary to evaluate whether eutrophication continues to be a problem.

Data for dissolved oxygen are most numerous. McCollor (1990) examined this parameter, along with several others, at 19 sampling sites that were located in the bay and upstream on the St. Louis River to Brookston. Using a nonparametric trend analysis (Wilcoxon rank sum test), it was determined that dissolved oxygen had significantly increased since WLSSD began operation at stations that had previously been downstream of historical point discharges. The frequency of violations of the dissolved oxygen standard (5mg/l) had decreased for all stations combined, from 25% prior to WLSSD operation to less than 1% in the 1979-87 period. Oxygen deficiencies, responsible for numerous fish kills occurring between the late 40's through the 70's, have not been attributed to the metabolism of algal matter, but to the decomposition of organic loadings. The improvement in dissolved oxygen concentrations appears to be a reflection of the decrease of Biochemical Oxygen Demand (BOD) loadings rather than a change in trophic status.

Other water quality improvements have been noted since the implementation of WLSSD. McCollor determined that several nutrient concentrations, including total phosphorus, total ammonia and organic nitrogen, had decreased in average. Nitrate concentrations, however, showed no significant change.

3. Phosphorus Loadings to the System and Phosphorus Concentrations in the Estuary

Cook and Ameel (1983) compared total phosphorus loadings from WLSSD in 1982 to the phosphorus loadings estimated in 1972 for the nine wastewater treatment plants that WLSSD replaced. This work showed that the phosphorus loading from WLSSD was one-fifth that of the previous treatment plants. In 1972, it was estimated that 50% of the phosphorus loadings to St. Louis Bay were from point sources (U.S. EPA, 1975). The nutrient budget for St. Louis Bay in 1982 estimated that 10% of the phosphorus input was from the point source (WLSSD). Neither budget considered loadings to the system from Superior. Despite the reduction in point source loadings of phosphorus to the river, the total phosphorus loading to Lake Superior from the St. Louis River were similar for those two years. This was because 1982 was an exceptionally high flow year, resulting in a greater total mass of phosphorus discharged from the river (Cook and Ameel, 1983).

McCollor (1990) examined the yearly average summer total phosphorous concentrations at three sampling sites (1973-1990). Plots of phosphorus data collected at the I-535 bridge, Burlington Northern Railroad bridge and Highway 2 sampling sites against time reveal a downward trend in the yearly average summer phosphorus mean concentrations (Figures IV.8 - IV.10). This trend is most pronounced with the highway I-535 bridge data. All of the available total phosphorus data ranged from 0.050 mg/l to 0.150 mg/l. These concentrations would suggest a eutrophic condition, and are considerably higher than what has been found in minimally impacted lakes in the northern lakes and forest ecoregion (Heiskary and Wilson, 1990), and much higher than levels encountered in the open waters of Lake Superior.

4. The Relationship of Nutrients to Algal Biomass

In the St. Louis estuary chlorophyll a concentrations generally have been less than 12 ug/l (U.S. EPA, 1975; Maschwitz et al, 1976; Hargis, 1983; Kingston et al., unpubl. data). This level of algal biomass is more suggestive of mesotrophic or oligotrophic (nutrient poor) conditions than the phosphorus data would indicate. If algal production is as low as the chlorophyll a data implies, then it would appear that there are other limiting factors. Several investigators have proposed that algal growth in the estuary may be limited by reduced light penetration caused from the water's turbidity and color (Maschwitz et al., 1976; US EPA, 1975). In sampling conducted at 18 sites from Allouez Bay to Fond du Lac in 1984-87, Kingston et al. (1987) found that nutrients in the estuary were not fully expressed as phytoplankton biomass, perhaps due to high turbidity. Paleolimnological examinations of core samples undertaken as part of that study indicated that sedimentation rates in the estuary have been increasing since 1900 (Kingston et al., 1987). Hargis (1983) also indicated that the turbidity of the harbor may explain to some degree the low numbers of blue-green algae he sampled in 1982. Blue-green algae indicative of eutrophic conditions were occasionally dominant in the Duluth Harbor prior to WLSSD's operation (Maschwitz et al., 1976). Algal bloom conditions have not been reported for the estuary.

5. Relationship to Lake Superior

The highest values for algal biomass and productivity in Lake Superior have been reported at the extreme western arm of Lake Superior (El-Sharrawi and Munnawar, 1978, Kwiatowski, 1980, Putnam and Olson, 1961). However, chlorophyll values for the western arm of Lake Superior, as well as the estuary, remain typical of an oligotrophic lake, <10 ug/l.

Although nuisance algal conditions do not appear to exist within the estuary and dissolved oxygen depletion problems have been reduced with point discharge controls, nutrient loadings are still of concern for the western end of Lake Superior and for effects they may have in the estuary. Both point and nonpoint sources, such as erosion and resuspension of sediment, contribute nutrient loads to the St.Louis River and estuarine system, and to western Lake Superior. More intensive investigation is needed to determine the dynamics of the nutrients and their impacts on this system.

Figure IV.8 Total Phosphorus at I-535 Bridge Sampling Station, St. Louis Bay

Figure IV.9 Total Phosphorus at Burlinton Northern Railroad Bridge, St. Louis Bay

Figure IV.10 Total Phosphorus at U.S. Hwy. 2 Sampling Station, St. Louis River.

K. RESTRICTION ON DRINKING WATER CONSUMPTION OR TASTE AND ODOR PROBLEMS

IJC Listing Criteria: When treated 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 comparable portions of the Great Lakes which are not degraded (i.e. settling, coagulation, disinfection).

Is the Beneficial Use Impaired? No

At this time, there are no drinking water intakes in the AOC, therefore there are no restrictions on the consumption of drinking water or taste or odor problems attributable to water supplies in the Area of Concern. In 1895, there was a severe epidemic of typhoid fever which resulted in the relocation of the City of Duluth's water supply away from the harbor area to a site further up Lake Superior's shoreline. There has been some concern expressed by people regarding recent discharges/bypasses of sewage and the potential to contaminate the municipal water supplies from Lake Superior. This concern is not confined to sewage: it also deals with spills, discharges of chemicals, wastewater, and debris into Lake Superior and/or the St. Louis Bay/River. Most of these concerns focus upon the potential for these effluents to enter drinking water systems via the intakes in Lake Superior and the resultant contamination. While concern seems warranted, the data does not warrant the listing of this issue as an impaired beneficial use.

The St. Louis Bay/River region of the Duluth-Superior Harbor is not used for drinking water. The waters of the St. Louis River below the Fond Du Lac dam are subject to water quality standards of both Wisconsin and Minnesota. Neither of these two states have this area designated for domestic consumption. The State of Wisconsin has designated the St. Louis River as suitable for recreation, fishing, waste assimilation, and commercial shipping. These waters must meet the water quality standards for "recreational use" and "fish and aquatic life." (Wisconsin Administrative Code, Ch. NR 102). The State of Minnesota has classified the St. Louis River, St. Louis Bay, and Superior Bay as class 2B, 3B, 3C, 4A, 4B, 5,and 6 waters. Each of these classifications address a different aspect of water usage. In brief, the State of Minnesota has designated this portion of the St, Louis River to provide the following uses:

(1) Propagation and maintenance of cool and warm water sport fishes, and aquatic recreation of all kinds, including bathing
(2) General industrial purposes except food processing
(3) Industrial cooling and materials transport
(4) Irrigation
(5) Use by wildlife and livestock
(6) Aesthetic enjoyment and unimpeded navigation
(7) Additional uses as designated by the State

The majority of the communities in the Area of Concern use Lake Superior as their primary drinking water source. The Minnesota classification for Lake Superior is 1B, 2A, and 3A. The designated uses for these waters include:

(1) Domestic Consumption: with approved disinfection, the treated water will meet in all respects both the mandatory and recommended requirements.

(2) Fisheries and Recreation: propagation and maintenance of warm or cold water sport or commercial fishes and their habitats and be suitable for aquatic recreation of all kinds, including bathing, and protected as a source of drinking water.

(3) Industrial Consumption: permit their use without chemical treatment except softening for ground water, for most industrial purposes, except food processing, and related uses for which a high quality is required.

The City of Cloquet receives drinking water from an intake that extends roughly two miles out into Lake Superior in addition to their five wells in the Cloquet Area. This major intake structure also supplies the City of Scanlon and City of Superior. The City of Superior is supplemented by wells located on the Lake Superior side of Minnesota Point.

The City of Duluth has a separate water intake extending into Lake Superior from a point on North Shore Drive. A five-foot intake pipe extends about 1,560 feet draws water at a depth of 65 feet. This water serves the municipalities of Hermantown, Rice Lake, Proctor, and Duluth. An Area of Fond Du Lac, consisting of 30-40 homes, is served by a well.

L. BEACH CLOSINGS AND BODY CONTACT

IJC Listing Criteria: When waters, which are commonly used for total body contact recreation, exceed standards, objectives, or guidelines for such use.

Is the Beneficial Use Impaired? Yes

Water quality data indicate that improvements have been made in the St. Louis River and bay since the late 1970's. However, there are still sources of potential microbial contamination. Sewage bypasses have occurred into the Area of Concern in both Minnesota and Wisconsin during 1990 and 1991 storm events. In addition, localized problems with microbial contamination could occur due to discharge of inadequately treated wastewater by marine traffic. Because of the sewage bypasses in both Minnesota and Wisconsin, body contact recreation is an impaired use.

Water is a mode of transport of many microorganisms that can cause infection and disease in humans. Microbial contamination is therefore of concern when water is used for drinking and/or recreational activities such as swimming and other body contact sports.

Areas of the St. Louis River, St. Louis Bay, and Superior Bay are used for body contact recreation. Certain stretches of the St. Louis River are used by kayakers, rowers, wind-surfers and canoeists. The bay in the vicinity of Barkers Island has swimming activity and there are official and unofficial beach areas on Minnesota Point. Fishing and recreational boating are also popular in the estuary.

Conversations with county health officials indicate only one case of a beach closing on Minnesota Point, Lake Superior side (B. Holmes, St. Louis County Health Department, pers. comm.). To assess in any more depth whether microbial contamination is a problem to recreational activities it is necessary to evaluate existing fecal coliform data. Due to the lack of methodology and difficulty of routinely analyzing many pathogenic microorganisms, fecal coliform has been used as the principal indicator of a water's suitability for recreational use. Both Minnesota and Wisconsin have standards that stipulate that recreational waters should not have fecal coliform counts higher than 200 organisms per 100 milliliters as a geometric mean of a series of measurements.

McCollor (1990) examined fecal coliform-MPN and fecal coliform-MF data available through the U.S. EPA STORET data base for the St. Louis River and bay for the time periods before WLSSD went on-line (1953-1978) and after (1978-1987). Using a nonparametric trend analysis, it was determined that there was a statistically significant decrease in both these variables at all stations below Brookston (the station upstream of historical discharges) for the period after WLSSD was constructed. In addition, the overall percentages of fecal coliform violations had decreased from 41% pre-WLSSD to 17% for the later time period.

A 1989 survey of Barker's Island beach areas showed low fecal coliform counts, well below 200 mpn/100 ml (S. Banz, City of Superior, unpubl. data). Occasional violations of fecal coliform standards are reported at the Cloquet water intake, but these are associated with periods of turbulence and storm activity (J. Stepun, WLSSD, pers. comm.).

In 1975, the City of Superior underwent a sewer separation project. In areas of the city where sanitary and storm sewers were not separated, (Billings Park, South Superior, and downtown Superior), combined sewer overflow (CSO) treatment facilities were installed. Recently it became known that the treatment units in two of the three CSO facilities were not operational. The City has begun initial repairs on the sewer system, which includes repair of the inoperable CSO treatment units.

Sewage bypassing problems in the City of Superior's sewer system, increase the possibility of bacterial contamination and bacterial contact by body contact recreational users in the AOC. Within the last two years it has become apparent that the sewer system is unable to handle the volume of sewage and storm water. Untreated sewage and stormwater has overflowed from the system during times of moderate precipitation or snowmelt. For example, one to two inches of rain has resulted in overflow of untreated sewage to the Nemadji River, St. Louis Bay, Superior Bay, and Bluff Creek. Discussions between the City and the WDNR are on-going to address this issue.

Since 1980, 62 spills of sewage and/or wastewater from WLSSD have been reported. Thirteen of these spills were greater than 1 million gallons and several were greater than 20 million gallons. These spills are large potential sources of microbial contamination (See Appendix J).

Discharge of inadequately treated wastewater by marine vessels is another source of microbial contamination. A 1980-1981 Coast Guard study of 99 ships in the Duluth-Superior harbor showed that 51% of the ships had wastewater discharges that exceeded the 200 mpn/ml fecal coliform limit. An average of 1197 lakers visit the harbor yearly. Since a ship produces approximately 400 gallons of wastewater per day, at least 239,200 gallons of wastewater exceeding the 200 mpn/ml limit is discharged into the harbor per year from ships. (See Section V.4 Marine Recreational/Commercial Activity for more information.)

M. AESTHETICS

IJC Listing Criteria: When any substance in water produces a persistent objectionable deposit, unnatural color or turbidity, or unnatural odor (e.g. oil slick, surface scum).

Is the Beneficial Use Impaired? Yes

The aesthetic values of the St. Louis River AOC are impaired in some locations. A systematic collection of evidence and data is recommended to determine the specific locations of degraded areas and the sources and types of degrading materials (i.e., oil slicks, chemical and tar residues, taconite pellets on shorelines, rotting grain scum on water surface, etc.). Hog Island Inlet and Stryker Bay are two areas that have repeated reports of oil, chemical, and tar residues on the water's surface. Complaints have also been registered about smells emanating from the sediments and water of Newton Creek and Hog Island Inlet (MPCA,WDNR Complaint Logs 1980-1990). Shoreline aesthetics will be addressed separately and will be remediated through actions taken with riparian interests.

N. ADDED COSTS TO AGRICULTURE OR INDUSTRY

IJC Listing Criteria: Where there are additional costs required to treat the water prior to use for agricultural purposes (i.e. intended for commercial or industrial applications and noncontact food processing.

Is the Beneficial Use Impaired? No

At this time, use of water by industry is not impaired nor are there significant costs to industry resulting *from degraded water quality in the St. Louis Bay/River. However, the potential of zebra mussel establishment does appear to pose a serious economic threat to the industries in the St. Louis River/Bay and Lake Superior area.*

Availability of inexpensive and high quality water from Lake Superior limits industrial use of water from the St. Louis River AOC. Most industrial uses of the St. Louis River consist of noncontact cooling or waste assimilation. Issues which elicit the most concern affecting water usage are spills and the introduction of exotic species.

The effects of spills on water quality and how this affects industrial operations is dependent on the type, quantity and, location of the spill and probably most importantly the cleanup of the spill. A prompt and effective cleanup operation would minimize the effects of the spill on water quality and thus reduce potential costs to industry. A detailed spill contingency plan exists for waters of the St. Louis River. The agency responsible for clean-up of a reported spill depends on the location of the spill. The U. S. Coast Guard maintains principal responsibility for waters below the Fond du Lac Dam. Lead responsibility for spills occurring in upstream areas of the St. Louis River rest with MPCA.

The exotic species that is of foremost concern in the St. Louis River and Bay due to added costs to agriculture and industry is the zebra mussel. Zebra mussels were inadvertently introduced to Lake Superior and may pose problems for a variety of industries if they thrive in the Area of Concern. Relatively warm waters and high calcium levels are expected to promote colonizing by the zebra mussel in this area. Zebra mussels attach in extremely large numbers to hard substrates as well as man-made structures. They have a life span of four to six years and a mature female can produce 30,000 eggs in a single season. This makes the zebra mussel almost impossible to eradicate and difficult to control.

Costs to remove, transport, and properly dispose of zebra mussels are high. The overall estimate for the Great Lakes cleanup and containment of the zebra mussel is three-and-a-half to four billion dollars. The potential exists for these added costs to drastically strain industrial resources.

The impact of zebra mussels on the shipping, fishing, and other various industries is expected to be similar to what has been experienced by other areas in the Great Lakes with zebra mussels. If the St. Louis River/Bay becomes infested with zebra mussels, shipping and recreational boating will experience additional maintenance costs. The mussels attach to the boat bottoms and internal parts which can lead to engine malfunctions /overheating, reduced boat speeds, and decreased fuel efficiency. Commercial vessel owners express concern over the projected, anticipated costs for testing and rectification procedures (more inspections, possible opening of piping systems, taking vessels out of service, and dry docking). Foreign vessels will also incur additional expenses associated with the handling of ballast water and the refilling of storage reserves with clear/clean water.

Zebra mussels may damage water structures and facilities by attaching to marinas, docks, piers, bridges, harbors, buoys, and pilings. The added weight to the structures decreases their stability and, in some cases, may cause the structure to sink. Since the mussels attach to the substrate, spawning and other habitat could be seriously compromised. Subsequently, the recreational industry may be affected.
Water intake/outflow pipes of any type purpose may become partially to completely clogged by zebra mussels. This could have a long term impact on the operation of influent and effluent systems. Increased operating costs could be realized due to implementation of one or a combination of the following control methods: (1) installation and maintenance of intake adult mussel exclusion barriers (2) mechanical removal of adult mussels on a periodic basis (3) installation, maintenance and operation of chemical, electrical or

thermal control equipment (4) redesign of the present intake structure and (5) construction of a new intake structure. The need to implement zebra mussel control measures could also result in loss of revenues due to periodic station shutdown for equipment maintenance and mechanical mussel removal.

Availability of local city water supplies from Lake Superior may be compromised if the mussels take hold. Social costs for limited water use of sewage treatment/disposal could become significant. This has occurred in other Great Lake states.

1. Zebra Mussel Treatment Strategies

The most common and cheapest treatment currently applied in the other Great Lakes infested with zebra mussels is the use of liquid chlorine directly applied at the water intake. The total expenditure for a medium-sized industry is estimated to be $80,000-$200,000 for the first year. Included in this is the cost of the chlorine, dechlorination, and construction of treatment facility and/or adjunctive machinery. There are several other chemical treatments that appear to possess similar treatment modalities. Hydrogen peroxide, liquid potassium permanganate, ozone, and molluskicides are several alternatives. The potential environmental impacts involved in the use of these methods and potential problems with spills emphasizes the need for better solutions.

There are several nonchemical alternatives available. One method of control involves pumping hot water through a closed system and literally cooking the mussels. Two more common methods are blasting the mussels off with high pressure water hoses and mechanical scraping. Other nonchemical methods include electric shock, draining and drying out of systems, and installing nets and fine screens. A method that is still in the experimental stages is using underwater sound to crack shells and dislodge mussels. Nonchemical forms of treatment are the preferred options.

2. Industries at Risk

a. Duluth

The potential establishment of the zebra mussels in the bay and upper portions of the St. Louis River system could have long-term economic impacts on the operation of Minnesota Power's four active hydro-electric stations and reservoirs since mussels could colonize the intake/outflow pipes. Mussels could also affect the M. L. Hibbard Station if electrical generation were resumed at the facility.

Minnesota Power:

(1) M. L. Hibbard Station - This station currently does not generate electricity and does not use St. Louis River/Bay water. However, the station is still fully permitted to generate electricity with its four turbines. If electrical generation were resumed at the facility, St. Louis River/Bay water would be used as noncontact cooling water for operation of four steam condenser.

(2) Fond Du Lac: This hydro station is located at mile 22.5 in Carlton County and has total generating capacity of 12,000 kilowatts. It was constructed in 1923.

(3) Thomson Station: This is the largest Minnesota Power hydro station with a total generating capacity of 70,000 kilowatts. It is located up the river from Fond Du Lac and was constructed in 1907.

(4) Scanlon: This hydro station is located in Carlton County above the Thomson station. It was constructed in 1923 and has a total generating capacity of 1,600 kilowatts.

(5) Knife Falls: This hydro station is located in Cloquet and built in 1918. It has a total generating capacity of 2,400 kilowatts.

Lake Superior Paper Industries does not currently have intake/outflow access to the bay and thus operation does not require use of bay water. LSPI contracts with the City of Duluth for its noncontact cooling water and water used in the paper-making process. Currently, LSPI uses 4 million gallons of water a day which comprises 25% of the total water usage for the City of Duluth.

Superwood uses bay water for noncontact cooling in the generation of steam and for water makeup in some of its vats. Superwood is permitted to use a maximum of 750 million gallons of water per year and monitors their outflow. University of Wisconsin-Superior (UWS) has a contract to sample and monitor zebra mussels and has a sampling station at the Superwood facility.

North Star Steel uses one million gallons of St. Louis Bay water a day for noncontact cooling. The water is drawn in through screens which are sized to exclude debris as well as walleye fry. Testing for zebra mussels has been done in conjunction with the cleaning of the intake screens. The results of the tests have been negative to date.

Haarman & Reimer uses river water for noncontact cooling of its reactor jackets. From January 1 - June 30, 1991, the volume of water used was 72 million gallons. Testing for mussels by UWS has been negative.

Western Lake Superior Sanitary District has objects placed in the bay near their discharge sites which are being monitored for zebra mussels. The results to date have been negative.

b. Superior

Superior Water Light and Power Company uses bay water for noncontact cooling water. The Winslow station is a member of Midcontinent Area Power Pool, which is a group of utilities that pool their generating resources. At the present, Winslow is on cold standby, but is required to operate a four-hour test load each year.

Superior Fiber Products uses bay water primarily for noncontact cooling and runs 700,000 gallons of filtered bay water through their facility each day.

The City of Superior Sewage Treatment facility is not currently testing their outflow pipes, but expressed concern about zebra mussels.

c. Cloquet

USG Interiors, located in Cloquet, also uses river water. In its particle board manufacturing process, the materials are made into a wet slurry that goes onto the forming machine, where 4 1/2 to 5% are solids. The remainder is water. This process uses 1 million gallons of river water a day. USG have no concerns with present water quality, but do have some concerns over zebra mussels since they have three fire house pump intakes and three water processing intakes.

Diamond Brands Inc., Cloquet, uses St. Louis River water mainly for the production of steam. In the summer, river water is used to keep the log piles wet so the veneer is not ruined. Diamond Brands is permitted to use up to 800 gallons per minute and not more than 30 million gallons per year. There is no zebra mussel testing at present.

Potlatch of Cloquet uses 7.6 million gallons of river water per day for noncontact cooling and 7.6 million gallons of Lake Superior water per day for the paper-making process (MPCA, 1991).

O. DEGRADED PHYTOPLANKTON AND ZOOPLANKTON

IJC Listing Criteria: 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.

Is the Beneficial Use Impaired? No - Threatened

The information available on phytoplankton and zooplankton communities does not suggest that they are degraded. Exotic species, particularly the zebra mussel (Dreissena polymorpha) and the spiny water flea (Bythotrephes cederstroemi), threaten plankton populations.

The St. Louis estuary is a complex environment in which to assess the status of phytoplankton and zooplankton populations. Little recent information exists on the plankton in the estuary. Hargis (1983) sampled zooplankton and phytoplankton in the harbor, including the vicinity of the WLSSD outfall.

Hargis (1983) reported finding a relatively rich assemblage of phytoplankton species in the 1982 surveys. In 1982, the most common phytoplankton in the Duluth-Superior Harbor for the months of June, July, and August were:

Bacillariophyceae (diatoms)
- *Cyclotella meneghiniana*
- *Melosira distans*
- *Melorira granulata*
- *Stephanodiscus spp.*
- *Navicula spp.*

Cryptomonadales
- *Cryptomonas erosa*

Work done in 1984-1987 on the St. Louis estuary also found diatoms and flagellates to be the dominant phytoplankton groups (Kingston et al., unpubl. data). Both Hargis (1983) and Kingston (unpubl. data) indicate a lack of blue-green algae species in their surveys.

In 1982, the most common zooplankton in the Duluth-Superior Harbor for the months of June, July, and August were:

- Copepoda
  - *Mesocyclops leuckarti*
  - *Diaptomus spp.*
  - *Halicyclops spp.*
  - *Paracyclops fimbriatus*
  - immature copepods
- Cladocera
  - *Bosimina coregoni*
  - *Daphnia galeata*
  - *Diaphanosoma leuctenbergianum*

Even though many factors such as the Lake Superior seiche, dredging operations and water color have effects on the plankton, all harbor sampling sites demonstrated the same essential pattern of distribution (Hargis, 1983).

Potential threats to the plankton are exotic species brought into the St. Louis River estuary by ocean-going ships in their ballast water. *Bythrotrephes cederstroemi* (BC), also known as the spiny water flea, is an exotic cladoceran zooplankton which feeds on Daphnia. The species was identified in samples taken from Lake Superior between August-September, 1987 (Cullis and Johnson, 1988). Although the presence of *B. cederstroemi* has not been documented in the St. Louis River/harbor, one researcher (Mary Balcer, UW-Superior, pers. comm.) noted its occurrence in the Bunge Slip near the Superior entry in 1990. The sighting is somewhat questionable, with the possibility that the cladoceran was brought in to the slip by wave action. Cullis and Johnson (1988) suggest that *B. cederstroemi* could alter the composition of the plankton community within Lake Superior if its populations become abundant. Larval fishes may not be able to use *B. cederstroemi* in their diets, due to its large size.

Secondly, the exotic zebra mussel (*Dreissena polymorpha*) could also cause problems for the plankton populations in the estuary. This filter feeder reproduces in large numbers. As they feed, the zebra mussels can in turn filter millions of gallons of water removing algae and other small aquatic plants from the food chain.

Other than the Hargis report of 1983, little information exists concerning the phytoplankton and zooplankton populations in the St. Louis estuary. However, a study completed in 1979-1980 (Balcer 1988), regarding the crustacean zooplankton community of the nearshore waters of western Lake Superior may aid in understanding the plankton populations within the harbor/estuary.

The species composition of the zooplankton community in western Lake Superior at the time of the study was:

Copepoda
Leptodiaptomus sicilis
Diacyclops thomasi
Cladocera
Daphnia galeata mendotae
Daphnia retrocurva
Bosmina longirostris
Eubosmina coregoni

Other species were occasionally present in low numbers and their occurrence was related to seasonal variations. Historically, few zooplankton surveys had been conducted in Lake Superior prior to the 1960's. After that time, more information was gathered on the numerical abundance and life histories of the most common crustacean species in the lake. The study also suggests that changes in zooplankton populations in the nearshore waters at the western end of the lake were due to seasonal temperature fluctuations. The study did not address the possible effects of contaminants on plankton population changes.

Bioassays with *Ceriodaphnia dubia* from the water of Hog Island Inlet of Superior Bay indicate a potential for toxicity to zooplankton at this site. (See Section IV.H. Degradation of Benthos.) Other contaminated sediment sites in the Area of Concern may also be toxic to zooplankton. Additional toxicity testing and field validation surveys need to be undertaken to determine whether plankton communities are being affected by water column toxicity or exposure to contaminated sediments.

P. LOSS OF FISH AND WILDLIFE HABITAT

IJC Listing Criteria: 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.

Is the Beneficial Use Impaired? Yes

In the past, fish habitat in the estuary was degraded because of impaired water quality. Currently, contaminated sediments may cause habitat degradation in several areas of the river system. Habitat degradation due to sediment contamination has been documented in two areas: Stryker Bay (Interlake Superfund site vicinity), and Newton Creek/Hog Island Inlet of Superior Bay. High rates of sedimentation in the estuary during the twentieth century, with ensuing turbidity and reduced light penetration, may limit macrophyte growth and therefore limit fish and wildlife habitat. Habitat loss due to sedimentation has not been documented for specific areas. Wetland habitat is being degraded due to the infestation of purple loosestrife. Fish and wildlife populations have not yet been noticeably affected by this infestation, but the potential exists if the loosestrife continues to spread.

The St. Louis River estuary has relatively large areas of undeveloped shoreline and wetland habitats, compared with many other Great Lakes Areas of Concern. Protection of these habitats is important to the stability of fish and wildlife communities. Critical habitats for some important fish and wildlife species have been identified and should be protected from loss through development or other degradation. Identification of important and critical habitats in the river system will be a continuing activity through the RAP and other planning efforts.

1. Habitat Loss Due to Water Quality Impairment

Loss of fish habitat due to water quality impairment was a feature of the St. Louis River from Cloquet downstream to Lake Superior in the twentieth century (Minnesota State Board of Health 1929 and 1948). Fish kills were frequent because of the presence of inadequately treated municipal and industrial wastes that consumed dissolved oxygen. MDNR records of fish kills in the river and estuary downstream from Cloquet include July/August 1956, May 1958, August 1969, August 1970, September 1971, and July 1973 (Peterson, 1979). Report of the 1956 fish kill in the Thomson reservoir lists low dissolved oxygen, grayish water color, high turbidity, gas bubbles on the water surface, and concentrations of sulphites and sulphides sufficient to kill fish. In 1958, the stretch of river between the Fond du Lac Dam and the Oliver Bridge experienced an extensive fish kill. Loss of wildlife habitat because of poor water quality can be inferred for waterfowl, shorebirds, and other wildlife dependent on the aquatic food chain. Since the improvements in wastewater treatment of the late 1970's, obvious widespread degradation of habitat caused by inadequately treated organic wastes leading to dissolved oxygen depletion is no longer the case.

The degree and extent of fish and wildlife habitat loss or impairment due to toxic contaminants is not documented. The full extent and spatial distribution of contaminated sediments has not been fully determined. In areas where the benthic community is degraded, it can be inferred that biological habitat for fish and wildlife is also impaired. Stryker Bay, adjacent to the Interlake Iron Superfund site, is an area where sediments are contaminated with PAHs among other compounds, and the benthic community appears to be degraded (MPCA, 1990). Surveys by MDNR over the last ten years have found that this area is poorly utilized by adult and young of year game fish (Spurrier, 1991). Newton Creek/Hog Island Inlet of Superior Bay is another area where the benthic community is degraded. In addition, bioassays with fathead minnows exposed to sediments, interstitial water, and overlying water from Hog Island Inlet have shown acute toxicity (See "Degradation of Benthos" section of this chapter). Contaminated sediments in other areas may contribute to degraded habitat for fish and wildlife, although further investigation is needed to document impacted areas.

Erosion, both natural and accelerated, results in the suspended red clay turbidity of the lower St. Louis and estuary. Sediment from throughout the watershed may be carried to the lower river. There is some evidence to suggest that sedimentation rates have increased over the period of settlement and logging, and high sedimentation rates continue into the present (Seiche, 1987). High turbidity and/or color may be major factors in limiting algal growth in the estuary. Likewise, sedimentation and turbidity can limit macrophyte growth and inhibit shoreland wetland communities. Sedimentation can also affect benthic communities, but available information is not sufficient to demonstrate degradation.

Aquatic plants are good indicators of water quality and wetland habitat. Koch et al. (1976) surveyed aquatic macrophytes in their study area between Pokegama Bay and the Blatnik Bridge. They reported that the distribution of aquatic macrophytes in this part of the estuary was spotty and that turbidity and water color limit plant distribution in some areas. Physical disturbance is a factor in some areas as well. The area around Grassy Point had the richest macrophyte flora in the region surveyed. Pokegama and Kimballs Bays were also reported to have many acres of wetlands. Several beds of wild celery were found in the estuary by MDNR during wetland mapping inventory activities in 1990. This important plant for waterfowl was not known to be present in the estuary before these observations (Staffon, 1992). Further investigation is needed on the effects of turbidity and sedimentation on macrophytes and shoreland wetlands in the St. Louis River system. In addition, baseline data are needed to determine patterns in abundance of aquatic plants. Permanent survey plots should be established to monitor changes in aquatic vegetation and wetland habitat.

2. Physical Habitat Loss

Sustaining fish and wildlife populations in the St. Louis River system requires suitable physical habitat. Productive shallow water and near-shore habitat provided by the St. Louis estuary is also important to the ecosystem integrity of Lake Superior. Compared to many industrialized harbors in the Great Lakes, the St. Louis River estuary contains relatively extensive remaining habitat, partly because of the estuary's large size. However, throughout the period of settlement and development, significant losses of wetland, shoreline, and aquatic habitat have occurred. When the estuary was first charted in 1861, the St. Louis entered Lake Superior between Minnesota and Wisconsin Points. The estuary was mostly less than 8 feet deep, with the exception of a wandering river channel at a depth of 15-20 feet (Meade, 1861). Most of the shoreline of the lower estuary was low and marshy. The WDNR has estimated that over 3,000 acres of marsh and open water have been filled in the lower estuary below the former Arrowhead Bridge (See Figure IV.11). It is also estimated that roughly 4,000 acres of the estuary have been dredged. This leaves an estimated 5,000 acres which have not been drastically altered, mostly in the upper estuary (MIC, 1985). The only large wetland area remaining in the lower estuary is Allouez Bay. Continued physical habitat loss threatens maintenance and stability of aquatic-dependent wildlife and fish populations.

a. Wetland Loss and Preservation

Wetlands and riparian zones have important roles in filtering nutrients and trapping sediment before they enter rivers, streams, and lakes. These areas also provide valuable fish and wildlife habitat. Urban and industrial expansion into wetlands and riparian zones removes these functions from the river system. Wetland loss and other land use alterations that promote erosion in the watershed can contribute to sedimentation and further habitat loss in the estuary. A review of permits issued by the U.S. Army Corps of Engineers under the Section 404 program for the period of 1981 to 1991 reveals the continuing trend of wetland loss in the watershed. Wetland acreage lost through fill activities and acreage gained through mitigation are listed in Table IV.12 for three counties which are partly within the St. Louis and Nemadji River watersheds. The records provided are not necessarily complete (M. Weburg, COE, pers. comm.).

Table IV.12 Wetland Loss: Summary of Section 404 Permits issued by the U.S. Army Corps of Engineers for 1981-1991

	Acres Lost	Acres Mitigated	Net Loss
St. Louis Co., MN	589.7	261.1	328.6
Douglas Co., WI	131.7	39.2	92.5
Carlton Co., MN	370.1	356.6	16.5

Wetland habitats in the estuary can be lost or impaired through dredge and fill activities, excess sedimentation, water level fluctuation, exotic species infestation, and toxic contamination. A comparison of the original harbor survey (Fig. IV.11) with a current map indicates how little of the pre-settlement wetlands remain in the lower estuary. Figure IV.11 shows that large expanses of shoreland wetlands were once found in the vicinities of Rice's Point, Minnesota Point, and what is now Duluth Harbor, the vicinity of Connors Point and Howard's Pocket, the upstream reaches of St. Louis Bay, the mouth of the Nemadji

River, Allouez Bay, and along Wisconsin Point. Most of these wetlands have been lost. The remaining parcels of these historical wetlands are included in the list of important natural resource parcels and critical habitats; their preservation is important to the ecosystem integrity of the estuary system. One of the RAP goals is to safeguard remaining wetlands in the estuary.

In addition to the loss of open water and marsh areas in the estuary, there is a decline in the quality of wetland habitat due to the infestation of purple loosestrife, an exotic plant introduced from Europe. Purple loosestrife has multiplied unchecked in the wet soils and shallow standing water of the estuary since it has no natural enemies in North America. The plant is presently mixed in with native vegetation in the estuary, however; it has the potential to quickly take over wetlands by crowding out the existing vegetation.

As loosestrife dominates a wetland, food and cover for wildlife decreases. Waterfowl, especially ducks, shun wetlands that have become dominated by loosestrife. Songbirds do not make use of the small hard seeds of the loosestrife and marsh animals like muskrats lose home building materials and food sources since native vegetation is eliminated. In addition, the loosestrife's growth is generally too compact to offer cover which is crucial to the survival of marsh wildlife. Overall waterfowl and wildlife production decreases as habitat is eliminated (MDNR, undated). In addition to these effects, loosestrife may affect fish production. Thick growths of loosestrife may choke off or eliminate access to fish spawning habitat.

Due to the hardy nature of the plant and the size of the estuary affected, removal or control of purple loosestrife in the estuary will be expensive and will require a joint effort by Minnesota and Wisconsin (Kuyava, MN Dept. of Agriculture, pers. comm.). Loosestrife can spread from underground roots, stem parts, and seeds. Each flower spike can produce 300,000 seeds in a single season and the seeds can remain dormant submerged in water for years until a dry spell occurs. When conditions are right, a small group of loosestrife plants can spread and cover a marsh in only one growing season (MDNR, undated). While purple loosestrife has had no documented impact on fish, waterfowl, and wildlife populations in the estuary, the potential exists due to the loosestrife's prolific nature.

b. Protection of Shoreline and Near-shore Habitat from Fill or Alteration

The MDNR is currently engaged in development of a comprehensive port plan for the Minnesota side of the estuary. Development of this port plan is a statutory prerequisite for issuance of Bed of Waters permits by the MDNR. Identification of critical habitat for protection from fill activities will be a part of the plan development process. In addition, the plan will stress no net loss of wetlands in the harbor.

As a part of the habitat characterization process, the MDNR examined information from annual summer fish surveys for the St. Louis River Estuary from 1980-1990 to develop rankings for specific sites of value to fish. This effort looked at 18 sampling sites in Minnesota between the aerial Lift Bridge and the Fond du Lac dam (Spurrier, 1991). The analysis showed trends in species composition and abundance which were used to rank sites as prime, good, and less than desirable for forage fish, adult and young of the year game fish. In general, it was found that all of the estuary provides vital habitat for various life stages of fish. The lower St. Louis Bay provides important nursery areas for young of the year game fish. The upper estuary has important areas for adult game fish and forage species. The sampling location near the Interlake Site and Stryker Bay was less than desirable for adult and young of the year game fish. All sites were rated as prime or good for forage species.

In Wisconsin, permits are required for shoreline alteration and fill activities. Permits are administered by the WDNR Water Regulation and Zoning Program, and permit applications are reviewed by WDNR Fish, Wildlife, and Water Resources Management staff. Based on information from WDNR fish and wildlife managers, critical shoreline and near-shore habitats that must be protected from alteration, fill, and degradation, include those listed below. Many of these habitats are discussed under the Critical Habitats Section.

-Allouez Bay
-Barkers Island (fish nursery area)
-Wisconsin Point
-Interstate Island
-Wisconsin shoreline of the estuary upstream from the Incan Dock.

In Superior, a Special Area Management Plan (SAMP) is underway. The SAMP process is a comprehensive plan providing for natural resource protection and reasonable coastal-dependent economic growth. It contains a detailed and comprehensive statement of policies, standards, and criteria to guide public and private uses of lands and waters, and mechanisms for timely implementation in specific geographic areas within the coastal zone.

The SAMP will classify the area within the municipal boundaries into three general categories of potential land use :

(1) Highly sensitive aquatic resources which should be clearly identified and protected by local, state, or federal authority,

(2) Areas of lower aquatic value where certain types of development will be permitted with minimal regulation,

(3) Areas where development may be appropriate, but a more rigorous review is needed, including a full public interest review on each proposal.

Mitigation will also be included in the planning process and identified in the final plan.

c. Important Natural Resource Parcels and Critical Habitats

A 1985 report by the Metropolitan Interstate Committee (MIC): "Superior-Duluth Harbor Natural Resources Management Program" identified and described 20 key habitat parcels or natural resource sites in the estuary. Criteria for choosing these parcels included their importance in support of critical status species and other important species, uniqueness of habitat, and recreation value, etc. A list and brief description of these parcels is provided in Appendix G. This MIC document also lists sites within the estuary rated as valuable natural areas by the WDNR Scientific Areas Program. An abbreviated description of these sites appears in Appendix G.

Identification of sensitive and critical areas for protection from development or environmental degradation will be a continuing process during Remedial Action Plan development. Most of the work to identify important or critical habitats in the St. Louis River system has concerned the estuary. Description of habitat types in upper reaches of the river can be found in the MDNR report: "Fish and Wildlife Resources of the St. Louis River" (Peterson, 1979). Certain areas in the estuary are currently recognized as important remaining habitat that requires protection. Information on critical habitats comes from several sources. For example, WDNR index station monitoring has helped to identify critical fish habitats in the estuary (WDNR, 1982). Efforts to identify important habitat areas should continue because habitat requirements for many species are largely unknown. Some of the known critical habitats for certain species in the estuary are listed below. It is expected that this list will continue to grow as habitat requirements for additional important or desirable species become known.

1. St. Louis River below Fond du Lac Dam to Highway 23 Bridge:

This is the primary walleye spawning habitat for the population of western Lake Superior. It will also be the prime lake sturgeon spawning area once lake sturgeon stocked in the St. Louis reach maturity. The Wisconsin shoreline of this stretch of river was purchased by WNDR in 1989 for habitat protection. Threats to the quality of this habitat include flow variation due to dam operation, poor water quality due to in-place pollutants in upstream impoundments, and in-place pollutant transport. Upstream industrial and municipal activities also increase the threat of spills and other water quality impacts.

2. Allouez Bay:

Allouez Bay is a major northern pike spawning area in the lower estuary. The lower Nemadji River and Allouez Bay are a major feeding area for post-spawning adult walleye (WDNR, 1982). It is important wildlife and water bird habitat.

3. Grassy Point Area:

This is a major northern pike spawning area. It is a shallow water area with abundant forage species, important for feeding northern pike and other predators. Juvenile walleye, smallmouth and bass, white bass are also sampled in the area (WDNR, 1982). The area supports diverse macrophyte communities.

4. Interstate Island:

The Interstate Island wildlife area provides nesting and young rearing habitat for colonial waterbirds, including common terns and ring-billed gulls. It is the site of a common tern (an endangered species) colony. A pair of Caspian terns nested here in 1991. (Other islands constructed from dredged material: Barkers Island, Hearding Island, Hog Island, in addition to Interstate Island, have been utilized by colonial nesting species. These other areas are discussed in Appendix G).

5. Wisconsin Point, Minnesota Point:

Wisconsin Point is undeveloped. Minnesota Point has considerable residential and commercial development. Wisconsin and Minnesota Points are unique sand spits with beach habitat for dune plant communities. Wisconsin Point also provides colonial bird species nesting habitat (Wisconsin Point Wildlife Area) and important migration habitat for bird species, especially warblers and shorebirds. The undeveloped portions of Minnesota Point provide important habitat for migrating birds.

6. Inland Bays: Mud Lake, Kelly Bay, Pokegama Bay, Kimballs Bay and Spirit Lake, and unnamed regions of side channel wetlands upstream from Oliver, WI:

These shallow water habitats provide spawning areas for northern pike, musky, largemouth bass, bluegill, and black crappie and are valuable wildlife and waterfowl habitat.

7. Shallow mud flats for burrowing mayflies: major areas include the upstream end of Spirit Lake, the vicinity of Dwight's Point, and around Buoy 77:

These mud flats supporting burrowing mayflies are very important feeding areas for juvenile walleye.

8. Channel undercuts located on deep bends of the river downstream from Highway 23.

Channel undercuts located on the outside of deep bends in the river, especially when filled with brush and logs are important channel catfish spawning and rearing areas.

V. SOURCES

SOURCES OF POLLUTION

Active and historical sources of pollution to the St. Louis River/Nemadji River Systems which have been identified to date are outlined in this chapter and estimated loadings of contaminants are discussed in Chapter VI. The identified sources are listed because they have the potential to contribute some type of contamination to the AOC. It is noted if contributions are known to be related to specific use impairments. While sources can be identified through the state and federal regulatory process, and through historical and anecdotal reports, it should be noted that quantitative information on the contribution of contaminants from these sources is often lacking.

A. POINT SOURCES

Current and historical point source discharge includes both conventional and toxic pollutants from municipal and industrial dischargers. Current point source dischargers are required to be permitted under the National Pollutant Discharge Elimination System (NPDES). The section on historical dischargers includes the hazardous waste sites on the National Priorities List (Superfund), and facilities which no longer discharge directly to the AOC's surface waters. The section on potential point source dischargers includes solid waste disposal sites and landfills in the AOC. In most cases, there are no data to document discharge of contaminants to surface waters from these solid waste sites, although inputs may be occurring through ground water transport.

1. Current NPDES Permitted Dischargers

Current point source dischargers are listed in Table V.I and located on Figure V.I. Dischargers of non-contact cooling water are not included in the table or discussions. In Minnesota, wastewater treatment was consolidated and improved by the WLSSD treatment plant which began operation in 1978. WLSSD and the facilities which discharge wastewater to it are discussed below. In Wisconsin, the City of Superior wastewater treatment plant was upgraded in the late 1970's. A number of industrial facilities on the Wisconsin side discharge wastewater to Superior Bay and to the St. Louis and Nemadji systems.

Western Lake Superior Sanitary District (WLSSD), Duluth, was constructed in the late 1970's to treat virtually all of the industrial and municipal waste discharges in the lower St. Louis River area of Minnesota. The district treats discharges from seven cities, ten townships, and seven major industries. These industries include the Potlatch Paper Company in Cloquet, U.S. Gypsum Acoustical Products, Lake Superior Paper Industries and Superwood Corporation in Duluth. The WLSSD facility has a design flow of 43.6 mgd and discharges an average of 34 mgd. Effluent is discharged into St. Louis Bay.

The NPDES permit for WLSSD (See Table V.1) sets effluent limits for traditional water quality monitoring parameters such as BOD and pH and requires monitoring for some metals and organic chemicals. However, WLSSD does receive wastewater containing chemicals other than those limited in the permit. As an example, in 1982, as part of a study of St. Louis Bay, the U.S. EPA analyzed 12 water samples from WLSSD's influent and effluent to determine the organic chemical composition. The samples were initially screened by gas chromatography and then analyzed by mass spectrometry. The analyses showed a total of 461 organic chemicals: 271 chemicals in the WLSSD influent and 190 chemicals in the effluent. Of the chemicals in the effluent, 134 or 70% of the chemicals were new substances that were not found in the influent. These chemicals include substances such as phenols, chlorinated hydrocarbons, halogenated hydrocarbons, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs). Many of these chemicals are known or suspected carcinogens. While the WLSSD facility removes some of the organic chemicals in the influent, it also creates new organic chemicals in the effluent through the use of chlorine in the disinfection process. Appendix H lists the organic chemicals found in the WLSSD effluent during the 1982 study.

City of Superior Wastewater Treatment Plant was constructed in 1948 to provide primary treatment to combined sanitary and storm water. The plant was later upgraded to include secondary sewage treatment. In 1975, the City of Superior underwent a sewer separation project except for the Billings Park, South Superior, and downtown Superior areas. Combined sewer overflow facilities were constructed in these three areas, however; just recently two of the three treatment units were found to be inoperable, allowing untreated sewage to enter neighboring waterbodies. Discharge of effluent from the main treatment plant is to Superior Bay. The design flow of the main treatment plant is 5 mgd.

Murphy Oil USA - Superior Refinery is a petroleum refinery producing gasoline (about 45-50% of the product volume), kerosene, diesel fuel, heating oils, heavy fuel oil, liquid petroleum gas, asphalt and elemental sulfur. The refinery receives its raw material, crude oil, from Canada's western provinces by pipeline utilizing the Interprovincial Pipeline Company in Canada and Lakehead Pipeline Company in the United States. The refinery began operation in 1951. It occupies 53 acres of land and an adjacent tank farm occupies approximately 180 acres, all within the City of Superior. It has recently operated at a rate of approximately 38,000 barrels of crude oil per day. Process wastewater, contaminated runoff, and uncontaminated runoff are directed to a wastewater treatment system prior to discharge to the headwaters of Newton Creek which is a tributary to Superior Bay, entering a backwater behind Hog Island known as Hog Island Inlet. Treated process wastewaters are discharged through outfall 001 at an average rate of 0.289 mgd and stormwater is discharged through outfalls 002 and 003.

The receiving water, Newton Creek, was previously classified as non-continuous and as capable of supporting a balanced fish and aquatic life community with a variance from fish and aquatic life criteria for ammonia. On June 1, 1991, the variance for ammonia was removed and Newton Creek was classified as capable of supporting an intermediate aquatic life community (defined in Wisconsin Administrative Law). In August 1991, a revised wastewater discharge permit was proposed based on recently promulgated Wisconsin administrative law concerning toxic substances and antidegradation policy and based on revisions to Wisconsin Water Quality Standards. Inclusion of more stringent effluent limitations and limitations for parameters not previously regulated will likely require changes in operations and treatment. At the time this was written, the proposed wastewater discharge permit was subject to public review.

Recent aquatic life toxicity test data indicate the effluent discharge from the refinery has a significant potential to cause acute toxicity effects to the fish and aquatic life community of Newton Creek. The potential for sublethal adverse impacts from the effluent is also significant.

Murphy Oil is classified as a major air source for suspended particulates, nitrogen oxides, volatile organic compounds and carbon monoxide. Solid wastes are generated at the refinery, some classified as hazardous.

Off-site sediment sampling in Newton Creek and Hog Island Inlet of Superior Bay has detected various polynuclear aromatic hydrocarbon (PAH) compounds. Other organic compounds as well as various salts and metals might be expected to be emitted in the refinery's effluent. Estimates of annual loadings from the refinery's wastewater discharge for those parameters for which there are sufficient data, are given in Chapter VI.

Superior Fiber Products manufactures high density hardboard paneling from aspen logs. About 150 cords per day are debarked, chipped, ground and digested. The final product is smooth-one-side hardboard panel sheets. Superior Fiber Products is a wholly owned subsidiary company of Georgia-Pacific Corporation.

An average of 10,000 gallons per day of process wastewaters are produced. Solids in process wastewaters are settled in ponds. Wastewater is combined with an average of 670,000 gallons per day of cooling water. The pH of the combined wastewater is adjusted with caustic soda and discharged to Superior Bay.

The existing wastewater discharge permit was issued in August 1988. In October 1988, Superior Fiber Products applied for a variance from water quality standards; the variance was denied in July 1989. In December 1989, Superior Fiber Products petitioned for an Adjudicatory Hearing contesting the discharge permit requirements for effluent toxicity testing and reporting. The bioassay and toxicity testing requirements, reporting, and effluent limits are held in abeyance until the petition is decided. A hearing date was not yet scheduled at the date this was written.

Violations of BOD effluent limits have occurred. These violations occur because Superior Fiber Products has no real treatment for BOD. The effluent BOD level is essentially determined by production levels, very limited pond storage and pulpwood moisture content. This leaves the plant with little control over wastewater strength. The high strength of the wastewater makes pH control more difficult, and causes problems with effluent toxicity tests. New pH control equipment and Wisconsin Pollutant Discharge Elimination System (WPDES) language eliminated most pH violations.

In addition to BOD and pH, the proposed permit will limit the discharge of zinc, mercury, other toxic substances and persistent bioaccumulating toxic substances, and will require biomonitoring. Acute and chronic whole effluent toxicity testing will be required. The proposed permit requires abandonment of the unsealed treatment ponds. The primary effect of the new permit is the requirement to replace the holding ponds with a new treatment system. At the time this was written, Superior Fiber Products and the state of Wisconsin were investigating the possibility of ceasing wastewater discharge to Superior Bay and abandoning (closing) the treatment ponds.

Figure V.1

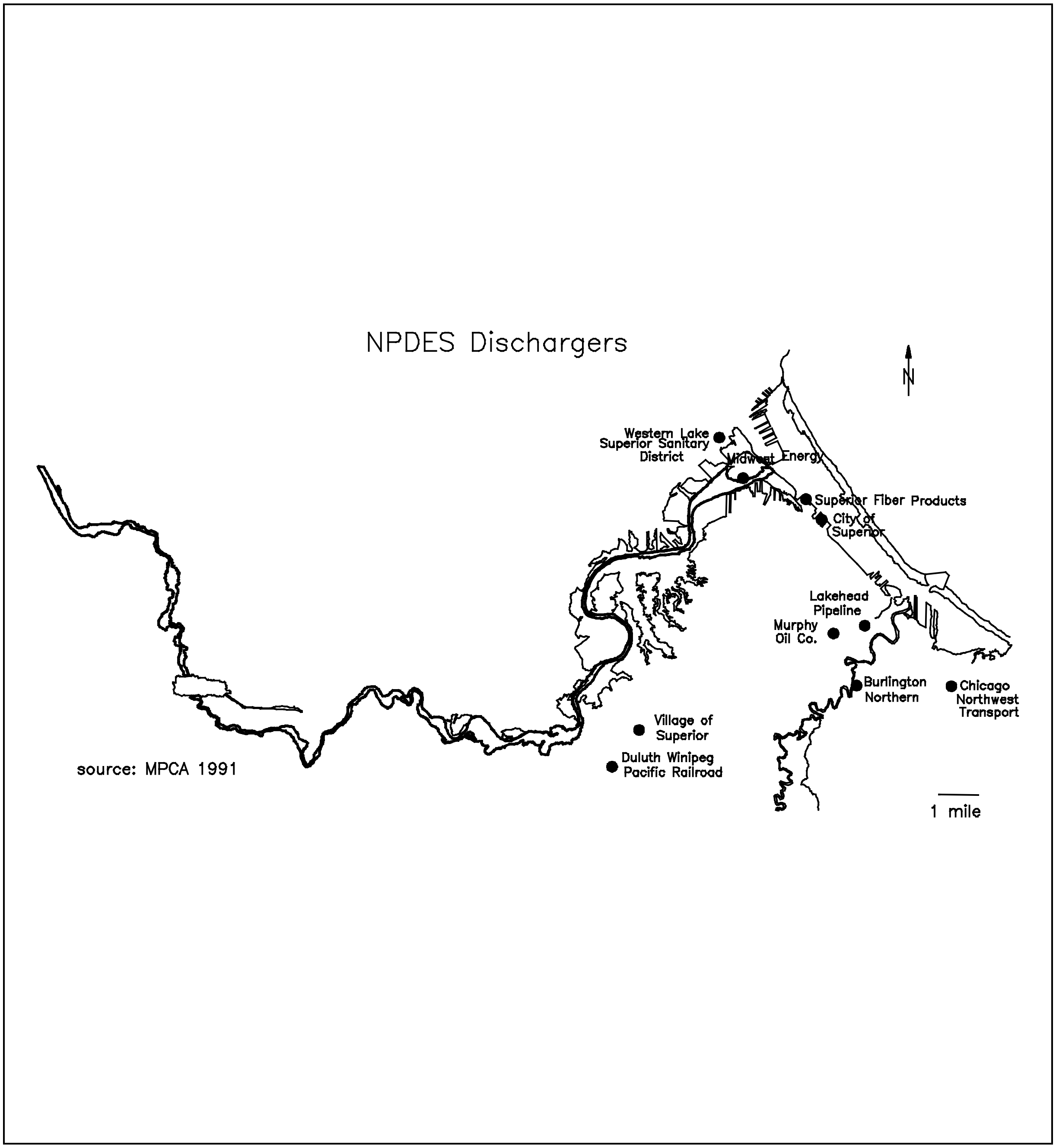

NPDES Dischargers
N
Western Lake
Superior Sanitary
District
Midwest Energy
Superior Fiber Products
City of
Superior
Lakehead
Pipeline
Murphy
Oil Co.
Burlington
Northern
Chicago
Northwest
Transport
Village of
Superior
Duluth Winipeg
Pacific Railroad
source: MPCA 1991
1 mile

Table V.I NPDES Permitted Dischargers Located in the St. Louis River Area of Concern

Facility	NPDES # Expiration	Discharge Flow	Receiving Water	Effluent Limitations	Additional Monitoring Requirements	Other
WLSSD	MN0049786 06/04/92	34 mgd average 43.6 design flow	St. Louis Bay	BOD, TSS, pH, Fecal Coliform, P, residual chlorine, oil/grease	Cu, Cd, Pb, Hg, 2,3,7,8 TCDD & 2,3,7,8 TCDF (after 06/04/92)	
Burlington Northern Allouez taconite transshipment facility	WI-0070726 06/30/95	variable, .064 mgd average	Nemadji River via drainage ditch	pH, BOD, TSS	Cu	Taconite pile runoff collected by underdrain system
Chicago Northwestern Railroad	WI-0003522 09/30/93	variable, precipitation related	Bear Creek via drainage ditch	oil/grease TSS	flow	oil/water separator
City of Superior Main Plant	WI-0025593 03/31/91	5 mgd design flow	Superior Bay	BOD, SS, pH, P, fecal coliform residual chlorine	Priority pollutant scan for permit reissuance	Permit reissuance with effluent limits for toxic substances underway.
CSO #2 CSO #5 CSO #6	" " "	variable	Superior Bay Nemadji River St. Louis Bay	BOD, SS, pH, P, fecal coliform residual chlorine		Pretreatment program will be required.
Duluth, Winnipeg, Pacific Railroad	WI-0044831 12/31/93	-----	Unnamed tributary to Pokegama River	BOD, SS, NH_3-N, DO, pH, oil/grease	flow and COD	sanitary/industrial

Table V.1 cont. NPDES Permitted Dischargers Located in the St. Louis River Area of Concern

Facility	NPDES # Expiration	Discharge Flow	Receiving Water	Effluent Limitations	Additional Monitoring Requirements	Other
Lakehead Pipeline Superior Terminal	WI-0044393 06/30/89	intermittent discharge	Nemadji River	TSS, pH, DO, oil/grease, NH_3-N	-----	lagoons for hydrostatic test water - large volume of test water anticipated in 1991.
Murphy Oil	WI-0003085 03/31/90	.289 mgd average	Newton Creek to Hog Island inlet of Superior Bay	BOD, TSS, COD,* phenols, NH_3-N, COD, oil/grease, sulfide, pH, Cr^{+6}, Cr - total	Priority pollutant scan for permit reissuance	1 process, 2 stormwater outfalls. *Permit reissuance with effluent limits for toxic substances underway.
Superior Fiber Products	WI-0002798 06/30/93	.68 mgd average	Superior Bay	BOD, SS, temp,* pH	oil/grease, hardness, Zn, effluent toxicity	*operating under terms of 1986 permit; 1988 permit being adjudicated, hearing date pending.
Superior Midwest Energy Resources Co.	WI-0038946 12/31/93	No discharge for over 8 years	St. Louis Bay	SS, pH, Fe, oil/grease	Al, Cd, Cr, Cu, Pb, Zn, As, turb.	Precipitation recycled for coal pile dust control.
Village of Superior	WI-0030431 06/30/92	.054 mgd Design Flow	Drainage to Pokegama River	BOD, SS, pH, DO, NH_3-N	-----	fill and draw system (spring & fall discharge)

Key to Abbreviations:

Al - Aluminum	Cr - Chromium	Fe- Iron	Pb - Lead	2,3,7,8 TCDD - tetrachlorodibenzo-p-dioxin
As - Arsenic	COD - Chemical Oxygen Demand	Hg - Mercury	SS - Suspended Solids	
BOD - Biochemical Oxygen Demand	Cu - Copper	NH_3-N - Ammonia Nitrogen	TSS - Total Suspended Solids	2,3,7,8 TCDF - tetrachlorodibenzo-p-furan
Cd - Cadmium	DO - Dissolved Oxygen	P - Phosphorus	Zn - Zinc	

2. Historical Dischargers

Historical dischargers are listed in Tables V.2 (industrial sites) and V.3 (municipal sites). Historical dischargers are included in this report for two reasons. First, some of them are continuing to contribute toxicants to the AOC even though operations have ceased. Secondly, all of them have potentially contributed to the in-place pollutants during the history of the AOC. Historical discharge types include domestic wastes, treated sewage effluent, wood pulp wastes, board and paper mill effluent, alum plant wastes, oil refinery wastes, steel mill wastes, fiber board plant wastes, railroad maintenance shop wastes, and other industrial plant wastes.

a. Industrial Dischargers

Table V.2 Historical Industrial Dischargers in the St. Louis River System

American Carbolite Company operated from 1908-1928 at a site by the St. Louis River near Keene Creek. The company used calcium carbide and carbolite to produce acetylene which was used for gas lighting. Approximately 12 million ft^3 of acetylene gas was produced per day. There is no record of waste disposal practices.

American Cyanamid Company, Cloquet, was an alum plant which discharged its process wastes to the lime sludge pond of the Northwest Paper Company. A septic tank and soil absorption field were used for disposal of sanitary wastes (MDH, 1961).

American Tar and Chemical Company, Duluth, was a manufacturer of roof shingles and roofing paper which operated in the early 1900s to 1940 on a site including the 59th Avenue peninsula next to Stryker Bay. It is indicated in records that American Tar received tar, a product of coking, from Interlake Iron. There are no records of waste disposal practices for American Tar. This site is now the Interlake Iron Superfund Site.

Arrowhead Black Topping maintained a surface water collection tank which discharged to the St. Louis River via Sargents Creek. The discharge permit terminated in 1977.

Arrowhead Refinery Company (Gopher Oil), Hermantown, operated as a refiner of waste oil from 1945 to 1977. Metal laden sludge was disposed of in a two acre lagoon which subsequently has contaminated soils, surface and ground water around the site. Contaminants include oil, grease, heavy metals, cyanide, phenols, polynuclear aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) (MPCA, 1989). The site has been under investigation since 1976 and was added to the MPCA Permanent List of Priorities and to the EPA National Priorities List. Monitoring, diversion and remediation activities are ongoing (MPCA, 1991).

Capitol Elevator Company, Duluth, listed by MDH (1961) as possible source of waste.

Conoco, Inc. (Wrenshall Refinery), Wrenshall, was operated as an oil refinery from 1953-1981. The facility provided septic tanks and absorption fields for sanitary waste disposal. Cooling water and boiler blowdown discharged to Silver Creek via an oil removal and cooling pond. Process wastes were treated by chemical neutralization and steam stripping, oil removed, and pumped to a seepage pond (MDH, 1961). The site has been placed on the MPCA Permanent List of Priorities and is presently used as a

Table V.2 cont. Historical Industrial Dischargers in the St. Louis River System

pipeline terminal. Contamination from landspreading of sludge, leaded tank bottom pits, and a slop oil pit is being investigated (MPCA, 1989). This site was previously the site of International Oil Refineries, Inc.

Conwed Corporation (now owned by US Gypsum Acoustical Products), Cloquet, utilized an initial waste treatment which consisted of fiber screens and a continuous digester to reduce discharge of suspended solids. An aeration unit was put into operation in 1961. Effluent was discharged into the St. Louis River. Sanitary sewage was discharged into the City of Cloquet's sewer system. Upgrade of waste treatment was scheduled for 1973. Current discharge consists of non-contact cooling water to the St. Louis River and effluent discharge to WLSSD.

Coolerator Company manufactured refrigerators from 1930 to 1955 out of two plants at 50th Avenue West and Wadena Street in West Duluth and south of McCuen Street (Highway 39) in Gary adjacent to the St. Louis River. The company used chemicals and paints in their manufacturing process. Metals were treated in chemical baths to prevent rust and refrigerators went through an extensive painting procedure. There are no records of waste disposal practices.

Cutler Magner Co. is an operating salt and cement storage and transfer facility.

Diamond National Corporation, Cloquet, currently has wood storage yard run-off to the St. Louis River. Effluent discharge is to WLSSD.

Duluth, Missabe and Iron Range Railway Company, Proctor, discharges oil wastes from the maintenance yards to an oil skimming basin with overflow discharging to St. Louis Bay via Kingsbury Creek. Yard run-off and roof drains also discharge to Kingsbury Creek (MDH, 1961).

Duluth Tar and Chemical Company was a manufacturer of tar paper and other products from tar in the early 1900s to 1940's. Duluth Tar operated in the region which includes the 59th Avenue peninsula region next to Stryker embayment. There are no records which give information on waste disposal practices. A horsemeat packing plant began operations sometime between 1927 and 1940 at the Duluth Tar site and this company had a direct outfall to St. Louis Bay. It is not known if Duluth Tar had previously utilized this outfall. This site is now part of the Interlake Iron Superfund site.

Huron-Portland Cement Company, Duluth, listed by MDH (1961) as possible source of waste.

Interlake Iron Company, a producer of coke and steel during the early 1900s-1960 located in the area of the 59th Ave peninsula and Stryker embayment. Records indicate that Interlake pumped waste tar directly to American Tar and Chemical. A boat slip and outfall pipe on the St. Louis River have been reported. This site is now part of the Interlake Iron Superfund site.

International Oil Refineries, Inc. separated the treatment of sanitary and process wastes. Sanitary waste was treated by septic tanks and discharged to a soil absorption field. Cooling water and boiler blowdown were disposed of through an oil removal and cooling pond which discharged into the St. Louis River via Silver Creek. Process waste was treated by chemical neutralization and steam stripping, oil removed by an API separator and the effluent pumped to biological oxidation ponds which emptied into a seepage

Table V.2 cont. Historical Industrial Dischargers in the St. Louis River System

pond. Some caustic wastes were recovered and shipped to consumers such as paper mills. This site is now the Wrenshall Refinery owned by Conoco, Inc.

Jeno's Inc., a food processing company that has several locations throughout Duluth. The property of concern to the Remedial Action Plan is located on 438 South First Avenue East, Duluth, near the harbor. An investigation prior to 1986 detected low levels of PCB contamination in the soils on the Canal Park Drive side of the property. In 1986, as a temporary solution, the area was paved over with two inches of bituminous paving to reduce the possibility of human contact. On the Lake street side of the property, a black, inky substance called coal tar was detected in the early summer months of 1991 when street post holes were dug. The coal tar, a product of coal gasification and coalcane, is located approximately 5 ft. to 7 ft. below the surface, just above the water table. To date, a permanent solution has not been executed.

Klearflax Linen Looms Company produced carpets, towels, and other items made from flax. The company began operations around 1913 at a site inland from the 63rd Street Peninsula. The company used dyes that likely contained arsenic and cyanide which were used as preservatives. Witnesses claim that the dyes could be seen in the surrounding waters. There is no record of the company's waste disposal practices.

Koppers Industries, Incorporated produces treated wood products at a plant located just south of the City of Superior. The plant has been in operation, under various ownership, since 1928. Wood products are treated with creosote in a carrier of number six fuel oil. Wood was also treated with pentachlorophenol during 1955-1979. Water from the plant site, approximately 112 acres, drains to Crawford Creek, a tributary to the Nemadji River which is a major tributary to Superior Bay. Some of the plant site also drains toward Bluff Creek which is a tributary to Allouez Bay. Wastewater had been discharged toward Crawford Creek for many years. Wastewater was treated in lagoons and spray irrigated. Use of the treatment lagoons and spray irrigation fields was discontinued in 1988, and discharge ceased as of June, 1988. The facility no longer has a permit to discharge. In 1988 the treatment lagoons underwent closure and site clean up under the hazardous waste program (RCRA). A long term management plan for the closed lagoons was developed as part of the closure process. Since that time, evaporation has been used to manage excess water. Beginning in 1991, the facility hauls wastewater to the City of Superior's wastewater treatment system.

Contamination at the site is being investigated and a corrective action plan is being developed under the hazardous waste program (RCRA). In addition to on-site investigations of the waste management facilities, off-site sediment sampling has detected various polynuclear aromatic hydrocarbon (PAH) compounds at the stormwater outfall discharging to Bluff Creek and in the wetland adjacent to the facility that drains into Crawford Creek. (This site is not shown on Figure V.2 since it is south of the area shown on the map.)

Lakehead Pipeline Terminal operated from 1950 until the early 1960's at a site adjacent to (northwest of) Hog Island. Petroleum products were transported by pipeline to the terminal and then transferred to ships for transport on the Great Lakes. Use of the terminal was discontinued in the 1960's when the pipeline was completed to Chicago.

Table V.2 cont. Historical Industrial Dischargers in the St. Louis River System

Orba Coal Shipment (Midwest Energy) is an operating coal transfer facility on the Superior side of St. Louis Bay.

Potlatch (Northwest Paper Corporation), Cloquet, is located on the south bank of the St. Louis River about one-half mile below Cloquet (MSBH 1982-1929). At the time of the 1928-1929 report discharge included five outlets and consisted of pulp, chemicals, liquors, wood acids, and screened white water. The facility is a wood pulping and board mill which initially had treatment facilities including in-plant fiber screening, lime sludge pond, and mechanical clarification for removal of suspended solids (MDH, 1961). The sulfite and kraft pulp mill and bleach plant, and lime sludge waters were then discharged to the St. Louis River (MBH, 1948). Spent sulfite liquors and sanitary sewage were discharged to City of Cloquet's sewer system. During summer months approximately 50% of the sulfite liquors were hauled away for use as road binders.

Plant treatment facilities were to be upgraded in 1973. Implementation of this system was delayed, however, until the 1979 diversion to WLSSD. Non-contact cooling water is currently discharged directly to the St. Louis River, sanitary wastewater to the municipal system, and industrial effluent to WLSSD after primary treatment on-site.

R.J. Reynolds Company, Duluth, was a food processing plant which was partially connected to the Duluth Main Plant in the late 1960s. Retort cooling water continued to be discharged to St. Louis Bay through an adjoining marsh.

Superwood Duluth Barge Slip 7, a former harbor slip, is located north of the main plant. A 1989 investigation found PAH contaminated soil among the demolition material used as fill for the barge slip in 1972 by Superwood (Barr Engineering, 1989). A consulting company is currently employed in the activity of bringing the site up to legal standards (MPCA, 1990). The site is under review by the MPCA.

Superwood Corporation, Duluth, operates a board mill producing high density board from aspen pulp. Sewage and industrial wastes were treated by septic tank and settling ponds, which discharged into the Duluth Harbor (MDH, 1961). As of 1969 waste treatment was considered to be inadequate (MPCA, 1969). Waste discharge was linked to the WLSSD system in 1978.

Universal Atlas Cement, Duluth, listed by MDH (1961) as possible source of waste.

US Steel Corporation - American Steel and Wire Division, Morgan Park, is located on the west side of the St. Louis River where it broadens into Spirit Lake (MSBH et al, 1928-1929). The facility discharged wastes including fly ash and flue dust from the blast furnace, cooling water, waste acids, oil from the steel mill, and phenolics from the coke plant. Sanitary wastes were not segregated from the process wastes. Wastes were treated in settling basins, oil retention devices, and flue dust ponds. All effluents and settling pond overflow were discharged into Spirit Lake, an oxbow of the St. Louis River (MDH, 1961). The facility is closed and the site is on the National Priority List (Superfund).

West Duluth Industrial Site (Union Compressed Steel Company, Inc.), Duluth. Activities were initiated in the early 1900s with the filling of wetlands with soil and lumber waste. The 10-acre site had been

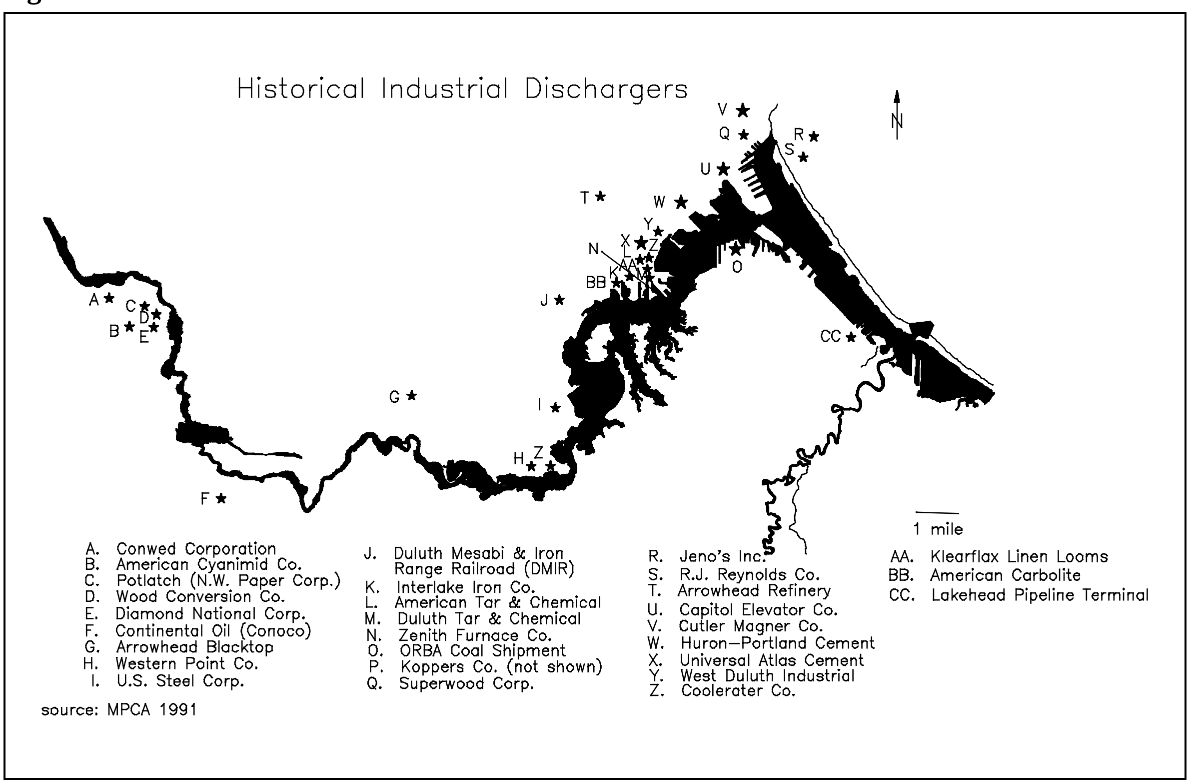
used as a scrap yard since at least 1939. Scrap material on-site included tires, batteries, white goods, scrap metal and scrap vehicles. A remedial investigation conducted in 1985 (Conestoga-Rovers, 1986) identified potential PCB, heavy metal (primarily lead), and dioxin contamination. The site was placed on the MPCA Permanent List of Priorities (MPCA, 1989). The site was cleaned up in the late 1980s and the waste materials were placed in an on-site containerized facility.

<u>Western Paint Company</u> manufactured paints, enamels, varnishes, and lacquers from 1920 to 1966 at a plant adjacent to the St. Louis River south of McCuen Street (Highway 39) in Gary. The company was a pioneer in the development of new and improved paints such as blisterproof housepaint and a thixotropic interior finish. In 1924, Western Paint was producing 300,000 gallons/year of both paint and varnish (Duluth News Tribune, 12-11-60 and articles from 1924, 4-1-30, and 10-19-66). There are no records of waste disposal practices.

<u>Wood Conversion Company</u>, Cloquet, was a wood pulping and board mill which provided fiber screening and continuous digester to reduce suspended solid discharge (MDH, 1961). Sanitary sewage was discharged to the City of Cloquet treatment facility (MBH, 1948).

<u>Zenith Furnace Company</u>, the predecessor of the Interlake Iron Company, was a producer of coke and steel in the early 1900s. Zenith was located in the region of the 59th Avenue peninsula adjacent to Stryker embayment. There are no records of waste disposal practices however, Zenith did provide tar, a byproduct of the coking process, to American Tar and Chemical and Duluth Tar and Chemical. The site is part of the Interlake Iron Superfund site.

Figure V.2



b. Municipal Waste Dischargers

Historical municipal waste dischargers are listed and followed by a brief description in Table V.3.

Table V.3 Historical Municipal Sewage Treatment Plants

Aurora Treatment Plant was a secondary sewage treatment plant constructed between 1930 and 1947 (MBH, 1948). The discharge to the St. Louis River was via a creek. (This facility is located outside the area shown in Figure V.3.)

Carlton Community Health Center utilized an Imhoff Tank, dosing tank and soil absorption field (MDH, 1961). At the time of the MDH 1961 survey the absorption field was not operating properly but it was not considered practical to extend the municipal system to the Health Center.

Carlton Treatment Plant was a primary sewage treatment plant constructed in 1955 (MDH, 1961). At the time of the MDH 1961 survey the plant appeared to be operating at a 'fair' level. Prior to this time untreated sewage was discharged to the old river course near Thomson Dam (MBH, 1948). Wastes are now diverted to the Western Lake Superior Sanitary Facility.

City of Duluth sewerage system as of 1929 (MSBH et al, 1928-1929) consisted of both combined (domestic and industrial) and sanitary systems. All discharges were untreated and into the St. Louis River, St. Louis Bay or Lake Superior. The Duluth Main Treatment Plant was built in 1940 as a primary treatment facility (MBH, 1948) and operated for twenty years with a 30-40 % "pollutant" removal efficiency. Raw sludge from the three district plants was digested at this plant (MDH, 1961). All flows in excess of 25 mgd were bypassed directly into St. Louis Bay. The plant was upgraded in 1978, at which point it was designed at 90-95% BOD removal efficiency. Effluent from the Duluth Plant was discharged into St. Louis Bay approximately one mile above the US Hwy 53 bridge. Beginning in 1978, wastes were diverted to the Western Lake Superior Sanitary Facility.

City of Superior sewerage system was originally installed in 1890. It was a combined domestic and industrial waste system and consisted of 18 outfall sewers discharging without treatment into St. Louis Bay, Superior Bay, and the Nemadji River. Superior Treatment Plant was built in 1948 as a primary treatment facility with combined sanitary and storm sewers. The treatment plant discharged into Superior Bay (MDH 1961). At some point a secondary sewage treatment system was constructed. This secondary treatment system was upgraded with phosphorus removal in the late 1970's (Sevener 1978).

Cloquet Treatment Plant was a primary sewage treatment plant constructed in 1957 (MDH, 1961). Prior to this in the 1940s sewage and wastes from the City of Cloquet discharged directly into the St. Louis River (MBH, 1948). At the time of the MDH 1961 survey the plant appeared to be operating at a 'good' level.

Esko Treatment Plant was a secondary sewage treatment plant which was constructed in 1940 (MDH, 1961). Prior to this time, partially treated sewage and creamery waste were discharged to the Midway River emptying into the Thomson reservoir (MBH, 1948). At the time of the MDH 1961 survey the creamery operation had been discontinued and the treatment plant was in generally poor maintenance. Wastes are now diverted to the Western Lake Superior Sanitary Facility.

Table V.3 cont. Historical Municipal Sewage Treatment Plants

Fairmont Park District Treatment Plant was built in 1960 as a primary treatment facility to treat the wastes from Proctor, MN and operated at similar efficiency levels as the Duluth Main Treatment Plant. Prior to construction these wastes were discharged directly into the St. Louis River without treatment. Effluent from the Fairmont Plant was discharged in the St. Louis River north of Tallas Island (MDH, 1961). Beginning in 1978, wastes were diverted to the Western Lake Superior Sanitary Facility.

Gary-New Duluth District Treatment Plant was constructed in 1960 as a primary treatment facility. The effluent was discharged into Mud Lake, an oxbow of the St. Louis River. Beginning in 1978, wastes were diverted to the Western Lake Superior Sanitary Facility.

Jay Cooke State Park utilized septic tanks until 1979 when the park was hooked up to the Western Lake Superior Sanitary Facility.

Nopeming Sanitarium had a secondary sewage treatment plant which was constructed in 1938. General operation was considered fair and discharge was a heavily chlorinated effluent (MDH 1961). (This site is located outside the area shown in Figure V.3.)

Proctor Treatment Plant- no information available.

Scanlon Treatment Plant was a primary sewage treatment plant built in 1941 and modified in 1953 (MDH 1961). Prior to this time, untreated sewage was discharged directly to the St. Louis River (MBH 1948). During the MDH 1961 survey, the plant was in operation but general maintenance was poor. Wastes are now sent to the Western Lake Superior Sanitary Facility.

Smithville Treatment Plant was built in 1960 as a primary treatment facility with essentially the same capabilities as the Fairmont plant (MDH, 1961). Effluent was discharged into the St. Louis River.

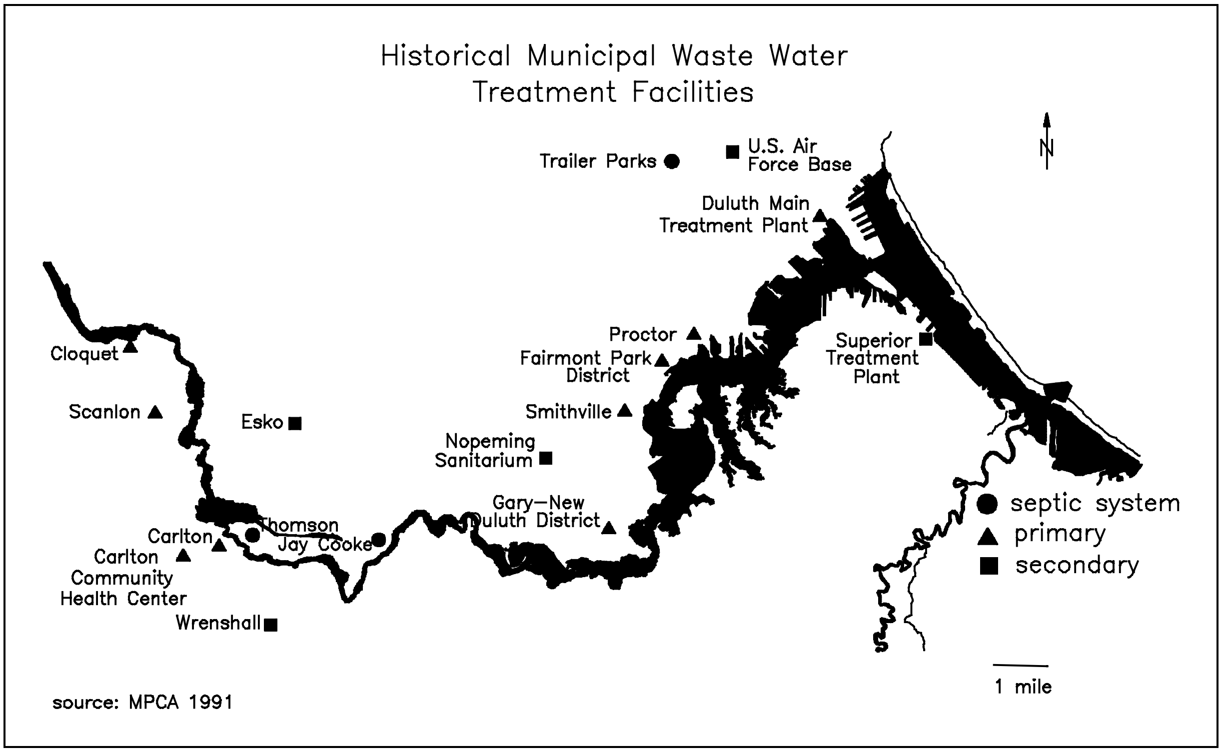
Trailer Parks north of Hwy 53 with individual septic tank systems evidenced surface discharge with runoff to St. Louis Bay via Miller's Creek (MDH, 1961).

United States Air Force Base, Duluth, had secondary sewage treatment facilities which were constructed in 1945 and expanded in 1956. Effluent was discharged to Miller's Creek via an open ditch. This discharge was considered a nuisance (MDH, 1961).

Village of Thomson had private septic tanks and soil absorption fields (MBH, 1948). Some septic tank effluents reached the St. Louis River via a tile system. A plan for sewage treatment facilities had been proposed but was deferred under a low priority rating at the time of the MDH 1961 survey. Wastes are now sent to the Western Lake Superior Sanitary Facility.

Wrenshall Treatment Plant contained 2.5 acre primary and 0.83 acre stabilization ponds. Effluent from stabilization ponds was discharged to Silver Creek via a ravine. The plant operated until the late 1970's when the wastes were diverted to the Western Lake Superior Sanitary Facility.

Figure V.3



c. National Priority List Hazardous Waste Sites

The National Priority list (Superfund) sites on the St. Louis river are a special class of historical dischargers. The facilities that previously occupied the sites are known to have discharged directly to the river and have contaminated soil and ground water. The sites are described below.

1) St. Louis River/Interlake/Duluth Tar Site

The St. Louis River/Interlake Iron/Duluth Tar (Interlake) Site is the former location of steel and iron plants, and separate tar and chemical companies which utilized byproducts of the steel plant coking operations (MPCA, 1989, U.S. EPA 1990). The site includes the region lying east of the 63rd Avenue Peninsula over to and including the 54th Avenue Peninsula. The site lies on the north bank of the St. Louis River approximately four river miles from Lake Superior and includes approximately 230 acres of land and river/embayment area. The property is currently owned by Hallett Dock Company. Facilities known to have been operating in the area since 1900 are listed below:

> *American Tar and Chemical Company* was a manufacturer of roof shingles and roofing paper which operated in the early 1900s-1940s on a site between 59th Avenue and 63rd Avenue Peninsulas. It is indicated in historical records that American Tar received tar, a waste product of coking, directly from Interlake Iron. There are no records of waste disposal practices for American Tar.

Duluth Tar and Chemical Company was a manufacturer of tar paper and other products from waste tar in the early 1900s-1940. Duluth Tar operated on a site between the 59th Avenue Peninsula and 63rd Avenue Peninsula. There are no records of which give information on waste disposal practices. A horse meat packing plant began operations sometime between 1927 and 1940 at the Duluth Tar site and this company had a direct outfall to what is now called Strkyer Embayment.

Interlake Iron Company, a producer of coke and steel during the early 1900s-1960s, was situated at between the present day Hallet Peninsula and the 54th Avenue Peninsula. Records indicate that Interlake pumped waste tar directly to American Tar and Chemical.

Zenith Furnace Company, the predecessor of the Interlake Iron Company, was a producer of coke and steel in the early 1900s. Zenith was located in the region of the present day Hallet Peninsula and just east of the 63rd Avenue Peninsula. There are no known records of waste disposal practices.

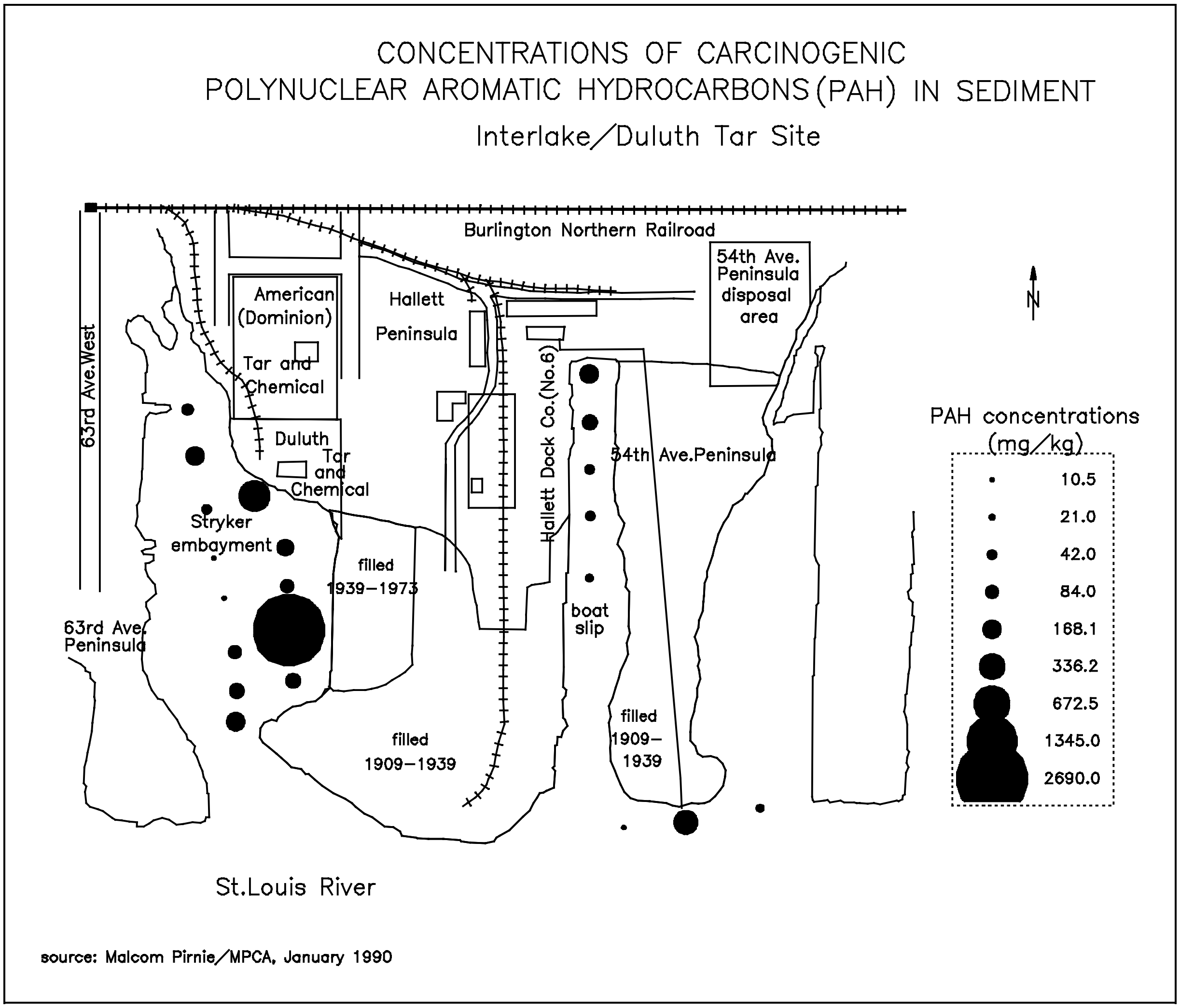
The Interlake Site was added to EPA's National Priorities List in 1983. The MPCA completed, documented, and passed EPA review of the first phase of investigation, the Remedial Investigation for the tar seep contamination, in February 1990. The contamination at the site was found to consist of tar seeping at the ground surface, tar deposits with the fill material, solid wastes consisting of coal and coke particles, ash, slag, clinker, and oily waste slicks. The tar materials are characterized by high concentrations of PAHs. Subsequently, chemical contamination at the site is dominated by the presence of PAHs. Trace metals identified at the site include arsenic, beryllium, cadmium, chromium, lead, mercury. These are all metals characteristically present in tars (Pilli, 1991).

A site-wide feasibility study for Interlake was started, but discontinued later as it became apparent that special studies were necessary to examine potential treatment of the large volumes of contaminated material and potentially high costs associated with site remediation. The decision was made, instead, to follow a strategy that divides the site into "operable units". The operable units include soils, tar seeps, and sediments components. Remedial options for addressing the first of these operable units, the tar seeps, was presented to nearby residents at a public meeting on August 15, 1990. The three alternatives presented for review at this meeting included no action, on-site containment of the tars, and excavation and treatment. The Record of Decision (ROD) issued in September of 1990 identified excavation and treatment of the tars as the selected remedy (State of Minnesota, 1990). An estimated 500 to 2300 yds^3 of tar will be excavated from tar seeps and incinerated off site.

Soils

Soil contamination at the Interlake Site is highly variable. The most contaminated surface soils are those adjacent to tar seeps or in areas previously occupied by bulk storage tanks. Concentrations of PAHs in excess of 1000 mg/kg were observed in the areas formerly occupied by the American Tar and Chemical (Dominion) and Duluth Tar and Chemical companies (see Figure V.4). Levels of carcinogenic PAHs compounds found in surface soils in these areas ranged from 12.7 to 695.3 mg/kg. In general, the highest concentrations of PAHs were found in surface soils at the location of a bulk storage tank shared by American Tar and Duluth Tar and Chemical Company (MPCA, 1990). The highest levels of PAHs detected in individual samples were those soil samples associated with or adjacent to tar seeps. A soil sample taken from an area near the former location of the Zenith Furnace Company contained levels of carcinogenic PAH of 20,900 mg/kg. Various heavy metals were also detected in soil samples. Heavy metals detected in surface soils include lead at concentrations ranging from 67 to 871 mg/kg, as well as two samples containing mercury concentrations of 10.7 and 3.7 mg/kg, respectively. A majority of site soil samples exhibited mercury concentrations ranging from 0.15 to 1.8 mg/kg (MPCA, 1990).

Figure V.4



<u>Sediments</u>

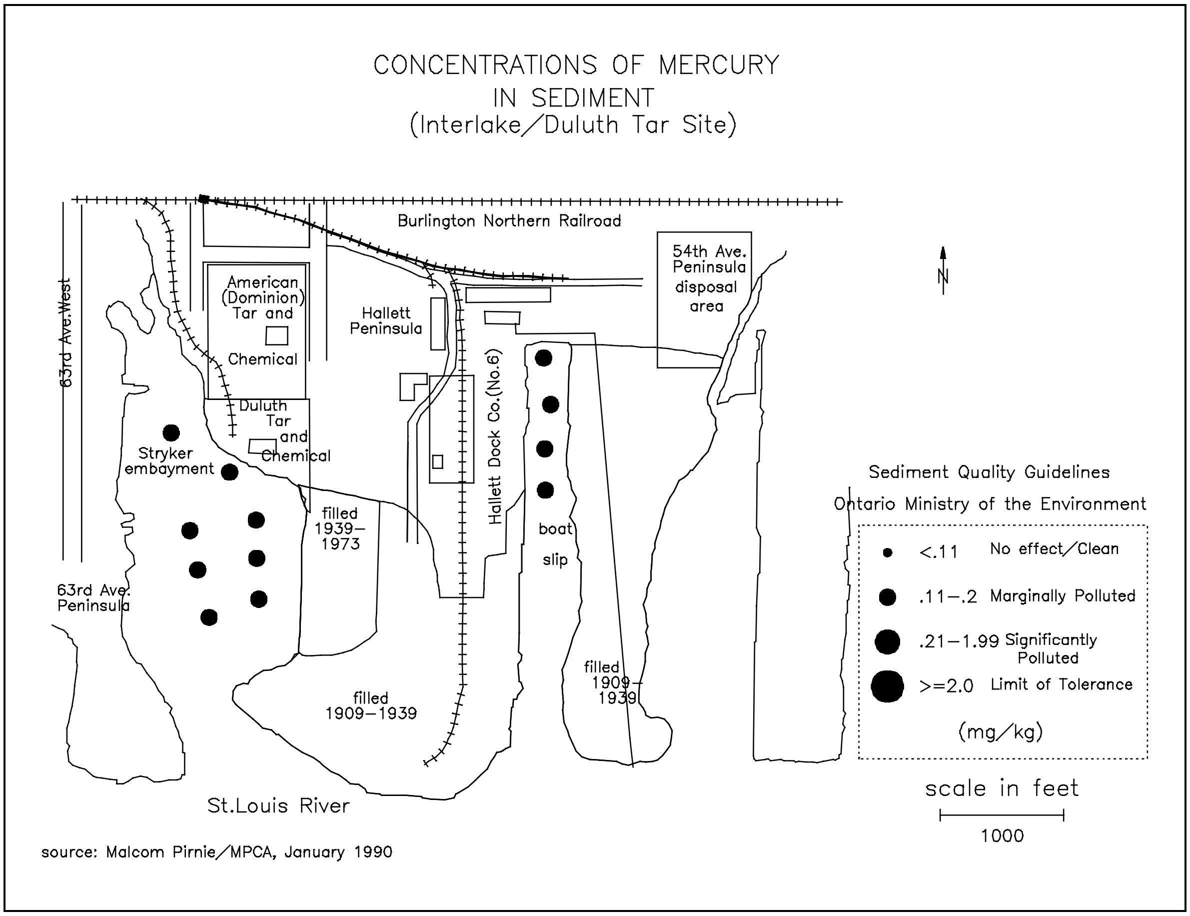
The Interlake Remedial Investigation identified the presence of contaminated sediments at three principal areas. These areas include Stryker Embayment, the Hallett Boat Slip, and the terminus of the 54th Avenue Peninsula (See Figures V.4 and V.5). Each of these three areas exhibited high concentrations of PAHs and other contaminants of concern. Sediments taken from the embayment area exhibited total PAH concentrations which range from 27.03 to 6090 mg/kg. Levels of carcinogenic PAH compounds detected in embayment sediments range from 7.83 to 2690 mg/kg (see Figure V.4). The highest levels of PAHs were collected near the location of the former Duluth Tar and Chemical Company site and adjacent to an area created from fill material over the period of 1939 to 1973. The concentrations of carcinogenic PAH compounds detected at these two sites were reported as 500 and 2690 mg/kg, respectively (MPCA, 1990). Members of the RAP Toxics Technical Advisory Committee expressed concern that the Hallet Peninsula itself may represent a source of tar materials and consequently PAHs to embayment sediments. This concern is predicated on the relationship of high sediment concentrations to filled areas along the western side of the Hallet Peninsula (see Figure V.4).

Sediment contamination also exists in the Hallet Boat Slip and near the terminus of the 54th Avenue Peninsula. Sediment samples taken in the Hallet Boat Slip contain elevated levels of PAHs, volatile organic compounds, and heavy metals. Naphthalene was observed in sediment samples at concentrations ranging from 12 mg/kg to 2500 mg/kg. Naphthalene is considered one of the least hazardous PAHs from a human health perspective, however; due to its low molecular weight, it has the potential to be toxic to aquatic organisms. Sediment concentrations of PAHs considered carcinogenic include concentrations of benzo[a]anthracene at levels ranging from 6.3 to 46 mg/kg, benzo[a]pyrene at levels ranging from 5.1 to 40 mg/kg, and chrysene at levels ranging 5.6 to 43 mg/kg. Benzo[a]pyrene is considered one of the most hazardous of the PAHs, causing cancer in laboratory mice and rats. A number of heavy metals in excess of what would be considered background levels were observed in samples taken from the Boat Slip. These sediment samples include concentrations of zinc at 210 mg/kg, mercury at an estimated value of 1.2 mg/kg (Figure V.5), and lead at 230 mg/kg (MPCA, 1990).

Groundwater

Two groundwater sampling rounds were carried out at Interlake during July and September of 1989. Analysis of samples taken from twelve locations identified three wells with elevated levels of toluene, ethylbenzene, styrene, and xylenes. These three wells were are all located in or adjacent to tar seeps. Levels of total volatile organic compounds (VOCs) at these sites ranged from 370 to 4800 ug/l during the first sampling round and 980 to 17000 ug/l during the second sampling round. As would be expected, semi-volatile organic compounds were observed in these same wells at concentrations ranging from 10 ug/l to 4800 ug/l. Elevated levels of benzene were detected at only one of these three wells during the second round of sampling. This well is situated at a location south of the Burlington Northern rail line and east of 59th Avenue West. No VOCs were detected in samples taken from three wells down gradient from the contaminated wells. It was concluded, therefore, that the groundwater contamination is of a very localized nature (MPCA, 1990).

Figure V.5



2) U.S. Steel Duluth Works Superfund Site

The St. Louis River/U.S. Steel Duluth Works Site was utilized by the United States Steel (USS) Corporation from 1915-1979 for the purposes of coke production, steel making and finishing, and materials storage. Major structures existing on-site prior to closure included a powerhouse, tool shops, two blast furnaces, coke batteries and ancillary support systems, a coke by-product plant, ten open hearth furnaces, a 40" blooming mill, a 28" billet mill, a merchant mill, a continuous rod mill, and a wire mill. The open hearth and blast furnaces ceased operation in 1975 and were subsequently demolished in 1979. Coking operations were also discontinued in 1979. (Barr Engineering, 1985). The wire mill facility continued to be operated until 1987 by the Hallet Forge Corporation. A majority of the structures standing at the time of closure are now demolished. Remaining buildings include the tool shop, the powerhouse, and wire mill.

USS Corporation investigated the Duluth Works Site in 1979 at the request of the MPCA. USS then submitted reports detailing contamination of soil, groundwater, surface, and river water. The site was investigated in 1982 by the USEPA Field Investigation Team and subsequently listed on the National

Priorities List (NPL) in September of 1983 (State of Minnesota, 1986). The U.S. Steel/Duluth Works Site and the Interlake Steel/Duluth Tar and Chemical are collectively referred to as the St. Louis River Site. Designation on the NPL list makes a site eligible for federal financial assistance in instances where a responsible party no longer exists or is unable or unwilling to assume the clean up costs. Superfund provides federal assistance for site clean up at rates of 90% federal and 10% state matching funds. This financial assistance does not absolve responsible parties of liability; rather, it only provides a mechanism to address contamination problems as searches for responsible parties continue. In the case of the U.S. Steel/Duluth Works Site, neither the State of Minnesota or federal government assumed a major financial role in site remediation. USS Corporation assumed site clean up responsibilities in 1985 after negotiating a Response Order by Consent with the MPCA (State of Minnesota, 1986). The characteristics of this agreement, types of investigations carried out, and the progress of site remediation efforts are described in Table V.4, Table V.5, and in Figure V.6. Table V.4 outlines the studies or investigations carried out at the site. Table V.5 provides a brief description of each operable unit and the current status of the clean up action proposed. The letters on the following map (Figure V.6) correspond with the operable units described in Table V.5.

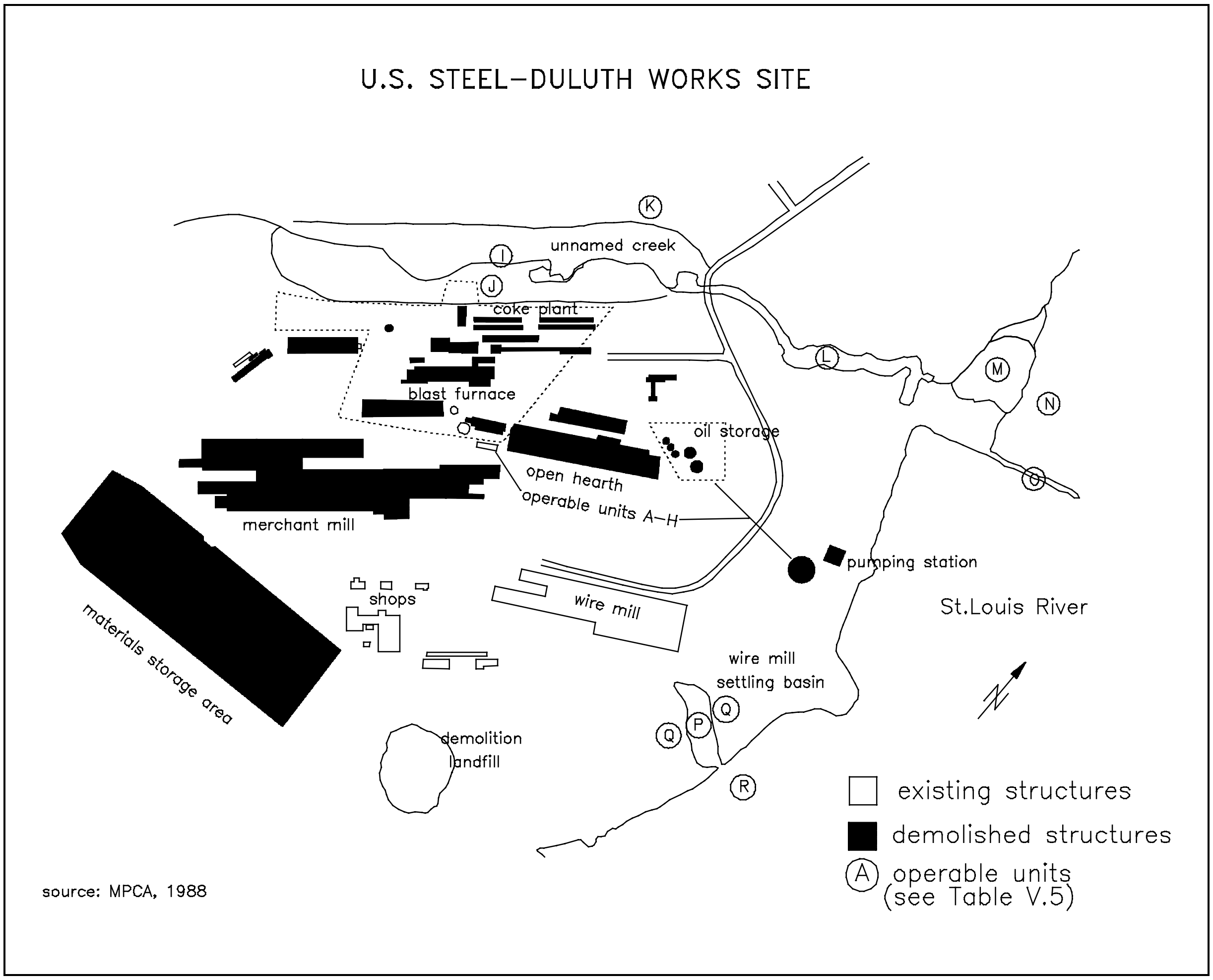
Table V.4 Studies/Investigations Conducted for the U.S. Steel/Duluth Works Site

1	Review of historical records, including those relating to waste disposal practices
2	Sampling of soil and tar deposits
3	Identification and inventories of onsite tanks and pipelines, including the characterization and evaluation of their contents
4	Surface water sampling of the St. Louis River and Un-named Creek
5	Soil borings to characterize site geology
6	Identification of transformers, drums, and other types of miscellaneous containers
7	Aquifer and water table elevation measurements

Table V.5

Table V.5

Figure V.6



Surface Water

Major surface water discharges from the Duluth Works Site to the St. Louis River include the Un-named Creek, which transects the property on its northern border, and the Wire Mill Settling Basin. These two drainage pathways received effluents from various parts of the Mill over the course of its operation. All effluents from operations in the vicinity of the Coke Plant were discharged via the Un-named Creek. Discharges from the Mill's hot rolling process, pickling, cold rolling, and galvanizing operations were channeled into the Wire Mill Settling Basin. Non-contact cooling water from the Hallet Forge Company and storm water from the site collection system were also routed to the Wire Mill Settling Basin (Barr Engineering, 1985). It is believed that storm water and ground water still discharge to the Settling Basin and consequently the St. Louis River. USS originally installed a oil skimming boom at the outlet of the Settling Basin to retard the direct discharge of oily substances or floating scum to the St. Louis River. A recent site visit by MPCA Superfund staff and various members of the RAP revealed that this boom was dysfunctional. MPCA Superfund staff subsequently required that the USS Corporation replace the boom and make monthly checks of its condition. USS was also directed to investigate methods aimed at reducing surface water discharges of PAH compounds from the Un-named Creek into the St. Louis River (Pulford, G., pers. comm.).

Surface water discharges from the 2.8 mi^2 drainage basin of the Un-named Creek en-route to its destination of the St. Louis River. Quality of this discharge is monitored at three separate locations. These locations include a station above the Coke Plant Settling Basin (CP-1), one at the control structure (CP-2), and a final station at the juncture of the creek and railroad track (CP-3). Water samples are analyzed for a variety of heavy metals and volatile and semi-volatile organic compounds. Rough estimates of annual pollutant loadings from the Un-named Creek drainage area to the St. Louis River can be approximated using this monitoring data in association with the region's average annual surface water runoff. These estimates are outlined in the following table:

Table V.6 Estimated Pollutant Loadings to the St. Louis River from the Un-named Creek

Un-named Creek Surface Water Monitoring Station CP3, 1986-1989	Estimated Loadings (lbs/yr)
Benzo(a)anthracene [1,2]	0.4
Chrysene [1,2]	0.1
Benzo(b)flouranthene [1,2]	0.2
Benzo(k)flouranthene [1,2]	0.2
Benzo(a)pyrene [1,2]	0.1
Ideno(1,2,3,cd)pyrene [1,2]	0.1
Dibenzo(a,h)anthracene [1,2]	0.1
Benzo(ghi)perlyene [1,2]	0.1
Pyrene [2]	1.2
Phenanthrene [2]	0.1
Cyanide	238.3
Mercury	*
Cadmium	*
Chromium	9.9
Arsenic	*
Lead	7.9
Magnesium	*
Nickel	*
Zinc	843.8

[1] Identifies a carcinogenic PAH compound as referenced in either the Final Remedial Investigation for the Interlake Steel/Duluth Tar and Chemical Company (Malcom Prinie and the Minnesota Pollution Control Agency, January 1990 and the Remedial Investigation Final Report USS Duluth Works Site, Barr Engineering, December,1986).

[2] Identifies Wisconsin Administrative Code N.R. 105.09 - Human Cancer Criterion.
An asterisk * refers to a parameter without sampling data or for which only one data value exists.

These annual loading values should not be interpreted as anything other than rough approximations. Small sample sets, such as those used to calculate these loading values, have a tendency to bias statistical analyses.

Groundwater

The Record of Decision (ROD) between the State of Minnesota and the USS Corporation provides an overview of the hydrologic setting of the Duluth Works Site. In terms of groundwater, the ROD states that the Duluth Works Site is hydrogeologically isolated. Groundwater recharge to the Site originates from direct precipitation falling on adjacent to or on the Site, or to a small degree from groundwater contributions of steep slope areas west of the Site. Groundwater discharge occurs in three principal boundary areas: these areas include the Un-named Creek, the Wire Mill Settling Basin, and the St. Louis River. In general, the movement of groundwater at the site is in the direction of the St. Louis River. This movement of groundwater through the underlaying geologic formations varies considerably. An April 1981 Barr Engineering Company report estimated that rates of groundwater movement are on the order of 1.0 ft. per day through the sands, 0.01 to 0.001 feet per day through the silt material underlaying the sands, and 0.0000001 feet per day in the clays located over 75 feet below the ground surface" (State of Minnesota, 1986).

As part of the Remedial Investigation, groundwater has been monitored at ten separate locations. Analyses of water samples taken from wells indicate the presence of a variety of carcinogenic and non-carcinogenic PAH compounds. Five wells and one seep were generally within the Minnesota Department of Health's drinking water standards for individual contaminants. The remainder of the wells were not satisfactory. In most instances, water samples drawn from wells at the Duluth Works Site contained a variety of contaminants. Advice offered by MDH for situations such as this are as follows: "Often water supplies will contain multiple contaminants, posing the possibility of additive or synergistic effects. Recommended Allowable Levels (RALs) are derived for individual contaminants and may not be adequately protective if multiple contaminants are present" (MDH, 1988). Area drinking water itself is not considered at risk because a municipal water system serves adjacent residential and business areas and the nearest known off site wells are situated two miles away and up gradient. It is unclear if the groundwater on this site represents a pollutant source to the St. Louis River. One report published by Barr Engineering in 1983 concluded that pollutant impacts to the St. Louis River from groundwater were insignificant because of the slow rates of groundwater movement beneath the site (State of Minnesota, 1986).

Sediments

There are three principal areas of sediment contamination associated with the Duluth Works Site which may impact the aquatic environment of the St. Louis River. These areas include that region defined as the estuary off the delta of the Un-named Creek, the sediments off-shore of the Wire Mill Settling Basin, and the sediments within the Wire Mill Settling Basin itself. An estimated 600,000 to 900,000 yds^3 of tar and tar contaminated sediment are believed to exist in the delta and estuary areas of the Un-named Creek. About 270,000 yds^3 of contaminated sediment and metallic scale are believed to exist in the St. Louis River near the mouth of the Wire Mill Settling Basin. The Wire Mill Settling Basin contains some 10,000 yds^3 of sediments contaminated by various PAH compounds. No remediation has been attempted or ordered on these sediment areas. Removal costs for sediments off-shore of the Wire Mill Settling Basin, alone, are estimated to range from $13 to $52 million (MPCA, 1988).

A number of unresolved questions remain about the long term stability and significance of sediments associated with activities at the Duluth Works Site. The first of these unresolved questions centers on the use of composite samples for the purposes of characterizing sediments off shore of the Wire Mill Settling Basin and in the estuary area of the Un-named Creek. In the estuary area of the Un-named Creek, five composite samples were prepared from equally weighted portions of sediment taken at eleven sampling locations. Although the Remedial Investigation does not specify a rationale for this sampling technique, one assumption can be inferred; this sampling methodology assumes sediment contamination to be homogenous by location and sediment horizon. Given the historical record of site activities and differences in effluent and sediment particle settling velocities, this assumption may not be accurate. Activities and waste discharges ceased at the coke plant in 1979 (Barr Engineering, 1985). This closure marks what presumably is a distinct change in contaminant levels associated with surface water discharges and/or partitioned to sediments delivered from the Un-named Creek. These newer or "cleaner" sediments delivered from the Un-named Creek and other sources would be expected to overlie more polluted sediment horizons. Settling velocities would also be expected to differentiate areas by sediment and effluent/waste particle size (see Table V.7). These factors all tend to make composite sediment samples questionable representations of sediment quality.

Table V.7 Settling Velocities for Soil Particles in Water

	Diameter (mm)	**Velocity (ft/hr)**
Fine sand	0.10	96.0
Coarse silt	0.03	8.6
Medium silt	0.01	.96
Fine silt	0.003	.088
Clay	0.001	.010

Source: University of Minnesota, Department of Agricultural Engineering, 1987.

Identification of sediment contamination by horizon is of importance because of the hydrologic complexity of the St. Louis River. The morphology of the lower St. Louis River is dominated by five hydroelectric facilities and accompanying dams. Operations at these facilities have significant impacts on sediment retention and downstream flows. Lake seiches are another factor impacting the transport and stability of estuary and harbor sediments. The dominant force driving mass transport in the harbor is the Lake Superior seiche, which acts on the harbor through two outlets. The seiche ranges in amplitude from 3 cm to 25 cm and reverses the flow of the St. Louis River up to the Oliver Bridge. High amplitude seiches generate channel currents in the harbor which exceed the 15 cm/sec threshold for the resuspension of unconsolidated sediments (Sydor & Stortz, 1980).

Streamflow variations or changes in depositional patterns brought about by Lake Superior seiches can act to create new channels through areas of sediment. This natural process may, in turn, result in the introduction of pollutants from sediment layers thought to be long since isolated from the water column. Natural processes of erosion can also act to channelize or expose such areas. This process of erosion or aging of a river goes on at varying rates and consequences throughout all major river systems. River reaches such as that near the Duluth Works Site can be characterized as old aged or mature. A river at this stage is near grade and is generally moving laterally in wide meanders across its floodplain. Maximum velocity and erosion occur at the outside of these wide meanders; deposition occurs on the inside or slack water areas of these meanders. Sediments near the Un-named Creek are on the inside of a broad meander and protected by a 28 acre peninsula. Sediments off-shore of the Wire Mill Settling Basin are on the outside of an incipient upstream meander. Meanders on the lower Mississippi River which is similar in character to the lower St. Louis River, have been known to move 60 feet a year (Tarbuck & Lutgens, 1979).

3) Indirect or Potential Point Sources

Indirect or potential point sources are sites that may not have a direct discharge to surface waters. They may contribute pollutants to the river system through contaminated soil or groundwater. These sources include sites such as leaking landfills or other contaminated sites where pollutants may be migrating off-site. In most cases, there is insufficient information to document or quantify inputs to surface waters or river sediments. In some instances, however, contamination of ground water and its direction of flow suggest the site as a source of contaminants to the River System. Solid waste disposal sites and contaminated sites on the MPCA Permanent List of Priorities are discussed below. The National Priority List sites (Interlake and US Steel) were discussed in the previous section.

Major Solid Waste Disposal Sites

The major solid waste disposal sites near the St. Louis River are listed below. Site locations are shown on Figure V.7.

Arrowhead Refinery Company (also known as Gopher Oil), Hermantown, is a ten acre site at Miller Trunk Highway-Ugsted Road intersection approximately eight miles northwest of Duluth. In the early 1940's, the site was used for retinning milk cans and as a dumping ground. It is believed that the area once contained a gas station since an underground storage tank was excavated from the site. In 1945, the site was converted to an oil recycling facility (MPCA, 1990). In 1961, the Arrowhead Refinery Company assumed ownership of the operations until MPCA ordered the company to halt operations in 1976 (U.S. EPA, 1991). Surface water flowing across the site was picking up contaminants and depositing them into Rocky Run Creek, a nearby stream that is a tributary to the St. Louis River. This coupled with the discovery of VOCs, lead, and PAHs led to the site's designation as a federal Superfund site.

The site is a marshy area underlain by clay and silt. The ground water flow is from the north to the southwest. The silt and clay have severely retarded the downward movement of contaminants into the ground water. The soils on-site have acted like a sponge immobilizing many of the contaminants. In addition, the site is an area of ground water discharge which inhibits contaminant movement into the ground water. There is, however, some threat of contamination of local wells located in the path of contaminated ground water (MPCA, 1990).

Since the designation of the site as a Superfund site, a public water main extension has been completed with the intent of providing safe drinking water to local residents (MPCA, 1990). The ground water will be pumped out of the ground and treated and the contaminated soils and sludge will be excavated and bioremediated and/or treated by a sludge solidification method. The U.S. EPA expects to complete extraction and treatment of the ground water in 1992, and will initiate clean-up of the contaminated soils and sludges in 1993 (U.S. EPA, 1991). This site is not shown on Figure V.7 since it is north of the area shown on the map.

Conoco, Inc., Wrenshall, was operated as an oil refinery from 1953-1981. The site was placed on the

MPCA Permanent List of Priorities. The site is presently used as a pipeline terminal. Contamination from landspreading of sludge, leaded tank bottom pits, and a slop oil pit is being investigated (MPCA, 1989).

DM&IR Car and Locomotive Shops, Proctor, was the site for disposal of oil sludges containing polychlorinated biphenyls (PCBs) from 1945-1972. The site was added to the MPCA Permanent List of Priorities. Site investigation and remediation began in 1982 (MPCA, 1989). Remediation was completed in 1989 and follow-up monitoring will be completed in 1992. On-going monitoring of ground water has detected no PCBs and the site will be removed from the Permanent List of Priorities if no contaminants are found (LaValley, DM & IR Railway Co., pers. comm.).

Duluth Air Force Base, Duluth, was placed on the MPCA Permanent List of Priorities. Monitoring and analysis have shown surface water to be contaminated by pesticides, benzene, and gasoline. Potential contamination of ground water and soil by pesticides, organic solvents, gasoline, polychlorinated biphenyls, and low level radioactivity is under investigation and clean-up (MPCA, 1989 and 1991). The site is not located within the area shown on Figure V.7.

Duluth Sanitary Landfill has been recently closed but was owned and operated since 1972 by the Western Lake Superior Sanitary District (WLSSD). The Duluth Sanitary Landfill is now part of the Rice Lake Landfill which is owned by WLSSD. The area has been receiving waste since 1957. A private party operated the landfill for some time and the city of Duluth maintained dump areas to the north and west of the existing site. The surrounding area is generally wetland except for the Duluth International Airport, which is located approximately 3,000 ft. southwest of the landfill boundaries. Surface water from the northern section of the landfill drains into Miller Creek, a tributary of the St. Louis River, which flows east to west across the landfill property. Bedrock under the site is Duluth Gabbro ranging 30-60 ft. below the land surface. Surficial material is silty and clayey sand till and silty sand with sandy clay topsoil. Soil borings have indicated that refuse deposits are located within the water table aquifer. Previously filled areas often lack cover and proper grading to encourage runoff. The site is surrounded by wetland and groundwater flow is south to Miller Creek. This is a poor location for a landfill due to its proximity to the airport and Miller Creek and the existence of a high water table. Monitoring data has shown contamination of both surface and groundwater (MPCA, undated).

Engineers Realty Demolition Landfill, Gary-New Duluth is a demolition landfill located approximately 300 ft. north of Sargent Creek and 3,000 ft. north east of the St. Louis River in Sections 4 and 9, T 48N, R15N, St. Louis County. An estimated 357,084 cubic yards of demolition, construction, asbestos, coal and wood ash waste, as well as unapproved industrial and solid wastes have been disposed of since the beginning of its operation in March 1977. The landfill has exceeded its capacity and the Minnesota Pollution Control Agency is reviewing an order to permanently close the site. It is presently operating under a consent decree which will be reviewed in April, 1992. The site has had numerous violations which include disposing of prohibited waste, inadequate cover and filling of unapproved areas (Pilli, 1991). The landfill is located in a continuous, fine grain sand unit with an average thickness of 50 ft. and a silt unit with a thickness ranging from 0 ft. to 39 ft. The upper sand unit and lower silt unit overlay a continuous, confining, lacustrian clay unit. The unconfined aquifer on site lies approximately between 15 ft. and 37 ft. below the surface within the silt and sand units. Groundwater on site flows to the southeast and the south with an average velocity calculated as 51 feet per year. On site monitoring well samples, taken over a three month period, indicate contaminate impacts on the groundwater. Contaminants detected above the Recommended Allowable Limits (RAL) for drinking water include: arsenic, lead, manganese and mercury. Volatile Organic Compounds (VOC) have also been detected in site groundwater samples. All of which have been below the RAL (RREM Engineering, 1991). The possibility of contaminant impact of the site on the St. Louis River via the Sargent Creek is evident. An evaluation of the surface and groundwater quality is necessary to determine the degree of contamination possible to the St. Louis River.

Old City of Duluth Dump is an unlined landfill located on Rice Lake Road in the Chester Creek drainage basin in Section 8, T50N, R14W. The landfill had received 230,000 cubic yards of mixed solid waste and demolition material during its operation from 1954 to 1959. The site is located in a silty sand unit of glacial till with scattered medium grained sandy lenses. This unit overlays the granophyric bedrock which is found at depths of 49 ft. to 68 ft below the surface. Surface water flows to the north northwest and discharges into the headwaters of the East Branch of Chester Creek, a designated trout stream, in the western margin of the Lake Superior drainage basin. The Miller Creek watershed, part of the St. Louis River drainage basin, lies directly to the west of the site. The unconfined aquifer, located in the sandy till unit, has an average linear velocity of 3.61 feet per year and generally follows the same flow pattern as the surface water. The landfill material extends below the groundwater table, which presents a contamination problem. High levels of chloride and sulfate in surface and groundwater samples were detected which indicate contaminants down gradient of the site. Also detected during groundwater sampling events in 1989 were Volatile Organic Compounds (VOC) and Polynuclear Aromatic Hydrocarbons (PAH). Benzene exceeded the Recommended Allowable Limits (RAL's) in all samples, and xylene exceeded the RAL's in some of the wells monitored. RAL's for total carcinogenic and noncarcinogenic PAH's were also exceeded in all four locations. Of the metals detected, iron and manganese concentrations were found to exceed the secondary drinking water standards. (RREM Engineering, 1989)

Potlatch Industrial Landfill, a 33 acre site, active since 1956, is located within 300 ft. of the St. Louis River in Section 19, T19N, R16W, Carlton County. Wastes deposited at the landfill include laboratory acid and formaldehyde wastes, pulp and paper sludge, lime mud, combined fly and bottom ash, and underflow from the water treatment plant clarifier. The waste currently being deposited consists primarily of wood ash from mill boilers. The site geology consists of a surface layer of fine to course sand with trace amounts of gravel. Beneath the sand unit is an organic fill layer which covers a relatively dense silt layer with a thickness ranging from 2 ft. to 6 ft. Bedrock is composed of highly weathered slate. The unconfined aquifer is located within the sand. Groundwater flow is believed to be south southwest to north northeast (STS Consultants Ltd.,1985). The St. Louis River has been monitored up and down stream of the landfill since August 1990. In July 1987, three samples were taken from leachate seeps along the west bank of the St. Louis River and tested for Volatile Organic Compounds (VOC) to locate possible migration of dioxins from the site. Two of the three samples revealed low levels of VOC's. Styrene, toluene, benzene, 1,1, dichloroethane and 1,1,2 trichloroethane were detected. The results of the chemical analysis not only indicate VOC movement; but they also recognize a potential for dioxin migration from the site (MPCA, 1987). Current stream monitoring occurs three times a year. The final cell of the existing landfill is expected to be capped in the summer of 1992. An application to expand the existing facility has been filed (Pilli, 1991).

Rice Lake Landfill is located North of Duluth in Section 31, T51N, R14W, adjacent to the Duluth International Airport. WLSSD acquired the landfill site from the Duluth Disposal Company in 1979. The Duluth Disposal Company had operated the site since 1972. Prior to 1988, an excess of one million cubic yards of mixed municipal solid wastes, ash, demolition debris, fuel contaminated soils and waste sludge had been disposed. Also located on the site is a synthetically lined ash storage area. Areas at and adjoining the north and west boundaries of the site were used by the City of Duluth and later by Duluth Disposal as a modified landfill, commonly referred to as the Duluth Sanitary Landfill. The Rice Lake landfill occupies 150 acres in a fine grained sand unit above the Duluth Gabbro bedrock. The groundwater table, located in the fine grained sand unit, is approximately 5 ft. to 12 ft. below the ground surface. Frequent release of leachate to surface water has been reported. Landfill surface runoff and leachate generated from the landfill had degraded Miller Creek, a designated trout stream, that previously flowed through the southeastern corner of the landfill. The creek was rerouted in 1981 thus improving water quality. A leachate collection system, encompassing three sides of the landfill, collects leachate and groundwater which are conveyed to the WLSSD's Municipal Waste Water treatment Facility (MPCA, 1988). On site groundwater monitoring has revealed contamination in the form of Volatile Organic Compounds (VOC). 1,2 Dichlorethylene was found to exceed the Intervention Limits. Benzene and cadmium, also detected during this sampling period, were present at three monitoring locations (MPCA, 1989). Groundwater is currently being monitored to determine the extent of contamination. This site has been placed on the MPCA Permanent List of Priorities .

Superior-Wisconsin Point Landfill is located on the shoreline of Lake Superior at the base of Wisconsin Point, between Allouez Bay and a wetland. It was operated for 28 years from 1950-1978. The approximately 20 acre site was originally wetland. There is no liner. The operation began as an open dump with open burning of refuse and minimal compaction. Municipal and some industrial wastes were accepted. Although no waste records were kept at the facility, some of the wastes which may have been placed in the landfill include oil tank bottoms, refinery wastes, glue wastes, paper wastes, and wood scraps. The landfill was closed in 1978 and capped with a two foot layer of clay. The east side of the landfill is bermed. In the fall of 1978, wave action exposed a portion of the northeast corner of the landfill, bordering Lake Superior. In the spring of 1980, four riprap groins were constructed perpendicular to the shoreline to trap drift and reduce erosion. In 1981 additional rock armoring was constructed on the Lake Superior shoreline.

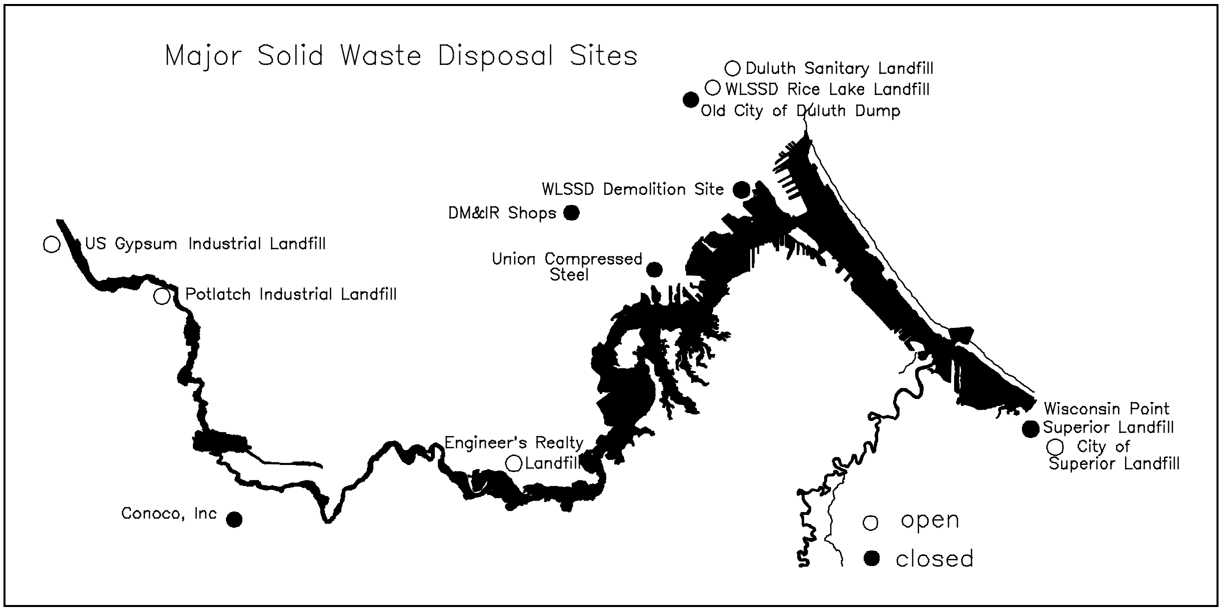
The City of Superior is responsible for monitoring groundwater at the landfill and reports to the WDNR. There are 21 groundwater monitoring wells at the site: 7 internal, 4 in the berm, and 10 external and adjacent to the site. The depth to the shallowest water table at the site is approximately two feet. Groundwater mounds at the site and flows away from the landfill. The net flow is toward Lake Superior. There can be an exchange of groundwater and Lake Superior water along the north edge of the landfill. Various organic compounds and heavy metals have been detected in the groundwater. Increasing contaminant levels have been documented in some of the monitoring wells over time. Surface water monitoring in the vicinity of the landfill has not resulted in detection of contaminants in Lake Superior or Allouez Bay, although dilution and wave action would make this detection unlikely. Input of contaminants to Lake Superior and Allouez Bay probably occurs, but the magnitude of this input is not known.

The U.S. EPA evaluated the landfill in the early 1980's as a potential Superfund site. At that time the site did not rank high enough for inclusion on the National Priorities List. The landfill has been screened by the WDNR for inclusion in the Environmental Repair Program.

Union Compressed Steel Company, Inc., Duluth, was located at the current site of Lake Superior Paper Industries. Site activities were initiated in the early 1900's with the filling of wetlands with soil and lumber waste. The 10-acre site had been used as a scrap yard since at least 1939. Scrap materials on-site included tires, batteries, white goods, scrap metal and scrap vehicles. A remedial investigation conducted in 1985 (Conestoga-Rovers, 1986) identified potential PCB, heavy metal (primarily lead), and dioxin contamination. In 1985, the MPCA recommended inclusion of the site on the National Priorities List. Scrap removal was conducted in early 1986.

USG Cloquet #1 Industrial Waste Landfill, Carlton County. The original solid waste disposal permit was issued to Conwed Corporation in January 1984. The permit was reissued to USG Acoustical Products Company in September 1985. The permit expires in September 1990. The permit authorizes disposal of mineral sawdust, wood waste and ash, and mineral wool shot.

Figure V.7



Minor Solid Waste Disposal Sites

Table V.8 lists the minor solid waste disposal sites near the St. Louis River. The site locations are shown on Figure V.8.

Table V.8 Minor Solid Waste Disposal Sites in the St. Louis River System

Acme Foundry, Douglas County, abandoned foundry sand landfill located in Superior

Carlton dump, Carlton County, abandoned municipal landfill located at T48N, R17W, S.1

City of Superior, Douglas County, abandoned demolition landfill containing greater than 50,000 yd^3 of material near the old city landfill on Wisconsin Point

CLM Corporation, Douglas County, abandoned one-time demolition landfill located at E Street, Superior

Table V.7 cont. Minor Solid Waste Disposal Sites in the St. Louis River System

Douglas County Fairground, Douglas County, abandoned one-time demolition landfill located at T49N, R14W, S.34

John Bacich, Douglas County, abandoned private landfill located at 2nd Street, Superior

Lakehead Blacktop, Douglas County, active small demolition landfill

North Carlton County Landfill, Carlton County, active county landfill located at T48N, R17W, S.9.

Peavey Grain Elevator, Douglas County, abandoned one-time demolition landfill, located at T48N, R13W, S.3

Scanlon dump, Carlton County, abandoned municipal landfill located at T49N, R16W, S.30

Superior Fiber Products, Douglas County, abandoned industrial wood landfill located at 2nd Street, Superior

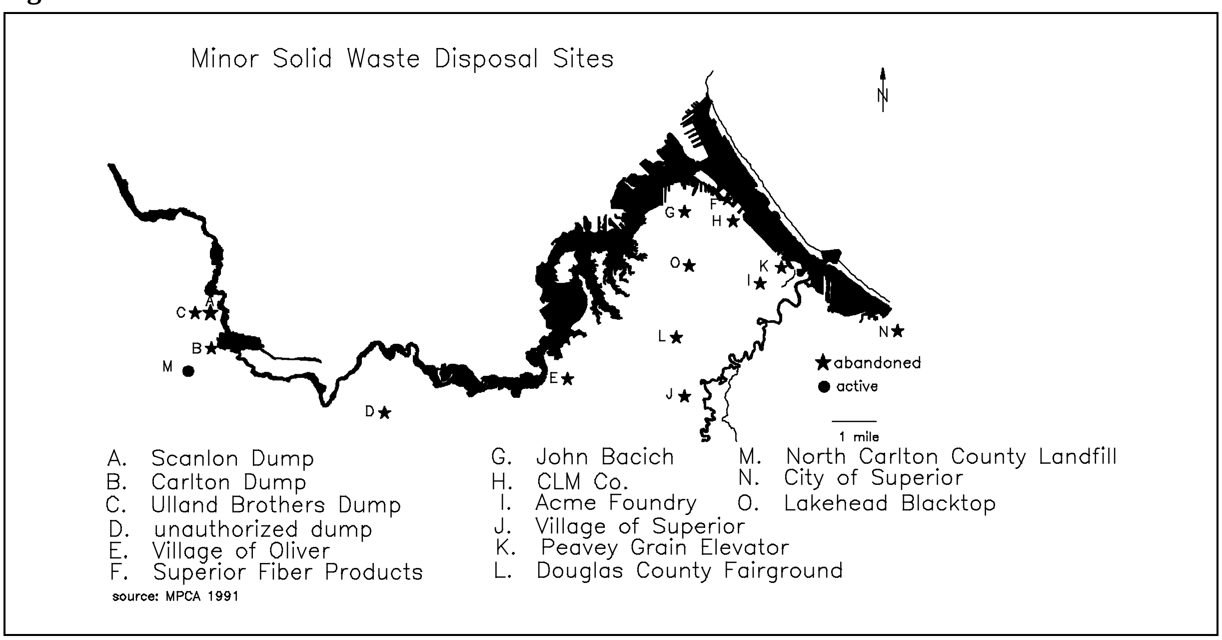
Unauthorized dump, Carlton County, abandoned municipal landfill located at T48N, R16W, S.24

Ulland Brothers dump, Carlton County, abandoned one-time demolition landfill located at T49N, R17W, S.25

Village of Oliver, Douglas County, abandoned municipal landfill, located at T48N, R15W, S.12

Village of Superior, Douglas County, abandoned municipal landfill, located at T48N, R14W, S.10

Figure V.8



Harbor Dredge Disposal Sites

Erie Pier, Duluth, was established in 1979 to receive and store the sediments removed from St. Louis Bay and Superior Bay during harbor dredging activities. Initial dredge material was deposited in 1980. Erie Pier is a diked area consisting of 12 acres of land and 70 acres of water. Storage capacity is expected to be exhausted between 1991-1993.

B. NON-POINT SOURCES

Non-point sources contribute sediments, nutrients, and toxic substances to the Area of Concern. Sedimentation rates have been accelerating since the turn of the century as evidenced by paleolimnological analyses of sediment cores from the St. Louis estuary. Modern rates have been estimated as high as 0.37 g. dry sediment weight/square cm/year (Kingston, 1987). Little or no current quantitative information on non-point source loadings of nutrients and toxic substances to the Area of Concern available.

In addition to high sediment loading in the Area of Concern, nutrient loading from non-point sources is of concern. Phosphorous availability and transport through the system may be connected to the high sediment loading. Nutrient (particularly phosphorus) concentrations in the estuary are relatively high, although eutrophication does not appear to be a current problem (See "Eutrophication/Excessive Loading" Section, Chapter IV). In 1972 the National Eutrophication Survey developed a nutrient budget for St. Louis Bay which estimated that 50% of the phosphorus inputs to the Bay were from non-point sources (U.S. EPA, 1975). In 1982, a study of nutrient loadings to the Bay concluded that point source loadings of nutrients had decreased to one fifth of their former inputs (Cook and Ameel, 1983). This study also found that 90% of the nutrient loadings to St. Louis Bay in 1982 were from non-point sources, and that overall loadings were similar between 1972 and 1982 because 1982 was a year of high flow. These nutrient budgets did not consider point source loadings from Wisconsin, and did not take into account the Lake Superior seiche. Although eutrophic conditions have not been noted within the St. Louis estuary in the last decade, nutrient loadings from the system to Lake Superior are of concern.

The types of non-point sources of sediments and other pollutants discussed in this section are agricultural/forestry runoff, stormwater discharge, unsewered communities, marine recreational and commercial activity, spills, and atmospheric deposition.

1. Run-off Affected by Land Use Practices

The impact of non-point source pollution from land uses such as forestry and agricultural practices is not well documented in the Area of Concern. The major non-point source concerns related to silviculture and agriculture are increased sediment loading resulting from past and current forestry practices, nutrient loading from feedlots along the St. Louis and Nemadji Rivers, and pesticide run-off. The following section describes what is known about land use practices and their relation to environmental impacts in the Area of Concern.

a. Effects of Land Use Practices in the Watershed on Erosion, Sedimentation, and Nonpoint Source Pollution.

1) Sediment Delivery

The red clay deposits of the western Lake Superior Basin affect the St. Louis estuary and western Lake Superior. The significance of red clay deposit erosion is highlighted when comparing the St. Louis River and Nemadji River watersheds to annual maintenance dredging volumes in Duluth-Superior Harbor. The St. Louis River drains a 3,500 mi^2 watershed of which 120 $miles^2$ is red clay deposit. The Nemadji River drains a 360 mi^2 watershed of which 100 mi^2 is red clay. The Nemadji River is responsible for nearly half of the US Army Corps of Engineers annual dredging volume of 200,000 cubic yards. This maintenance dredging volume comes with a disposal cost that has averaged $7.00/$yd^3$ (Northwest Regional Planning Commission, 1989). Deer Creek is a typical red clay area tributary of the Nemadji River. Deer Creek's average annual sediment yield exceeds 200 tons/$mile^2$ and is among the highest in Minnesota (USGS, 1986). An estimated sediment load of 280,000 metric tons per year is transported from the Nemadji River to Lake Superior (Bahnick, 1977). This represents only the sediment fraction which is small enough to stay in suspension and reach the Lake. The Nemadji sediment plume extends as far as 25 km into Lake Superior after storm events (Appendix L - Banks and Brooks, 1992).

2) Erosion in the Red Clay Area

A relatively high rate of erosion is to be expected in the geologically young, highly erodible red clay deposit around western Lake Superior. However, Minnesota Sea Grant sediment core sampling shows that accelerated sedimentation is occurring in the St. Louis River estuary. Core samples showed steadily increasing rates of sedimentation from the 1860's to the present (Minnesota Sea Grant, 1987). Land use and land cover type changes since the mid 1800's has resulted in hydrologic and geologic alteration.

The Red Clay Project of the 1970's concluded that the major source of sediment in the watershed was from stream banks, lakeshore, and other slopes (U.S. EPA, 1979). The Red Clay Project was a joint research and demonstration project of the U.S. Environmental Protection Agency, Soil and Water Conservation Districts and USDA Soil Conservation Service in the Nemadji watershed in Carlton County, MN and Douglas County WI. The project described the erosion and sedimentation in the red clay area as a natural ongoing process exacerbated by human activities. The study looked at the mechanical properties of the clay slopes and the effects of vegetation on the slopes. Stabilization demonstration projects were also conducted on the slopes. However, the effects of hydrological changes in the watershed on the processes of erosion from the slopes was not examined by the project.

The work of the Sedimentation and Erosion Technical Advisory Committee points to the need to expand upon the Red Clay Project to consider watershed-wide processes and their influence on erosion from streambanks and slopes. Upland surface runoff was increased with the removal of the native vegetation during the clear-cut logging in the late nineteenth and early twentieth centuries. The removal of the native vegetation and the changes in land use following removal of the forest cover resulted in drastic changes in the hydrology of the watershed that in turn has affected the processes and rates of erosion and sediment transport. In addition, the existence of sandy parent material beneath the red clay deposits creates an unstable situation where drastic erosion can take place.

3) Watershed Processes and Changes Affecting Erosion

Prior to settlement in the nineteenth century, the watershed cover type was dominated by coniferous boreal forest (Curtis, 1959). Much of the basin was in a climax stage of forest succession. The climax coniferous forest consisted mainly of white pine, spruce, fir, and red pine. The Red Clay Study (1979) describes white pine as the dominant tree in the overstory due to its size and long life span. The study also describes that spruce and balsam fir occurred with near or greater frequency.

The extensive clear-cut logging of this area in the late 19th and early 20th century significantly altered the hydrology of the watershed. Subsequent fires that raged over the region after the forests were cut are believed to have altered the soils in the area. A duff layer of 2-4 inches may have been burned off as a result of the post logging fires. Presently, under the existing predominantly deciduous cover-type, a duff layer of only 0-2 inches can be found (Goerg, USDA SCS, pers. comm.). The intensity and rate of stormwater runoff drastically increased with the removal of timber cover and the loss of the moisture retaining duff layer. Storm events produced higher and more frequent peak river flows because of the degraded hydrologic condition of the watershed. This promoted mass wasting of red clay banks along the river courses (McCawley, USDA SCS, pers. comm.).

Following the logging and fires, much of the land was cleared for agricultural purposes. The remaining woodland grew back to an aspen/maple/spruce/fir covertype. Drainage and landsmoothing activities associated with agriculture and urbanization further increased the runoff rate. Throughout the watershed, cover type has an influence on runoff rates and consequently on erosion. Increased runoff is promoted when approximately 60% or more of a watershed is comprised of open lands and young forest cover types (ages 0-15 years), as found on abandoned agricultural land for example (Verry et.al, 1983). Sustained yield forest management practices that create age class diversity would help avoid the predominance of cover type which encourages increased runoff from the watershed.

Core samples and historical documents substantiate an increase in the rate of sedimentation. A three sample core survey of the St. Louis estuary and the Duluth harbor shows a steadily accelerating rate of sedimentation since 1900. These cores, analyzed using diatoms, geochemistry, algal pigments, and pollen record the limnological transition during the last two centuries from relatively clear, low nutrient water to that of high turbidity and high nutrient water. The most notable change took place during the nineteenth century coincident with the deforestation. Carbon-14 dates indicate a much higher rate of deposition during the deforestation period (Seiche, 1987; Kingston, 1987).

The change in forest cover from a predominantly mature boreal forest to open land and mixed hardwood/conifer forest increased runoff rates in many of the western Lake Superior watersheds. The greater energy of elevated peak flows during flood sequences accelerated the rate of geologic erosion along streams. The numerous high red clay banks that presently dominate many areas along the rivers represent evidence of accelerated geologic erosion (McCawley, USDA SCS, pers. comm.).

4) Sand Bedloading

Sand bedloading of stream channels and the St. Louis estuary is thought to be presently occurring at an accelerated rate as compared to what would have naturally occurred under the boreal forest condition of the Lake Basin in the 1800's. The possible sources of this sand have implications for watershed management.

One source may be the sand that occurs in the surface clay soils. The red clay soils of the area typically contain 20-30% sand (Goerg, USDA SCS, pers. comm.). Down cutting of upland drainages and slumping along main river channels may be releasing the sands from these clayey soils and introducing it into the streams.

A second source of sand may be the Copper Falls till layer that underlies the clayey Miller Creek Till. It is possible that portions of some of the streams in the west end of the Lake Superior Basin have cut through the Miller Creek Till layer and are flowing thought the sandy Copper Falls Till. Streams flowing through the Copper Falls Till would have an available source of sand adjacent to the stream channels. This sandy till is a loosely bonded matrix that could be very susceptible to cutting by meandering stream action. Also, because it is overlain by the clay till of the Miller Creek Formation the cut banks retain a steep unstable slope profile because the clay acts as a "cap." This clay cap can withstand a large amount of undercutting before the resilient strength of the clay succumbs to gravity, resulting in mass wasting (slumping). This may explain some of the extreme steep "slump banks" that are visible along these streams. Land use practices that cause excessive runoff and create more frequent flooding of streams could be accelerating the undercutting of the banks by wearing away the sandy toes of the clay banks leading to increased slumping. This would prevent stabilization. The rate of streamflow and streambank erosion is affected by land use practices and cover type above these slopes. Under the scenario of a stream cutting through the sand layer beneath the red clay, the prospect of mechanical stabilization of these banks becomes very difficult and efforts to alleviate high runoff from the watershed are important.

5) Management on Slopes

Erosion along slopes is particularly responsive to cover type. Aspen covertypes that result in drying and cracking of red clay soils promote erosion because of high transpiration rates. Aspen growth on red clay slopes may exacerbate massive slope failure (Andrews et al., 1980). The Red Clay Project also found that of all vegetation types, climax woody species (such as fir, pine and maple) provide the best erosion control for a combination of the following reasons; stronger root systems, low transpiration rates, and increased interception of rainfall.

Transpiration and interception of moisture by tree crowns influences structural stability and erosion of red clay soils, particularly on slopes along flowing streams and rivers (Andrews et al., 1980). During dry periods, clay soils may dry, shrink, and crack. This is important on the slopes because flowing water will follow cracks and cut into the soil. Decreased structural strength will allow blocks of red clay soil to slide down slope. The magnitude of this drying is reduced under a conifer stand because of the low transpiration rate of the trees and the shading affect of the dense overstory canopies. Under aspen stands, which occupy large areas of the red clay slopes, the clay soil surface is dried to extremely low levels during dry periods. This is due to the ability of aspen and grass, which is often associated as an understory component with the aspen, to transpire large amounts of soil moisture. When this occurs cracks and deep fissures form in the soil surface. These fissures act as avenues for water to infiltrate what would normally be an impermeable clay soil. This moisture causes the clay soil to become plastic, creating zones of rupture in what was once a strongly bonded soil matrix. When this weakened soil condition occurs along these waterways where stream action is constantly eroding the "toes" at the base of steep slopes, large blocks of clay are more easily slumped down slope.

An examination of 1939 aerial photography compared to 1990 photography in a portion of the watershed shows that the eroded banks were much larger and in worse condition 40 years ago. Peak flows immediately after the logging and fire era would, as expected, be higher and consequently more damaging to the cut banks in the red clay soil region. As the watershed is re-forested, the hydrology has been changing as well. Many of these eroded banks seem to be slowly healing as judged by aerial photographic records.

b. Agriculture

The northeastern portion of Minnesota and northwestern Wisconsin are not considered to be an intensive agricultural area, however the total acreage of cropland in Carlton County is 66,492, in St. Louis County is 93,438, and in Douglas County is 26,826, which gives a combined total of 186,756 acres.

The main source of nutrients from agricultural operations is animal waste runoff from the livestock and poultry operations and fertilizer runoff. However, there is no information on the relative importance of these sources to nutrient levels in the estuary. The majority of animal wastes are generated from livestock and poultry operations in Douglas County, Wisconsin and Carlton and lower St. Louis Counties in Minnesota. Lower St. Louis County has 69 dairy operations, ninety five percent of which are situated directly on the St. Louis River or its tributaries. Table V.9 below shows the livestock operations in Carlton, Douglas, and St. Louis counties. Table V.10 shows land acreages treated with commercial fertilizers.

Pesticide runoff to surface waters or seepage to ground water is another potential non-point source pollution problem from agricultural activities. Pesticide uses include control of insects, nematodes, and diseases; control of weeds, grasses, or brush in fields; and control of crop growth, thinning of fruit, and defoliation of areas. The acreage in Carlton, Douglas, and St. Louis counties where agricultural chemicals were applied in 1987 is listed in Table V.10.

Table V.9 Total Number of Farms and Acreage in the Three Counties in the Area of Concern

		Carlton County, MN	**Douglas County, WI**	**St. Louis County, MN**
Cattle	Farms	411	195	506
	Acres	14,010	8382	14,659
Hogs & Pigs	Farms	27	15	49
	Acres	470	249	4733
Poultry	Farms	57	34	49
	Acres	720	NA	1386
Sheep & Lambs	Farms	17	17	92
	Acres	489	321	1324

Source: U.S. Department of Agriculture, 1991.

Table V.10 Agricultural Chemical Use in Area of Concern (Acreage chemical applied to)

Chemical Use	Carlton County, MN	Douglas County, WI	St. Louis County, MN
Fertilizers	9,603	4,994	14,738
Insect, nematode, disease, and weed control	4,531	1,800	6,393
Defoliation and crop control	104	-	90

Source: U.S. Department of Agriculture, 1991.

c. Other Land Uses

In addition to agriculture, pesticides are used for a variety of purposes. Some of the uses are listed below.

1) lawn and garden use by homeowners
2) pest management on golf courses
3) maintenance of rights-of-way (roads, pipelines, transmission lines, and railroad tracks)
4) preparation for forest replanting
5) pest control at grain handling facilities

Table V.11 lists the more commonly used pesticides in the AOC. The most commonly used pesticide is Glyphosate, known by its trade name, Roundup. There is no information on the amount of pesticides used in the AOC for the five purposes listed previously. In addition, there is no information on the impacts of these pesticides on aquatic life.

Table V.11 Commonly Used Pesticides in the Area of Concern

Pesticide	Trade Name
Atrazine	AAtrex, Atratol
Cyanazine	Bladex
EPTC	Eptam, Eradicane
Glyphosate	Accord, Roundup, Lorox, Ranger
2,4-D Sol Amine	Weeder

Table V.11 cont. Commonly Used Pesticides in the Area of Concern	
Insecticide	**Trade Name**
Aldicarb	Temik
Diazinon	DZN, Knox-Out
Malathion	Cynthion
Sevin	Sevin
Fungicide	**Trade Name**
Benelate	Benelate
Captan	Captan

Source: University of Minnesota Extension, 1991

2. Stormwater Discharge

a. Effects of Land Use on Stormwater Runoff

Stormwater discharge from urban areas like Duluth and Superior can be a source of pollutants to water bodies. As areas develop and the land surface is paved and covered, surface runoff from storms increases, since the water can no longer percolate into the ground. Many of the natural depressions that historically stored stormwater are filled in and leveled, thus stormwater storage is eliminated and all runoff is directed straight into sewers and/or water bodies. The end result of altering the natural drainage patterns is that peak rates and volume of runoff increase.

Stormwater picks up pollutants as it runs off parking lots, streets, and sidewalks. The Nationwide Urban Runoff Program, which studied urban runoff on a large scale throughout the United States, found that urban runoff can contain sediment, nutrients, trace metals, oxygen-demanding substances, toxic chemicals, bacteria, hydrocarbons, and chloride (U.S. EPA, 1983). Table V.12 lists urban sources for these pollutants (MPCA, 1989).

The quality of stormwater depends on the activities and land uses in the watershed. The U.S. EPA found that for the most part, mean pollutant concentrations were higher in residential areas than in open/non-urban areas. Table V.13 lists some mean pollutant concentrations for residential and open areas (MPCA, 1989).

Water quality data from nineteen Minneapolis-St. Paul monitoring sites was collected in Minnesota in 1982 by the U.S. Geological Survey and the Metropolitan Council. This data shows extreme variations in water quality according to land use practices within four watersheds. The data represent pollutant concentrations for an area with minimal development (Elm Creek), a residential area under development (Iverson Avenue), a medium to high density residential area in a stabilized watershed (Yates Avenue), and a light industrial area(Sandburg Road). Table V.14 shows the flow-weighted pollutant concentrations and ranges for the different types of watersheds.

Table V.12 Urban Sources for Pollutants

Pollutant	Source
Sediment	Runoff from construction sites Streambank erosion due to increased peak rates and volumes of runoff due to urbanization Application of road sand
Nutrients (phosphorus, nitrogen)	Organic matter - lawn clippings, leaves Improper/excessive use of fertilizers Application of road sand and salt
Trace metals (lead, zinc, copper, chromium, cadmium, nickel)	Automobile emissions Galvanizing and chrome plating Application of road sand and salt
Oxygen-demanding substances (BOD, COD)	Pet wastes Street litter Organic matter
Toxic chemicals	Not normally found
Bacteria	Pet and other animal wastes
Hydrocarbons (e.g. oil, gas)	Spillage at oil storage and fueling facilities Leakage from crankcases Improper disposal of drain oil
Chloride	Application of road salt Stockpiles of sand and sand-salt mixtures

Table V.13 Mean Pollutant Concentrations for Residential and Open Areas

	Residential (mg/l)	Open Areas (mg/l)
Chemical Oxygen Demand (COD)	83	51
Total Suspended Solids (TSS)	140	216
Lead	0.18	0.054
Zinc	0.18	0.23
Total Kjeldahl Nitrogen (TKN)	2.35	1.36
Nitrate/Nitrogen (N/N)	0.96	0.73
Total Phosphorous (P)	0.46	0.23
Soluble Phosphorous	0.16	0.06

Table V.14 Flow-Weighted Mean Pollutant Concentrations and Ranges for Various Land Uses (Based on 1982 Monitoring of Minneapolis/St. Paul Waters) (mg/l)

	Monitoring Site[1]			
Pollutant	Elm Creek (Minimal Development)	Iverson Avenue (Residential-Under Construction)	Yates Avenue (Residential-Stabilized Area)	Sandburg Road (Light Industrial)
COD	65 (45-157)	38 (1-697)	90 (24-879)	138 (10-850)
TSS	10 (2-374)	740 (17-26,610)	133 (2-758)	10 (2-374)
Lead	0.005 (0.001-0.012)	0.02 (0.008-0.31)	0.23 (0.015-1.8)	0.19 (0.003-1.5)
Zinc	0.012 (0.005-0.019)	0.235 (0.028-0.53)	0.198 (0.02-2.2)	0.185 (0.02-0.81)
TKN	2.1 (1.2-5.4)	1.2 (1.0-29.2)	3.6 (0.6-28.6)	25 (0.4-16.0)
N/N	0.27 (0.05-1.35)	0.07 (0.05-2.45)	0.79 (0.05-2.45)	0.42 (0.05-2.4)
Total P	0.35 (0.11-2.23)	0.62 (0.2-13.1)	0.63 (0.10-3.85)	0.63 (0.07-4.3)

[1] Elm Creek - minimal development, relatively open, less than 25% farmed, 14.3 mi^2 watershed
Iverson Avenue - residential area under construction, 0.15 mi^2 watershed
Yates Avenue - medium to high density residential, stabilized watershed, 0.35 mi^2 watershed
Sandburg Road - light industrial, 0.12 mi^2 watershed

Source: MPCA, 1989

b. Duluth/Superior Stormwater Discharge

The City of Duluth has separate sanitary and stormwater sewer systems. For the most part, natural creeks and ditches are used as main trunk lines to conduct stormwater from collection points to Lake Superior or the St. Louis Bay. Smaller trunk sewers and laterals feed stormwater from city streets into these creeks and ditches (U.S. Army COE, 1974). Due to the steep topography in much of the city, stormwater retention or detention facilities have not been feasible. However, retention ponds are now required when new development will increase the rate of stormwater flow to the system (H. Berg, Duluth Public Works Dept., pers. comm.). Since much of the new development has occurred over the hill, retention/detention ponds have been built in these areas.

In 1973, the U.S. Army Corps of Engineers (1974) conducted a study of stormwater quality in Duluth. Six sampling and gaging stations were established on five area creeks (Mission, Kingsbury, Miller, Brewery, and Amity) which transport stormwater directly to Lake Superior and St. Louis Bay. Samples and flow measurements were obtained for eight precipitation events from March through October. Class 2A water quality standards for fisheries and recreation were consistently exceeded for turbidity, color, nitrogen as ammonia, and oil and grease. Fecal coliform and chlorides standards were exceeded less often. The study found the highest degree of pollution in streams draining older, more highly developed areas of the city while streams in the extreme west and east portions of the city had the lowest pollution levels. Due to leaky sewer lines near the creeks, it could not be determined whether the creek water quality was representative of urban runoff, sanitary water, or a combination of the two. In 1974 the WLSSD began monitoring 31 creeks in the Duluth area to locate and remediate sources of contamination to the creeks. This effort was discontinued several years ago due to a lack of staffing (J. Stepun, WLSSD, pers. comm.).

The City of Superior underwent a sewer separation project in the 1970's. Sanitary and stormwater sewer systems are now separate except in district #5 which covers South Superior, district #6 which covers Billings Park, and district #2 which covers the downtown. In these unseparated districts the city has holding ponds which store combined sewer overflows during storm events. This water is either treated on-site using the dissolved air flotation method or it is pumped to the main treatment plant and treated before it is discharged. However, two of the three overflow treatment facilities were recently found to be inoperable. Untreated sewage has been discharged into the Nemadji River, St. Louis Bay, Superior Bay, and Bluff Creek. The stormwater in the separated districts is collected and discharged directly into creeks or the bay. Retention or detention facilities are not used. During large storm events the sewer system has experienced infiltration and inflow problems. In the separated districts the infiltration/inflow has resulted in sanitary sewer back-ups into basements of private homes. The city is attempting to determine the source(s) of the infiltration/inflow problem (S. Banz, City of Superior, pers. comm.).

c. Construction Site Erosion

Construction site generated sediment in runoff is a documented problem in the AOC. Elevated levels of total suspended solids in runoff water leaving construction sites result from erosion generated sediment. Construction activities include work on rough grading, utility installation, road construction and improvement as well as residential, industrial, and recreational land development. In 1989, one storm event caused sheet and rill erosion losses exceeding 100 tons/acre on the Duluth-Enger Golf Course expansion project (SCS, 1989). The U.S. EPA has recognized that sediment loss from construction sites commonly exceeds 30 tons/acre/year, many times that of the national average sediment loss from agricultural land. The sediment delivery rate from Duluth construction sites to the St. Louis River, St. Louis Bay, and Lake Superior often reaches 100% due to the extremely steep topography and resultant high velocities attained by runoff water. That is, the sediment picked up by runoff from the construction site does not settle out of the water until it reaches the river, bay, or lake. Due to the flat terrain in Superior, the sediment delivery rates in that city are likely lower.

3. Unsewered Communities

Two municipalities located on the lower St. Louis River are not served by wastewater treatment plants. These unsewered communities, their populations, and number of housing units are listed below.

Fond du Lac, MN: population 315, 128 housing units
Oliver, WI: population 265, 102 housing units

Area soils make it difficult for septic systems to function properly. Failing septic systems can contribute nutrients and bacteria to the river system. It is unlikely that these unsewered communities significantly affect overall water quality of the lower river, however, localized problems with bacteria could occur. Neither the St. Louis or Douglas County health departments indicated a problem level of failing septic systems or health concerns from wastewater disposal in these communities.

4. Marine Recreational/Commercial Activity

The St. Louis River estuary includes the Duluth-Superior Harbor, which is a heavily used commercial port. The estuary is also heavily used by recreational boaters. Commercial and recreational vessels can be sources of treated and untreated wastewater which can contribute nutrients, bacteria, and oily waste to the harbor and estuary. Discharges from these sources are of concern relative to excessive nutrient loading, aesthetic impairment of the water (oil and other unsightly waste), and impairment of full or partial body contact recreational uses. The importance of these sources to overall loading of nutrients and bacteria to the estuary are not known. This section explores what is known about the potential for discharges from commercial and recreational vessels to be significant sources of pollutants to the harbor and estuary.

The importance of watercraft discharges to nutrient loading is not known. Wastewater discharges from commercial and recreational vessels may be a significant source of bacteria to the estuary. There has been little recent monitoring of the estuary for fecal coliform levels. The harbor has become increasingly popular for body contact recreation such as swimming, sailboarding, kayaking, and rowing. A mid 1980s survey of Barkers Island beach areas showed low fecal coliform counts, well below 200 mpn/100 ml(S. Banz, City of Superior, unpublished data). Occasional violations of fecal coliform standards are reported at the Superior and Cloquet water intake in Lake Superior that are associated with periods of turbulence and storm activity.

Wastewater discharges from boats are classified as personal waste which consists primarily of sewage ("black water") and "gray water" which is composed of galley and washwater. Bilge water is considered operational wastewater and is associated with the vessel's mode of propulsion (IJC, 1977). Estimating the quantity of these wastewater discharges is difficult, due to inadequate monitoring of disposal practices. Federal regulations prohibit discharge of sewage or any discharge to navigable waters that causes an oily sheen, sludge or emulsion to the water.

a. Commercial Vessels

The Seaway Port Authority of Duluth ship traffic reports for 1989 and 1990 showed that 1,293 and 1,318 vessels, respectively, entered the Duluth-Superior harbor. Of the total, 217 were ocean-going vessels and 2,394 were lakers. Most of the 1,318 vessels that entered the harbor in 1990 were vessels making repeat trips. Staff at the Corps of Engineers Marine Museum estimate that approximately 60 different ocean vessels and 65 different lakers entered the harbor in 1990.

Discharge of treated sanitary waste by commercial vessels is allowed in the Duluth-Superior harbor and in western Lake Superior. Wisconsin had applied to the U.S. EPA to designate the Wisconsin portion of Lake Superior as a "no-discharge zone" but this request was denied.

Under federal regulations (33 CFR Part 159), commercial vessels are required to use one of the following three marine sanitation devices:

Type I- Produces an effluent having a fecal coliform bacteria count <u>less than or equal to</u> 1000 mpn/100 ml and no visible floating solids.

Type II- Produces an effluent having a fecal coliform bacteria count <u>less than or equal to</u> 200 mpn/100 ml and suspended solids <u>less than or equal to</u> 150 mg/l.

Type III- Designed to prevent the overboard discharge of treated or untreated sewage or any waste derived from sewage.

Vessels greater than 65 feet in length must use a Type II or Type III marine sanitation device unless a Type I device was installed on the vessel prior to January 31, 1978 and the device is still operable (33 CFR 159.7). The majority of lakers have Type II marine sanitation devices (K. Alway, U.S. Coast Guard, pers. comm.). That is, the vessels treat the sanitary waste and discharge the effluent into a waterbody.

Ocean-going vessels can have any type of marine sanitation device so long as they do not discharge untreated waste into navigable waters of the U.S. These vessels may utilize a holding tank when operating in the U.S. waters or they may treat the waste and discharge it into a waterbody (J. Amson, U.S. EPA, pers. comm.).

While Type I and II sanitation devices are designed to meet specific effluent limits, it is questionable whether these devices perform up to standard. A 1980-81 Coast Guard survey of marine sanitation device discharges from 99 ships in the Duluth-Superior harbor showed that the discharges from 51% of the ships exceeded the 200 mpn/ml limit. The average fecal coliform value was 2788 mpn/100 ml. These results are consistent with the levels found by the Canadian government in the mid 1980's. Another study of waste treatment effectiveness was conducted in the 9th Coast Guard District at Cleveland, Ohio. The Type II sanitation device discharges from between 700 to 1000 commercial vessels were examined for fecal coliform and suspended solids. Approximately 75% of the vessels had fecal coliform levels greater than 200 mpn/100 ml: 50% of the vessels had fecal coliform levels of 3000 to 7000 mpn/100 ml and 25% had coliform levels higher than 7000 mpn/100 ml. The study concluded that the marine sanitation devices were not serviced regularly and thus were not effectively treating the waste (J. Amson, U.S. EPA, pers. comm.).

Degradation of water quality in the Duluth-Superior harbor can occur if 1) ships with Type I marine sanitation devices discharge into the water or 2) if ships with poorly operating Type II marine sanitation devices discharge into the water. It is unlikely that ships on the Great Lakes would still have operable Type I devices. However, most of the lakers and possibly the ocean-going vessels use Type II devices. Past studies have shown that lack of servicing has led to marine sanitation devices that provide only minimal treatment of sanitary waste. It is possible that half of the ships using Type II devices are discharging wastewater that exceeds the fecal coliform limit. Based on a design estimate of 30 gallons of sanitary water/person/day and a 13-person crew, a ship will discharge about 400 gallons of treated wastewater per day (J. Amson, U.S. EPA, pers. comm.).

Because of the magnitude of marine traffic, ships may be a significant source of wastewater discharged to the Duluth-Superior Harbor. An estimate of wastewater discharge volume can be made based on conservative assumptions. In 1989-1990, there were an average of 1197 visits by lakers to the harbor per shipping season. For this estimate, it was assumed that the duration per visit was one day, although many lakers may remain in the harbor for a longer period of time. Assuming all of these lakers are equipped with Type II wastewater treatment devices, one can estimate that 0.48 million gallons of treated wastewater is discharged from lake vessels into the harbor per year.

Gray water from galley and wash facilities is discharged directly into the lake or harbor. Approximately 90 to 120 gallons of gray water are produced per person per day. With a 13-person crew a ship will discharge around 1200 to 1500 gallons of gray water per day. The three major constituents of gray water are soaps, oils and greases, and fecal coliform. To reduce oils and greases, galleys must contain grease traps that remove the majority of oils and greases. Fecal coliform levels should be fairly low (J. Amson, U.S. EPA, pers. comm.). Using the same assumptions as stated in the previous paragraph, and assuming 1200 gallons of gray water per ship per day, it can be estimated that 1.4 million gallons of gray water per shipping season is discharged from lake vessels into the harbor.

Bilge water disposal is dependent on the type of commercial vessel. The majority of ocean-going vessels have oily water separators and holding tanks. Bilge water is run through the separators and then discharged into the waterbody. An oil sensor monitors the discharge and an alarm sounds if oil is detected. The oil that is removed from the bilge water is stored in a holding tank until it can be pumped out into tank truck on land. The bilge water in the tank trucks is taken to a treatment/disposal site. OSI Environmental, a company located in Virginia, Minnesota, offers this kind of service for ships. In the 1990 shipping season, they serviced 14 ships in the Great Lakes Fleet (S. Hendrickson, OSI, pers. comm.). They treat the water first if it contains oil and then dispose of the water at the WLSSD facility (J. Stepun, WLSSD, pers. comm.). An estimated 100 to 300 gallons of bilge water containing 2 to 3 gallons of oil can be produced by a ship in one day (J. Sharrow, Great Lakes Fleet, Duluth, pers. comm.).

Bilge water disposal from commercial vessels has apparently changed within the last years due to requirements of the Clean Water Act. Indications from local, state, and federal agencies reveal that the majority of commercial vessels are complying with the federal law that prohibits the discharge of oil (e.g. bilge water) into the Great Lakes which are a zero discharge area for oil. However, occasional accidental discharges of 5 to 10 gallons of oil have occurred (J. Sharrow, Great Lakes Fleet, Duluth, pers. comm.). Any oily sheen in the water would constitute a reportable quantity and would have to be reported to the U.S. Coast Guard National Response Center.

b. Recreational Vessels

Currently, there are four major marinas (Spirit Lake Marine, Inc., Harbor Cove Marina, Lakehead Boat Basin, and Barker's Island Marina) located within the Duluth-Superior port and St. Louis Bay (G. Kreag, MN Sea Grant, pers. comm.). There are approximately 724 seasonal and 35 transient boat slips available at the marinas. A 1984 study of Western Lake Superior Marinas showed that percent occupancy within the Duluth-Superior marinas was 90% during full season, while transient slip percent occupancy was 43% on week days and 63% on week-end days. The majority of motorboats housed at these facilities were 16-39 feet, while the same held true for sailboats (Dawson and Plass, 1985). Craft that were approximately 26 feet and larger were most likely to contain holding tanks, thus utilizing pumpout facilities. Three of the marinas have pumpout facilities for "black water" disposal, while boats from the Harbor Cove Marina utilize pumpout facilities at Lakehead Boat Basin.

There are two other areas within the Duluth/Superior port that have docking facilities for recreational crafts. One facility is located at the Minnesota (Meierhoff) Slip and is used by charter captains and the Duluth Yacht Club. The other facility is located on Park Point and houses approximately seventeen 30-40 foot motorboats. This facility is privately owned and includes pumpout services.

Discussion with the marina owners and staff revealed that the majority of watercraft owners utilize the pumpout facilities for "black water" disposal. However "gray water" and bilge waters are pumped directly into the bay or lake. Conscientious boaters might pump their oily bilge water into barrels, allowing the oil and water to separate before pumping the water into the lake. Oil absorbent rags might also be used in separating the oil from the bilge water (J. Radtke, Barkers Island Marina, pers. comm.). The Coast Guard investigates all reports of sheens, sludges or emulsions, thus they would respond to an oil sheen in a marina caused by improper bilge water disposed. Based on the low number of reported spills and the high probability of a spill in a marina being reported, the Coast Guard believes that oily bilge water is not routinely discharged from recreational watercraft (C. Fust, U.S. Coast Guard, pers. comm.). By and large, wastewater discharges from recreational watercraft are not monitored and therefore the impacts of improper disposal are difficult to ascertain.

c. Ballast

Currently, the United States and Canada have agreed to a voluntary exchange of ballast water before entering the St. Lawrence Seaway. The Canadians, along with St. Lawrence Seaway Commission staff, are boarding the ships at the first lock and requesting the ships' captains to fill out a form certifying that their ballast water was exchanged prior to entry into the Seaway. This method of ballast water exchange has about a 90% compliance rate. The 10% non-compliance rate is high when you consider that the ballast water from just one ship is enough to provide a founding population for some exotics. The standards for ballast water exchange are printed in the March 15, 1991 Federal Register.

5. Spills

Spills in the St. Louis River estuary, Lake Superior, and throughout the St. Louis River system may pose a threat to water quality and biota. Many of the spills documented in the area have not occurred directly to waterways, but may indirectly contribute contaminants to the aquatic system through movements of contaminated groundwater and surface runoff. At this time, it is not possible to quantify contaminant loading to the aquatic environment from spills.

A spill in the St. Louis River or harbor would be subject to the reversing river flows and the oscillations of water in the harbor due to the Lake Superior seiches. A U.S. EPA study (1980) determined that a momentary spill of a dissolved pollutant near the Midwest Energy coal docks in Superior would reach areas of the harbor extending from the Burlington Northern Railway Bridge, which is 2.5 km upriver from the coal dock, to the lake outlets. If the pollutant was uniformly distributed throughout the channel adjacent to the coal dock, it would take from 8 to 21 days for the pollutant to reach Lake Superior at a peak concentration. A peak concentration is defined as a concentration that is from 0.05% to 0.1% of the initial concentration in the loading channel. At 0.1% concentration level, the spill would extend over 30% of the harbor and would remain at this concentration for 30-40 days.

Appendix J is a listing of the spills documented by the MPCA and WDNR in the last ten years in the St. Louis River watershed. A total of 375 spills were reported in Minnesota and 96 were reported in Wisconsin. The most common types of spills in the Twin Ports have been spills of petroleum products, sewage and industrial wastewater. The quantities vary from a few pints to millions of gallons depending on the material and the type of spill. The WLSSD facility in Duluth was the most frequently reported facility, with 16% of the reported spills in Minnesota. These spills of wastewater and sewage were attributed to causes which included overflow during storm events, sewer main breaks, and pump failures. The primary type of spill reported in the Superior area is petroleum products. Spills at the Murphy Oil facility accounted for 46% of the reported spills in Wisconsin. Above-ground tank failures, valve failures, overflows, and leaking lines have all been cited frequently in the spill reports as causes of petroleum product releases. In the last ten years, spills and dumping of PCBs have been documented in the upstream portions of the watershed on the Iron Range, in Cloquet, and in Duluth and Superior.

The United States Coast Guard and the two state agencies, MPCA and WDNR, are responsible for spill remediation. The U.S. Coast Guard based in the Twin Ports has the responsibility for navigable water for the entire Port, including the St. Louis River to the Fond Du Lac dam, and for Lake Superior from the Twin Ports to the Canadian Border and to the Keweenaw Peninsula in Michigan on the south shore. The Coast Guard has a contingency plan for handling spills, which can involve utilization of the Atlantic Strike Team based in the State of Virginia. Responsibility for other waters and land in the watershed rests with MPCA in Minnesota and WDNR in Wisconsin.

6. Atmospheric Deposition

Atmospheric deposition is considered to play a major role in the delivery of pollutants/toxics to the Great Lakes. Due to the lake's large surface area and relative paucity of inputs, Lake Superior is especially influenced by atmospheric loads as compared to the other Great Lakes.

In 1974, studies of the accumulation of selected persistent organic residues in fish species of Lake Superior indicated increased levels of PCBs and toxaphene in the flesh of fish taken from Siskiwit Lake on Isle Royale. Since this lake is remote from inhabited areas and has no local source of PCBs or toxaphene, the results of the study were unexpected. Further research showed atmospheric deposition as the source of the organic compounds. In addition, since toxaphene was primarily used for agricultural purposes in the southern U.S., the presence of toxaphene in Siskiwit Lake fish indicated that chemicals are transported long distances through the atmosphere to the Great Lakes basin (Arimoto, 1989).

Since the research at Siskiwit Lake in the early 1970's, considerable work has been done on long-range transport of atmospheric contaminant loads to the Great Lakes. In northern Minnesota most air pollution arrives via long-range transport from urban areas to the south, notably the lower Ohio River Valley and St. Louis, Missouri region, and as far away as the Texas/Louisiana oil fields and chemical plants. These contaminant loads can be highly episodic, e.g., when an extension of the North Atlantic Subtropical High (the Bermuda High) generates a northward airflow throughout the central U.S. which is usually quite stable and therefore highly contaminated.

Clearly, long-range transport is important to atmospheric inputs to Lake Superior. The magnitude of atmospheric inputs to the St. Louis River, via long-range transport or from local sources is largely unknown. With the exception of Glass' et al. (1990) work on mercury, there has been no study of the relative importance of contaminant loading from atmospheric sources to the St. Louis River system.

Atmospheric sources within the Area of Concern could contribute contaminants to the St. Louis River and to Lake Superior. The Duluth-Superior area is susceptible to low-level inversions which trap air in the harbor region. The stable lake air and the topography of the region are factors which periodically prohibit mixing in low-wind regimes.

Within the St. Louis River watershed there are a total of 63 facilities which have state regulated discharges to the atmosphere of total suspended particulates, lead, carbon monoxide, sulfur dioxide, nitrogen oxides, and/or total volatile organic chemicals. These facilities include a petroleum refinery, paper mills, forest products plants, iron mining and taconite production facilities, grain elevators, coal transfer facilities, a regional treatment plant, and other miscellaneous industries.

Some of these facilities emit toxic chemicals into the atmosphere. Under Section 313 of the Superfund

Amendments and Reauthorization Act (SARA), manufacturing facilities which produce or use certain toxic chemicals in excess of specified amounts, must annually submit reports on the amounts of these chemicals released to the environment. Tables V.15 and V.16 list stack air and fugitive air emissions of toxic substances that facilities must report under SARA reporting requirements. Stack air emissions are measured within a smoke stack; fugitive air emissions are measured on-site, but outside of the smoke stack. An estimated 712,000 pounds of toxic emissions were reported from Minnesota and Wisconsin facilities within the St. Louis River watershed. Appendix K lists the facilities and their estimated emissions.

Table V.15 1989 Estimated Emissions: MN Portion of AOC

	Fugitive Air (lbs)	Stack Air (lbs)
Aluminum oxide (fibrous)	1040	250
Ammonia	21,000	-
Chlorine dioxide	250	19,000
Chromium and compounds	500	250
Copper and compounds	250	750
Formaldehyde	250	500
Hydrochloric acid	-	180,000
Maleic anhydride	-	3
Manganese and compounds	250	250
Methanol	20,000	130,000
Phenol	-	250
Sulfuric acid	-	19,000
1,1,1 - Trichloroethane	96,200	-
TOTAL EMISSIONS	139,740	350,253

Source: MN Dept. of Public Safety, 1990.

Table V.16 1989 Estimated Emissions: WI Portion of AOC

	Fugitive Air (lbs)	Stack Air (lbs)
Aluminum oxide	-	37,400
Anthracene	20	20
Benzene	2,550	1,190
Cumene	-	250
Cyclohexane	2,090	400
Dibenzofuran	30	40
Ethylbenzene	1,700	7,800
Ethylene	2,480	1,180
Manganese	250	250
Napthalene	280	550
Propylene	12,560	2,300
Toluene	7,550	20,340
Xylene	5,470	112,300
1,2,4-Trimethylbenzene	-	2,970
TOTAL EMISSIONS	35,000	186,990

Source: WDNR, 1990

a. Mercury

Atmospheric deposition of mercury has been cited as a source of mercury to the St. Louis River estuary. A 1988 study (Glass et al., 1990) of mercury concentrations in rain and snow near Lester Park in eastern Duluth, showed average mercury concentrations of 22 ng/L. The summation of over one year of measurements indicates that approximately 14 μg of total mercury was deposited as wet deposition per square meter of estuary surface area. This precipitation loading rate applied equally over the 4700-hectare surface area of the St. Louis River estuary yields about 660 grams of mercury/year or 1.8 grams of mercury/day.

In addition to the mercury derived from wet deposition directly to the estuary, there is a larger source of mercury from upstream sources (15 grams of mercury/day) that could be from atmospheric deposition. If the upstream source of mercury is assumed to be mostly from atmospheric deposition (wet and dry) then the total input to the estuary from precipitation would be approximately 17 grams of mercury/day. This is a small input compared to the input from the WLSSD wastewater discharge which was estimated to contribute 60 grams of mercury/day and was believed to contribute 66% of the mercury in the St. Louis River estuary (Glass et al., 1990). Since WLSSD has instituted a mercury reduction program, the WLSSD discharge contributes 27.2 grams of mercury/day (See Table VI.3).

The mercury in the atmosphere is from both local and distant sources. Locally dry deposition of mercury from the WLSSD sludge/garbage incinerator has been estimated at 70 to 125 grams of mercury/day; however, this has not been measured. Other urban air emissions can also be a source of mercury to the atmosphere. Estimates from model calculations (particulates only) indicate that 5-7% of total local emissions may be deposited within 50 kilometers of the source through both wet and dry deposition (Glass et al., 1990).

The Wisconsin DNR (1986) estimated that in 1983 there were 88 pounds of mercury emitted to the atmosphere by local facilities and activities within Douglas County. The following table lists the sources of the mercury emissions and the emissions in pounds:

Minor coal emissions (coal combustion and washing)	1 pound
Oil emissions (oil combustion)	7 pounds
Paint use (mercury used as preservative and mildewcide)	56 pounds
Disposal of electric lamps	5 pounds
Lime Kilns	19 pounds
Total	88 pounds

Long distance sources of mercury are contributing to the mercury levels seen in the precipitation in the Duluth-Superior region. Studies from Minnesota and surrounding areas show a tripling in sediment concentrations of mercury over the past 150 years. Kemp et al. (1978) showed that mercury concentrations in six Lake Superior cores increased by an average of 2.6 times. Rada et al. (1989) showed an average mercury increase of 2.7 times from analyses of cores from 11 lakes in north-central Wisconsin. Henning et al. (1989) showed an average mercury level increase of 3.4 to 3.9 times for at least 10 cores from 4 lakes in north-east Minnesota. In addition, they concluded that direct atmospheric deposition to the lake surface could account for 60-80% of the measured rate of mercury deposition in the lakes. The consistency of these data suggests that atmospheric deposition of mercury is spatially constant, at least across northern Minnesota, if not for the Upper Midwest (Swain, 1989).

Two mercury deposition studies conducted in 1982-83 (Glass et al., 1986) and in 1987-90 (Glass et al., 1991), calculated air parcel back-trajectories (origins) for precipitation events to determine source areas for airborne mercury. The 1982-83 study examined back-trajectories for a 48-hour period while the 1987-90 study examined back-trajectories for a 72-hour period. The 1982-83 study found that the predominant source regions for the highest airborne mercury concentrations were the northwest and the southwest and the lowest concentrations were from the south, west, and northeast sectors. The 1987-90 study found that possible source regions within 72-hour travel time were located to the south, southeast, and southwest. The Ohio River Valley was consistently noted as a source of mercury to the atmosphere. However, no direct correlation between source direction and levels of mercury in precipitation can be made due to factors such as prior precipitation events that decrease the levels of mercury in the air mass by the time it reaches Duluth.

b. PCBs

It has been estimated by Strachan and Eisenreich (1988) that 90% of the total inputs of PCBs to Lake Superior are attributable to atmospheric deposition. The remaining 10% of the inputs are primarily from tributaries. The rivers that flow into Lake Superior primarily drain nonindustrialized, forested land thus PCB inputs from the tributaries are minimal. The annual PCB budget for Lake Superior is estimated as follows:

Inputs

Atmosphere - wet deposition	312 kg
- dry deposition	236 kg
Tributaries	54 kg
Municipal/industrial	4 kg
Total	606 kg

Outputs

Water-to air transport (vapor)	1900 kg
Sedimentation	246 kg
Outflow	43 kg
Total	2189 kg

It is interesting to note that outputs of PCBs from Lake Superior exceed inputs by a factor of 3.6.

Since the St. Louis River and harbor has much less surface area than Lake Superior, the atmospheric contribution of PCBs is most likely less than that for the lake. Local point and nonpoint discharges to the water probably play a greater role in PCB loading to the system. To date, atmospheric deposition of PCBs to the St. Louis River and harbor has not been quantified. The information on atmospheric deposition of PCBs to Lake Superior is the best information presently available even though it cannot be directly applied to the St. Louis River system.

Total PCB concentrations in air over Lake Superior have been measured at the following levels (Baker & Eisenreich, 1990):

	Average (ng/m^3)	Range (ng/m^3)
1978	1.5	0.9 - 3.5
1979	0.9	0.4 - 1.4
1980	1.0	0.1 - 0.6
1981	0.3	0.1 - 0.6
1983	3.2	1.5 - 5.2
1986	1.2	0.9 - 2.0

These levels are similar to the total background PCB concentration in air over North America which remains relatively constant at approximately 1 ng/m^3.

Despite decreased water column concentrations and decreased estimated PCB loadings to the Great Lakes, atmospheric levels of PCBs over all the lakes have remained relatively constant over the last 10 years at 1 ng/m^3. Recent research by Baker and Eisenreich (1990) has shown that the open waters of Lake Superior are in equilibrium with atmospheric loadings; however, this equilibrium varies with the seasons. Organic chemicals such as PCBs are deposited in the lake through both wet and dry deposition. Precipitation events though, are responsible for intense episodic inputs of PCBs to the lake. During interceding dry periods in the summer, a percent of the PCBs and other organics are volatilized and return to the atmosphere. Thus during the summer, Lake Superior can be a source of organic contaminants to the atmosphere. Indeed, the 1988 estimates of inputs and outputs to the lake show that about 548 kg of PCBs enter the lake annually due to atmospheric deposition and 1900 kg leave the lake due to volatilization.

PCBs can be emitted to the atmosphere through municipal waste combustion, sewage sludge incineration, hospital waste incineration, and waste oil combustion (U.S. EPA, 1988). Locally the WLSSD sludge incinerator is the only permitted facility of this type. While the incinerator has the potential to emit PCBs, it has not been considered a major source of PCBs in the area. If the facility discharges PCBs, they are at concentrations below the detection limit (J. Stepun, WLSSD, pers. comm.). While several of the area hospitals used to incinerate their medical wastes, they have all discontinued this practice in the last several years due to stricter incinerator regulations. There is one permitted used oil burner facility, Superwood Co., within the St. Louis River watershed. In addition to this facility, there are other oil burning facilities which do not require permits. Facilities in Minnesota that produce used oil through their work practices may burn their oil and any oil they receive from do-it-yourselvers. The companies must burn the oil in a space heater that burns at a rate less than or equal to 0.5 million BTU/hour. Companies that fall in this category would include trucking firms and vehicle repair service stations (P. Matuseski, MPCA, pers. comm.).

The source of the PCBs may be distant since PCBs can be transported long distances in the atmosphere. Eisenreich (1987) found that approximately 90 percent of the PCBs were transported as vapor and 10 percent were transported on particulates in the atmosphere. Atmospheric residence times for particulates range from 6 days - 2 weeks for particles > 1 μm and 1-3 years for smaller particles (Strachan and Eisenreich, 1988). Eisenreich (1987) found that the PCBs were sorbed to particles in the 0.1-1.0 μm range, thus some of the PCBs could be from extremely distant emissions.

c. Dioxin

There is little or no information available on atmospheric deposition of dioxin to the St. Louis River system or even Lake Superior.

A 1990 Government of Canada report listed the primary sources of dioxin to the environment as manufacture and use of commercial chemicals, incineration of municipal waste, and pulp and paper mills that use chlorine in their bleaching process. Following is a list of the major chemicals that have been considered sources of dioxin contamination in Canada.

Pentachlorophenol (wood preservative)
Sodium pentachlorophenate and tetrachlorophenate
2,4,5-T (herbicide)
2,4-D (herbicide)
Hexachlorophene (anti-bacterial agent)

The largest atmospheric source of dioxins in Canada is municipal incinerators. Locally, the WLSSD sludge incinerator in Duluth releases an average of 0.12 ng of dioxin per dry standard cubic meter. Due to the use of chlorine in its bleaching process, Potlatch also discharges dioxins to the environment. However, most of the dioxins from Potlatch are discharged in the wastewater that is treated at WLSSD. Potlatch presently discharges 4.48 x 10^{-7} pounds/day of dioxin to WLSSD (MPCA, 1991). While the Potlatch waste is considered a source of dioxins at WLSSD, municipal waste is also considered to be a contributor of dioxins.

The dioxin in the St. Louis River system can also be from distant emissions. Studies have shown that dioxin can travel long distances in the atmosphere. For example, arctic bears, seals, and whales have dioxins in their tissues, yet they are far from any dioxin sources.

VI. POLLUTANT LOADINGS

A. INTRODUCTION

Pollutant loadings from point and nonpoint sources of pollution to the St. Louis River AOC are discussed in this chapter. Most of the information used to calculate pollutant loadings was taken from discharge monitoring reports for point source dischargers in Minnesota and Wisconsin. No estimate of nonpoint loadings were done at this time due to the limited data available and the variety of sources. Nonpoint sources of pollution include runoff from urban areas, construction sites, industrial sites, and agricultural land. The point sources of pollution can be traced to a pipe or outfall from a municipal or industrial facility.

1. Point Sources

There are four major discharges to the St. Louis River AOC of which two are municipal sewage treatment plants and two are industrial facilities. The discharges from these facilities are described in Table VI.1. Loadings are broken down by Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS), and Phosphorous. Average monthly discharge flows are given in million gallons per day (mgd). The tables are based on discharge monitoring reports from 1989 and 1990. These reports list the average monthly discharge loadings and flows that are monitored periodically by each facility.

Total pollutant loadings for conventional pollutants from all point sources are described in Table VI.2. This includes all permitted facilities that monitor for conventional pollutants. Loadings were calculated from monthly averages so the actual loadings could vary significantly in a given period from estimates given in the report. Four of these facilities do not have a continuous discharge throughout the year so the loadings listed are estimated based on the months they actually discharged. Facilities that discharge noncontact cooling water only have not been included in this report.

Pollutant loadings for toxic parameters have been estimated for those parameters where there are sufficient data (Table VI.3). Loadings estimates from point sources were not made for parameters with only one or two samples. Priority pollutant scans for permit reissuance were a major source of these data. In many cases however, there have been only one or two recent tests for a toxic parameter. Past discharge monitoring for heavy metals and most organics has not been done on a continuous basis, consequently an accurate estimate cannot be made at this time for many parameters. The process of permit reissuance is underway for Murphy Oil USA, The City of Superior, and Superior Fiber Products, the three major dischargers on the Wisconsin side of the AOC. These permits will require monitoring for and will limit discharge of many parameters, including bioaccumulating substances.

Mercury is known to be a concern in the discharge from the Western Lake Superior Sanitary District. Elevated concentrations have been found in the water and sediments of the St. Louis River near the discharge from the WLSSD. This discharge is due to mercury removal from the incinerator stack by a wet scrubbing process. The discharge permit for WLSSD was reissued in August 1990 and will require continuous monitoring for a range of toxic parameters.

The WLSSD Regional plant in Duluth was constructed in the late 1970's to treat waste from virtually all the industrial and municipal discharges in the area. Since that time dramatic improvements have occurred in general water quality as a result of BOD and Phosphorus reductions to the river. Concentrations of toxics in the sediments and water column are still at levels of concern leading to fish consumption advisories and the biological effects.

2. Nonpoint Sources

The St. Louis River AOC receives nonpoint pollution from a variety of sources due to the many types of land uses in the watershed. The most obvious source is the red clay erosion from tributaries such as the Nemadji River, Pokegama, Little Pokegama, and Red Rivers. These rivers contribute a seasonally heavy load of sediments to the St. Louis River and Superior Bay causing turbidity and sedimentation. The Red Clay project study conducted in the 1970’s found that a large amount of erosion was due to naturally occurring bank slumpage. However, land use practices in the watersheds can contribute significantly to erosion. In addition to sediment input it was found that nutrients can attach to sediment particles causing excess nutrient loading.

The heavy concentration of industries located adjacent to the River and Bay on both the Wisconsin and Minnesota side contribute a variety of pollutants through storm water runoff. This type of runoff typically contains heavy metals, volatile organic chemicals (VOCs), oil, grease and a variety of organic and inorganic contaminants. Research has shown that shock loadings from stormwater events can have a greater effect than point source discharges. Storm sewers from Duluth and Superior discharge to the St. Louis River contributing the types of contaminants previously mentioned. Pollutant loadings from the Superior combined overflow #2 are described in Table VI.1. This indicates the significance of stormwater runoff in the area.

Table VI.1 Monthly Average Loadings for 1989-1990 from Facilities Discharging to the St. Louis River AOC

Western Lake Superior Sanitary District Effluent - 1989-90 - Average

	Flow (mgd)		*BOD_5(lbs/day)		TSS (lbs/day)		Total Phosphorus (lbs/day)	
Month	Ave.	Max.	Ave.	Max.	Ave.	Max.	Ave.	Max.
January	29.61	33.57	1053	1251	2475	3077	183	380
February	29.64	32.93	1155	1444	2100	2792	178	305
March	35.09	72.49	1406	2820	1906	3915	158	462
April	42.17	77.33	2011	4263	3789	8699	159	717
May	38.24	61.47	1490	2380	2141	5427	164	1343
June	36.12	42.15	1554	2116	2850	4669	193	366
July	32.54	40.61	1501	1974	4702	6954	201	551
August	36.82	76.68	1985	3524	6289	11827	262	889
September	42.37	94.27	1523	3299	6067	20,253	242	1480
October	38.00	55.16	1261	2759	1878	4254	203	390
November	32.99	37.03	996	1317	1514	2606	1397	341
December	30.76	33.12	1009	1239	1187	1665	190	282
Ave.	35.36	54.70	1412	2353	3075	6345	294	626

*Reported as Carbonaceous BOD

Table VI.1 cont. Monthly Average Loadings for 1989-1990 from Facilities Discharging to the St. Louis River AOC

City of Superior Effluent - 1989-1990 - Average

Month	Flow (mgd) Ave.	Flow (mgd) Max.	BOD_5(lbs/day) Ave.	BOD_5(lbs/day) Max.	TSS (lbs/day) Ave.	TSS (lbs/day) Max.	Total Phosphorus (lbs/day) Ave.	Total Phosphorus (lbs/day) Max.
January	3.49	4.20	426	1081	303	791	16	39
February	3.63	4.46	498	1066	256	647	15	42
March	3.96	5.43	629	1399	349	1205	16	38
April	4.03	5.48	525	1481	326	1193	11	40
May	4.12	5.02	658	1466	378	1621	13	44
June	3.58	5.10	669	1504	251	1594	9	40
July	3.61	4.88	695	1820	291	1253	12	37
August	3.74	4.99	478	1230	203	864	10	29
September	4.40	5.23	418	1001	272	618	12	32
October	3.77	4.83	388	1323	226	749	9	31
November	3.45	4.43	549	1394	202	684	9	22
December	2.51	3.21	440	930	134	301	9	26
Ave.	3.68	4.77	531	1308	266	960	12	35

Table VI.1 cont. Monthly Average Loadings for 1989-1990 from Facilities Discharging to the St. Louis River AOC

City of Superior Effluent - Combined Sewer Overflow #2 - 1989-90 - Average

Month	Flow (mgd) Ave.	Flow (mgd) Max.	BOD_5(lbs/day) Ave.	BOD_5(lbs/day) Max.	TSS (lbs/day) Ave.	TSS (lbs/day) Max.	Total Phosphorus (lbs/day) Ave.	Total Phosphorus (lbs/day) Max.
January	4.60		544		822		22	
February	ND	--	--	--	--	--	--	--
March	12.02	18.28	1865	4028	3488	9031	85	232
April	10.76	20.56	1107	3143	1800	4876	48	110
May	9.10	14.78	989	3314	1247	4736	29	63
June	7.67	9.49	748	1019	889	1379	13	20
July	8.28	10.60	424	906	1276	4723	15	21
August	19.08	32.80	3346	11,727	5952	15,628	85	216
September	11.33	42.34	904	3061	1972	9351	51	164
October	13.54	30.10	1119	1866	2998	5204	60	96
November	8.79	--	440	--	807	--	45	--
December	ND	--	--	--	--	--	--	--
Ave.	10.52	18.47	1149	2961	2125	5575	44	94

ND - No Discharge

NOTE: The averages represented in this table are calculated only for the days of actual discharge. These discharges occur intermittently. The averages would be significantly lower if they were calculated as an average daily discharge on a monthly basis which assumes 30 days of discharge per month.

Table VI.1 Cont. Monthly Average Loadings for 1989-1990 from Facilities Discharging to the St. Louis River AOC

Superior Fiber Products Effluent - 1989-1990 Average

	Flow (mgd)		BOD_5 (lbs/day)		TSS (lbs/day)	
Month	Ave.	Max.	Ave.	Max.	Ave.	Max.
January	.667	.714	2633	4386	197	369
February	.667	.712	2836	3786	109	360
March	.697	.734	1880	3038	168	259
April	.677	.733	1980	5764	193	258
May	.657	.742	2161	5225	158	331
June	.668	.697	2760	4327	222	331
July	.685	.750	2545	4547	205	602
August	.697	.745	2320	4166	182	338
September	.680	.740	2441	5114	209	482
October	.688	.741	2531	3792	218	471
November	.665	.735	2755	3905	204	286
December	.665	.721	2843	5389	190	324
Average	.676	.730	2473	4453	188	368

Table VI.1 Cont. Monthly Average Loadings for 1989-1990 from Facilities Discharging to the St. Louis River AOC

Murphy Oil Company Effluent - 1989-1990 Average

	Flow (mgd)		BOD_5 (lbs/day)		TSS (lbs/day)	
Month	Ave.	Max.	Ave.	Max.	Ave.	Max.
January	.302	.424	72	106	25	42
February	.209	.252	64	82	16	29
March	.322	.596	77	128	30	61
April	.376	.896	76	163	29	72
May	.340	.721	61	167	24	57
June	.319	.576	43	90	16	37
July	.280	.520	35	84	18	57
August	.314	.864	36	61	19	55
September	.388	.900	31	74	31	148
October	.313	.632	93	105	23	60
November	.221	.480	69	83	19	30
December	.237	.328	86	97	22	42
Average	.302	.599	62	103	23	58

Table VI.2 Total Annual Loadings of Conventional Pollutants from Point Sources to the St. Louis River AOC for 1989 and 1990

Average Annual Loadings in lbs.

Facility	BOD_5	Total Suspended Solids	Total Phosphorus	Ave. Monthly Discharge (mgd) Flow
Western Lake Superior Sanitary District	515,380	1,122,375	107,310	35.36
City of Superior	193,724	96,937	4,121	3.68
City of Superior CSO) #2	50,468	88,441	1,816	10.52[(1)]
Superior Fiber Products	901,886	72,270	--	.676
Murphy Oil	22,630	8,212	--	.302
Burlington Northern[(1)]	--	953	--	.16[(2)]
Chicago & Northwestern[(2)]	--	395	--	.019[(3)]
Duluth Winnipeg and Pacific	1017	153	--	.006
Village of Superior[(3)]	146	630	--	.279[(4)]

[(1)]This represents the average flow when the facility is actually discharging. Discharge occurred approximately 37 days each year in 1989 and 1990.

[(2)]Burlington Northern discharged in 7 months each year in 1989-90. This represents an average flow for those months.

[(3)]Chicago and Northwestern discharged 8 months each year in 1989-90. This represents an average flow for those months.

[(4)]The Village of Superior operates a fill and draw lagoon system which is usually drained in the spring and fall. Since no discharge occurred in 1989 this represents the average flow of the two drawdowns in 1990 over a 16 day and 28 day period.

Table VI.3 Annual Mass Loadings Estimates - Toxic Substances Point Source Discharges Into the St. Louis River AOC

Facility	Flow mgd	Dates of Samples	Substance	Estimated lbs/yr discharge	Total number samples
Murphy Oil	.285 ave. discharge	2/89 - 9/90	Cr^{+3}	2.8	174
			Cr^{+6}	<0.7	174
			Cu	5.5	25
			Ni	8.5	25
			Zn	30.1	25
			CN	97.2	25
			total phenols	43.8	104 (from 2C application)
			Hg	(0.06)[1]	25 (3 detects)
			PCBs	no data	
			dioxin*	----	*detected in process
			pentachlorophenol	----	1
			NH_3-N	588	174
Superior Fiber	.68 ave. discharge	7/86 - 1988	Hg	1.28	19 (13 detects)
			Zn	255.	32
			Cu	21.7	30 (29 detects)
			PCBs	not detected	1
			dioxin	no data	
			pentachlorophenol	not detected	1
			total phenols	994.	12 (from 2C application-1986)

[1] Hg loading estimate very tenuous, sporadic detections

**Table VI.3 cont. Annual Mass Loadings Estimates - Toxics Substances
Point Source Discharges Into the St. Louis River AOC**

Facility	Flow mgd	Dates of Samples	Substances	Estimated lbs/yr discharge	Total number samples
City of Superior	5 mgd design flow	1990 - 91	Insufficient data to estimate loadings 1990 Priority pollutant scan: 1 set metals data, organics pending		
Burlington Northern	.0645 ave. discharge	4/88-10/89	Cu	0.29	17 (4 detects)
			Zn	0.77	17 (9 detects)
			Cd	not detected	3
			Cr	not detected	3
			Pb	not detected	3
WLSSD	36 mgd av. discharge		Cd	324.85	
			Cr	2555	
			Cu	3452.9	
			Pb	4164.65	
			Hg	21.9	
			Ni	3766.8	
			Se	3682.85	
			Zn	10227.30	
			Acetone	1825	
			2-Butanone	1095	
			Carbon Disulfide	2190	
			2,4-Dimethylphenol	0	
			Phenol	262.8	
			Benzyl Alcohol	365	
			Benzoic Acid	2190	
			2,4,5-Trichlorophenol	365	
			2,4,6-Trichlorophenol	0	
			Bis(2-ethylhexyl) Phthalate	7544.55	
			Butybenzyl Phthlate	0	
			Chloroform	11300.4	

Methylene Chloride	1752
Hepyachlor Epoxide	0
2,3,7,8 TCDD	0.00006205
2,3,7,8 TCDF	0.0000949

Figure VI.1 Biochemical Oxygen Demand Loadings from Major Point Sources

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APPENDIX A.

Acronyms, Abbreviations, and Glossary
of Terms Used in the Document

Appendix A. Acronyms and Abbreviations

AOC - Area of Concern
ARBC - American Revolution Bicentennial Commission
BAT - best available technology
BC - *Bythrotrephes cederstroemi*
BCFs - bio-concentration factors
BOD - biochemical oxygen demand
bw - body weight
CAC - Citizens Advisory Committee
cm - centimeters
COE - (U.S. Army) Corps of Engineers
CSO - combined sewer overflow
DHSS - (Wisconsin) Department of Health and Social Services
EPA - (U.S.) Environmental Protection Agency
FERC - Federal Energy Regulatory Commission
FIFRA - Federal Insecticide, Fungicide, and Rodenticide Act
FDA - (U.S.) Food and Drug Administration
ft - feet
FWPCA - Federal Water Pollution Control Act
g - gram
GLFC - Great Lakes Fisheries Commission
Hg - Mercury
hr - hour
IARC - International Agency for Research on Cancer
IJC - International Joint Commission
kg - kilogram
l - liter
lbs - pounds
LC_{50} - lethal concentration 50%
LSPI - Lake Superior Paper Industries
MBH - Minnesota Board of Health
MDH - Minnesota Department of Health
MDNR - Minnesota Department of Natural Resources
MDOT - Minnesota Department of Transportation
mg - milligram
mgd - million gallons per day
mi - mile
MIC - Metropolitan Interstate Committee
mm - millimeter
MN - Minnesota
MOE - (Canadian) Ministry of the Environment
mpn - most probable number
MPCA - Minnesota Pollution Control Agency
MSBH - Minnesota State Board of Health
ng - nanogram

Appendix A cont. Acronyms and Abbreviations

NPDES - National Pollutant Discharge Elimination System
NPL - National Priorities List
NW - northwest
PAHs - polynuclear aromatic hydrocarbons
PCBs - polychlorinated biphenyls
PCP - pentachlorophenol
pg - picogram
POTW - publicly owned treatment works
ppm - parts per million
RALs - recommended allowable levels/limits
RAP - Remedial Action Plan
RCRA - Resource Conservation and Recovery Act
ROD - Record of Decision
SAIC - Science Applications International Corporation
SQG - Sediment Quality Guidelines
TAC - Technical Advisory Committee
TCDD - 2,3,7,8 tetrachlorodibenzo-p-dioxin
TWCL - tissue water concentration level
ug - microgram
um - micrometer
USDA - U.S. Department of Agriculture
USFWS - U.S. Fish and Wildlife Service
USGS - U.S. Geological Survey
UWS - University of Wisconsin-Superior
VOCs - volatile organic chemicals
WDNR - Wisconsin Department of Natural Resources
WI - Wisconsin
WLSSD - Western Lake Superior Sanitary District
WPCF - Water Pollution Control Federation
yr - year

Appendix A. Glossary of Terms

Area of Concern: A geographic area which fails to meet the objectives of (AOC) the Water Quality Agreement and where such failure has caused or is likely to cause impairment of beneficial use or of the area's ability to support aquatic life (IJC 1989).

Ambient: Refers to the environmental conditions that affect a body or system, but that are not affected by it (Freedman 1989).

Anthropogenic: Occurring because of, or influenced by, the activities of people (Freedman 1989).

Aroclors: A trade name for a family of chlorinated organic chemicals.

Bioaccumulation: A general term describing a process by which chemicals are taken up by aquatic organisms from water directly or through consumption of food containing the chemicals (Rand and Petrocelli 1985).

Biochemical oxygen demand: (BOD) The amount of dissolved oxygen required for the bacterial decomposition of waste in water. The determination is made with an empirical test which measures biochemical degradation, oxidation of inorganic sulfides, ferrous ions, and nitrogen (APHA 1981).

Bioconcentration: A process by which there is a net accumulation of a chemical directly from water into aquatic organisms resulting from simultaneous uptake and elimination (Rand and Petrocelli 1985).

Biodegradation: The process by which biological metabolism, usually microbial, transforms certain toxic chemicals or sewage into other chemicals, either innocuous or toxic (Freedman 1989).

Biomagnification: A result of the processes of bioconcentration and bioaccumulation by which tissue concentrations increase as the chemical passes up two or more trophic levels (Rand and Petrocelli 1985).

Biomonitoring: Use of living organisms as "sensors" in water quality surveillance to detect changes in an effluent or water, and to indicate whether aquatic life may be endangered (Rand and Petrocelli 1985).

Concentration: The quantifiable amount of chemical in the surrounding water, food or sediment (Rand and Petrocelli 1985).

Congener: A chemical of the same family having a different chemical structure.

Appendix A cont. Glossary of Terms

Conservation:	The protection, preservation and careful management of a natural resource (Freedman 1989).
Contaminant:	A substance that causes a deviation from the normal composition of the environment. Contaminants are not classified as pollutants unless they have some detrimental effect (Manahan 1984).
Conventional pollutant:	Pollutants which have been measured as indicators of water quality, e.g. fecal coliform, pH, biological oxygen demand (BOD) and suspended solids (Findley and Farber 1988).
Criteria:	An estimate of the concentration of a chemical or other (water quality):constituent in water which if not exceeded, will protect an organism, an organism community, or a prescribed use or quality with an adequate degree of safety (Rand and Petrocelli 1985).
Critical pollutant:	Substances which persist at levels that, singly or in synergistic or additive combination, are causing, or are likely to cause, impairment of beneficial uses despite past application of regulatory controls. These substances are present in open water, and are either a recognized threat to human health or aquatic life, or bioaccumulate (IJC 1987). The International Joint Commission has identified eleven toxic chemicals in this category. These chemicals include dioxins and furans, benzo(a)pyrene, DDT, dieldrin, HCB, alkylated lead, mirex, mercury, PCBs and toxaphene.
CSO (combined) sewer overflow):	Overflow of untreated water from a treatment plant/outfall during heavy storm events due to the fact that the sanitary sewers and storm sewers are connected.
Ecosystem:	A system of interacting components, physical and biological (including humans), having some degree of internal linkage and some implied boundary (NRC 1985).
Ecosystem approach:	The philosophy embodied by the 1978 Water Quality Agreement which incorporates the "interacting components ... within the drainage basin of the St. Lawrence River ... to restore and maintain the chemical, physical, and biological integrity of the Great Lakes Basin ecosystem." (NRC 1985).
Enrichment:	Enhancement of the rate of supply of nutrients to a system causing an increase in productivity (Freedman 1989).
Environment:	The complex of all biotic and abiotic influences on an organism or group of organisms (Freedman 1989).

Eutrophic:	A descriptor of a water body that has high nutrient levels.
Eutrophication:	The process of stimulation of biological production by increase of plant nutrient input either naturally or from agricultural, municipal, or industrial sources (NRC 1985).
Graywacke:	A conglomerate rock consisting of rounded pebbles and sand firmly unified.
Groundwater:	Water occurring below the soil surface and that is held in the soil itself or in an aquifer (Freedman 1989).
Half-life:	Time required to reduce by one-half the concentration of a chemical in a medium (e.g., soil or water) or organism (e.g., fish tissue) by transport, degradation, transformation, or depuration (Rand and Petrocelli 1985).
Harmful quantity:	Any quantity of a substance that if discharged into a receiving water would be inconsistent with the achievement of Water Quality Objectives (IJC 1989).
Hazard:	Likelihood that a chemical will cause an injury or adverse effect under the conditions of its production, use, or disposal (Rand and Petrocelli 1985).
In-place pollutant:	Sediment associated contaminants which have the potential to contaminate or act as a pollutant source to overlying water (NRC 1985).
Leaching:	The process by which dissolved substances are removed by a percolating water solution (Freedman 1989).
Management:	The care and tending of a natural resource (Freedman 1989).
Mesotrophic:	A descriptor for a water body that has intermediate nutrient levels.
Monitoring:	A process which utilizes a scientifically designed system of continuing standardized measurements and observations and includes the evaluation thereof (IJC 1989). Surveillance undertaken to ensure that previously formulated standards are being met (Cairns 1988).
Natural:	A situation that is not measurably influenced by humans (Freedman 1989).
Non-conventional pollutant:	Chemicals which are neither toxic nor conventional pollutants as classified by the EPA and the Clean Water Act (Findley and Farber 1988).

Appendix A cont. Glossary of Terms

Non-governmental organization:	A public sector organization without direct links to the government (Freedman 1989).
Non-point source:	A land management or land use activity that contributes or may contribute to ground and surface water pollution as a result of runoff, seepage, percolation, or deposition.
Nutrient:	Chemicals that are required for life, e.g., nitrogen, phosphorus, iron, carbon or oxygen (Freedman 1989).
Oligotrophic:	A descriptor for a water body that has low nutrient levels.
Persistence:	The amount of time a chemical remains in the environment in its present form. The IJC (1989) defines persistent chemicals as having a half-life in water of greater than eight weeks.
Persistent toxic substance:	Toxic substances which are resistant to physical, chemical or biological modification or breakdown into less toxic substances (Muldoon and Valiante 1988).
Pesticide:	A substance used to kill unwanted fungi, plants, insects, or animals. This generic term is used to describe fungicides, algicides, herbicides, insecticides, or rodenticides (Rand and Petrocelli 1989).
Point source:	A single point of emission such as a smoke stack or sewage outfall pipe (Freedman 1989).
Pollutant:	A substance present in greater than natural concentration as a result of human activity and having a net detrimental effect upon its environment or upon something of value in that environment (Manahan 1984).
Remedial Action Plan (RAP):	Under the direction of the IJC, a plan which is developed for an Area of Concern. The plan describes the environmental problem, defines impaired uses, evaluates in place and alternative remedial measures, identifies responsible agencies for implementation, evaluates implementation, describes surveillance and monitoring and confirms restoration of uses.
Research:	Includes the development, interpretation, and demonstration of advanced scientific knowledge for the resolution of issues. It does not include monitoring or surveillance of water or air quality (IJC 1989).
Residence time:	The length of time that a quantity of substance remains in an environmental compartment (Freedman 1989).
Residue:	The quantity of a pollutant that remains in a particular environmental compartment (Freedman 1989).

Risk:	A statistical concept defined as the expected frequency of probability of undesirable effects resulting from a specified exposure to known or potential environmental concentrations of a material. Estimates of risk may be expressed in absolute or relative terms. Absolute risk is the excess risk due to exposure. Relative risk is the ratio of risk in the exposed population to the risk in the unexposed population. (Rand and Petrocelli 1985).
Seiche:	A movement back and forth of the water in a lake or other land-locked body of water, varying in duration and resulting in fluctuation of the water level.
Significant:	Refers to the statistical probability that the conclusion which has been reached is correct (e.g., 95% probability or $p < 0.05$ are common expressions of significance) (Freedman 1989).
Standard: (water quality)	The limiting concentration of a chemical which is permitted in an effluent or waterway. Standards are established for regulatory purposes and are determined from a judgement of the criteria involved. The standard is dependent on the use (e.g. potable, agricultural) of the water to be protected. (Rand and Petrocelli 1985).
Stress:	Physical, chemical or biological constraints that limit the potential productivity of the biota (Freedman 1989).
Surface water:	Fresh water occurring free at the surface as in lakes, ponds, rivers, streams (Freedman 1989).
Surveillance:	Includes specific observations and measurements relative to control or management (IJC 1989). A continued program of surveys systematically undertaken to provide a series of observations in time (Cairns 1988).
Survey:	An exercise in which a set of standardized observations is taken from a station(s) within a short period of time to furnish qualitative or quantitative descriptive data (Cairns 1988).
Tolerance:	Refers to the genetically based resistance of an environmental stress or combination of stresses (Freedman 1989).
Toxicity:	The inherent potential or capacity of a material to cause adverse effects in a living organism (Rand and Petrocelli 1985).
Toxic pollutant:	One of 129 specific chemicals listed in the Clean Water Act for which specific treatment, e.g. best available technology, zero discharge; is employed to protect public health with an ample margin of safety or to attain ambient water quality standards (Colborn et al. 1990).

Appendix A cont. Glossary of Terms

Toxicant:	An agent or material capable of producing an adverse response (effect) in a biological system, seriously injuring structure or function or producing death (Rand and Petrocelli 1985).
Undetectable concentration:	Refers to the concentration of a substance that is smaller than the detection limit of the available analytical technology and does not imply a concentration of zero (Freedman, 1989).
Virtual elimination:	The policy embodied by the International Joint Commission which advocates the elimination of all known sources of toxics excepting the possibility of spills and natural occurrences. Virtual elimination is the actualization of the "zero discharge" philosophy (Colborn et al. 1990).
Water quality:	The condition of ambient water as measured by fecal pollution causing bacterial and viral disease and toxic contamination where pollutants include: industrial chemicals such as chlorinated hydrocarbons, heavy metals (cadmium, lead, mercury); municipal and industrial wastes in general (Manahan 1984).
Wisconsin Endangered Species:	Any species whose continued existence as a viable component of this state's wild animal or wild plant is determined by the Department of Natural Resources to be in jeopardy on the basis of scientific evidence (Department of Natural Resources 1989).
Wisconsin Threatened Species:	Any species which appears likely, within the foreseeable future, on the basis of scientific evidence to become endangered (Department of Natural Resources 1989).
Xenobiotic:	A chemical or material not produced in nature and not normally considered a constitutive component of a specified biological system. This term is usually applied to manufactured chemicals (Rand and Petrocelli 1985).
Zero discharge:	A philosophy introduced by the International Joint Commission towards achieving the standards for persistent toxic chemicals in the environment. A ban on the production of a chemical, e.g. DDT, reflects one facet of such a philosophy. Control of secondary emissions, e.g. release of sediment stored toxic chemicals, needs also to be addressed in this philosophy (Colborn et al. 1990).

APPENDIX B

Fish Tissue Data

APPENDIX B

ST. LOUIS RIVER SYSTEM AOC FISH TISSUE DATA
MINNESOTA POLLUTION CONTROL AGNECY

Latitude/Longtitude Location	Anatomy	Sample Size	Weight	Year	Species	MG/KG PCBS	UG/G DDT	MG/KG PCP	MG/KG ARSENIC	MG/KG MERCURY	MG/KG LEAD	PG/G TCCD
46 50 58 92 46 13 USH 2 Near Brookston	Whole Organism	2	1.0	1978	Channel Catfish	0.127	0.016	*	0.010	0.140	0.059	*
		3	1.2	1978	Northern Pike	*	*	*	0.010	0.190	0.050	*
		1	1.5	1978	White Sucker	0.035	0.149	0.018	0.020	0.120	0.050	*
		5	1.8	1978	Shorthead Redhorse	0.121	0.013	0.018	0.030	0.180	0.50	*
		4	1.1	1978	Shorthead Redhorse	0.077	0.017	0.037	0.020	0.150	0.050	*
	Plug with Skin	3	1.2	1978	Northern Pike	*	0.010	*	0.030	0.280	0.020	*
		5	1.8	1978	Shorthead Redhorse	*	0.010	*	*	0.290	0.050	*
	Whole Organism	5	1.2	1979	Walleye	*	*	*	*	0.390	0.040	*
		5	1.3	1979	White Sucker	*	*	*	*	0.160	0.90	*
		5	0.7	1979	White Sucker	*	*	*	*	0.150	0.060	*
	Fillet with Skin	1	10.5	1986	Northern Pike	*	*	*	*	*	*	*

APPENDIX B

ST. LOUIS RIVER SYSTEM AOC FISH TISSUE DATA
MINNESOTA POLLUTION CONTROL AGNECY

Latitude/Longtitude Location	Anatomy	Sample Size	Weight	Year	Species	MG/KG PCBS	UG/G DDT	MG/KG PCP	MG/KG ARSENIC	MG/KG MERCURY	MG/KG LEAD	PG/G TCCD
46 45 5 92 6 0 St. Louis Bay	Whole Organism	5	1.1	1978	Northern Pike	0.151	0.006	0.090	0.010	0.170	0.060	*
		7	1.9	1978	White Sucker	0.319	0.018	*	0.010	0.180	0.110	*
		1	1.7	1978	Shorthead Redhorse	0.789	0.032	*	0.020	0.190	0.100	*
		5	0.7	1979	Walleye	*	*	*	0.020	0.250	0.080	*
		5	2.1	1979	White Sucker	*	*	*	0.020	0.120	0.390	*
		5	1.9	1979	White Sucker	*	*	*	0.010	0.100	0.050	*
	Plug with Skin	5	1.1	1978	Northern Pike	*	*	0.144	0.010	0.250	0.060	*
		7	1.9	1978	White Sucker	0.131	*	0.131	0.010	0.250	0.070	*
	Fillet with Skin	4	1.8	1980	Northern Pike	0.122	*	*	*	0.270	*	*
		4	3.9	1980	Northern Pike	0.064	*	*	*	0.590	*	*
		3	5.8	1980	Northern Pike	0.142	*	*	*	0.450	*	*
		2	1.5	1980	Walleye	0.369	*	*	*	0.710	*	*
		3	2.2	1980	Walleye	0.057	*	*	*	1.000	*	*

APPENDIX B
ST. LOUIS RIVER SYSTEM AOC FISH TISSUE DATA
MINNESOTA POLLUTION CONTROL AGNECY

Latitude/Longtitude Location	Anatomy	Sample Size	Weight	Year	Species	MG/KG PCBS	UG/G DDT	MG/KG PCP	MG/KG ARSENIC	MG/KG MERCURY	MG/KG LEAD	PG/G TCCD
		3	1.8	1980	White sucker	0.529	*	*	*	0.340	*	*
46 45 5 92 6 0 St. Louis Bay cont.	Fillet with Skin	2	2.3	1980	White Sucker	1.030	*	*	*	0.230	*	*
46 45 5 92 6 0 Duluth/Superior	Fillet with Skin	4	5.5	1982	Northern Pike	2.200	*	*	*	0.450	*	*
		3	3.5	1982	Walleye	3.600	*	*	*	0.780	*	*
		5	3.5	1982	White Sucker	0.090	*	*	*	0.290	*	*
46 43 57 92 9 9 St. Louis Bay 0.05 Mi East of Duluth	Whole Organism	5	1.6	1982	White Sucker	0.028	*	*	*	*	*	*
	Fillet with Skin	5	1.6	1982	White Sucker	0.280	*	*	*	0.250	*	*
45 45 17 92 10 25 St. Louis Bay 0.05 Mi S of Duluth	Whole Organism	2	2.2	1982	Northern Pike	*	*	*	*	*	*	*
		5	1.9	1982	White Sucker	*	*	*	*	*	*	*
	Fillet with Skin	2	2.2	1982	Northern Pike	0.100	*	*	*	0.250		
	Fillet with Skin	5	1.9	1982	White Sucker	0.370	*	*	*	0.230	*	*

APPENDIX B

ST. LOUIS RIVER SYSTEM AOC FISH TISSUE DATA
MINNESOTA POLLUTION CONTROL AGNECY

Latitude/Longtitude Location	Anatomy	Sample Size	Weight	Year	Species	MG/KG PCBS	UG/G DDT	MG/KG PCP	MG/KG ARSENIC	MG/KG MERCURY	MG/KG LEAD	PG/G TCCD
46 41 33 92 17 56 St. Louis Bay 2 Mi NE of Gary	Whole Organism	2	2.2	1982	Northern Pike	*	*	*	*	*	*	*
		5	1.7	1982	White Sucker	*	*	*	*	*	*	*
	Fillet with Skin	2	2.2	1982	Northern Pike	0.060	*	*	*	0.330	*	*
		5	1.7	1982	White Sucker	0.230	*	*	*	0.220	*	*
		3	6	1986	Carp	0.230	*	*	*	*	*	8.200
		5	2.6	1986	Northern Pike	*	*	*	*	*	*	0.500
		5	2	1986	Walleye	*	*	*	*	*	*	0.500
46 42 37 92 25 8 St. Louis Bay 0.5 Mi E of Scanlon Dam	Fillet with Skin	2	4.4	1983	Carp	*	*	*	*	*	*	*
		3	8.4	1983	Carp	1.5	*	*	*	*	*	*
46 43 33 92 26 59 St. Louis Bay At Knife Falls	Fillet with Skin	1	10.5	1986	Northern Pike	*	*	*	*	*	*	*
		3	0.9	1986	Walleye	*	*	*	*	*	*	*
46 44 34 92 29 0 St. Louis Bay At Cloquet	Fillet with Skin	4	1.6	1988	White Sucker	*	*	*	*	0.230	*	*

SS = Spottail shiner
ES = Emerald shiner
WP = White perch
YP = Yellow perch
BC = Black crappie
LP = Logperch
BG = Bluegill
RF = Ruffe
AW = Alewife
RS = Rainbow smelt
JD = Johnny darter
CS = Common shiner
WS = White sucker
TP = Trout perch
LB = Largemouth bass
FM = Fathead minnow
SHR = Shorthead redhorse
SR = Silver redhorse
RB = Rock bass

Appendix F

St. Louis River Remedial Action Program
Toxics Technical Advisory Committee
Sediment Subcommittee Report
28 February, 1990

(Mary Schubauer-Berigan, Larry Brooke, Daniel Call)

This report describes the findings and recommendations of the subcommittee to determine appropriate criteria for classifying sediments. We first examined IJC's guidelines for assessing sediment contamination; the IJC recommendations are summarized. Several U.S. EPA Environmental Research Laboratories are currently developing methods to examine sediment contamination; techniques which may be useful to apply to the St. Louis River/Bay area of concern are described below.

The IJC (1988) recommends use of a "sediment quality triad" approach (Chapman 1986) in determining degree of sediment contamination. This approach combines bulk sediment contaminant concentrations, *in situ* benthic diversity, and toxicity tests to give a composite picture of overall sediment "health". The IJC Assessment subcommittee recommends performing assessment in two stages (Figure 1).

The first stage consists of an initial assessment in the area to determine whether there is cause for concern about sediment contamination. This stage consists of measuring bulk chemical concentrations of the contaminants of interest, measuring concentrations of residues in fish tissues, and/or evaluating whether there is a general loss of benthic community structure. If these assessments reveal a contamination problem, the second stage assessments are then initiated. This begins with an extensive physical mapping of the region of concern to identify areas of sediment which are homogenous in their physical composition and likely to be similarly polluted. This step reduces the number of sites to be assessed in the next phases. Phase 2 of Stage II involves measuring surficial sediment chemistries, including metal and organic contaminant concentrations, and surveying benthic communities to establish areas which have been adversely impacted. Areas which have low community diversity and high chemical concentrations (both relative to "background" levels) are then subjected to extensive toxicity tests to determine the sorts of effects that these contaminants have upon a variety of organisms in the laboratory. All stages of these procedures require parallel assessment of a "control" sediment, which is a nearby, unimpacted sediment whose physical characteristics (e.g., particle size, water content, dissolved organic carbon concentrations) closely resemble the sediment of concern. Values obtained for the control sediment are then compared with those obtained for the contaminated sediment to determine the extent of the problem.

With respect to meeting the IJC assessment guidelines, Stage 1 has been essentially completed on the St. Louis River/Bay site. Fish advisories and existing chemical concentration data indicate the existence of toxic sediments. Data on the Bay/River sediments are currently being summarized and mapped by Arrowhead Regional Development Corporation (ARDC). Conversations with representatives of ARDC indicated that they are expecting to release a report and/or maps of the sediment concentration data in two months, funding permitting. However, from the studies we have seen thus far, there appears to be very little data applicable to the Stage II IJC subcommittee recommendations. One problem is that much of the existing research on the harbor focuses on the ship channel sediments and was instigated to determine the effects of dredge disposal. There is very little information on backwater areas in the bay or river, which probably contain the most important sediments impacting the benthic biota and the organisms which feed on them. Also, most of the data which does exist for the harbor area is restricted to bulk sediment concentration data, which gives very little information on the biotic effects of these sediments; there appear to be only limited data on bioassays or benthic surveys in the St. Louis Bay/River area. We feel this committee should strongly recommend further study of sediments in the area of concern before expensive and time-consuming remediation is proposed. Implementing these studies will necessitate the identification of an appropriate control site for the region. Such a site should be selected carefully, as findings in the St. Louis River/Bay will be contrasted to this site to determine degree of contamination at each site.

In addition to the IJC assessment recommendations, there are a variety of other types of sediment quality criteria currently (SQC) in development. The citizens advisory committee may want to investigate the addition of these to IJC recommendations. Freshwater sediment quality criteria are currently being developed at several U.S. EPA Environmental Research Laboratories, including the Duluth lab. Non-chemical specific criteria use benthic species representing several taxonomic levels in toxicity tests with both whole sediments and various aqueous fractions (i.e., interstitial water and elutriates). These types of tests, as mentioned above, are also recommended for use by IJC. The chemical-specific SQC being developed are quite different from the dredge disposal guidelines traditionally used by EPA regions, the U.S. Army Corps of Engineers, and state agencies (Table 1) because they acknowledge that total sediment concentrations of chemicals of concern often relate little information on bioavailability of these contaminants, and that parameters in sediments such as grain size, organic carbon content, and hardness, for example, can control the fate of many contaminants. Basically, the goal of developing chemical-specific SQC is to determine concentrations of contaminants in sediments which will cause some detrimental effect upon the biota of the system (e.g., acute toxicity, chronic toxicity, bioaccumulation, tumor formation).

There are currently SQC being developed for nonpolar organic compounds. Researchers have found that the primary route of exposure to benthic organisms for some nonpolar organics (e.g., pesticides, PCBs, chlorinated benzenes) and metals is through the sediment interstitial (pore) water (Adams et al. 1985, Knezovich and Harrison 1988, Swartz et al. 1985). The equilibrium partitioning theory (DiToro 1989) allows prediction of pore water concentrations of organic compounds based on bulk sediment concentrations and the amount of organic carbon in the sediment. The pore water values can then be compared to water quality criteria for the chemical measured to determine the effect on biota. Although this approach does not work for all non-polar organic compounds, especially for those whose primary route of exposure is through ingested particles, it does work for some. This approach has the advantage of being relatively simple to apply: all that is needed is the sediment contaminant concentration and the amount of sediment organic carbon. However, this subcommittee is unaware whether organic carbon concentrations have been measured in sediment studies to date. There may be a federal guidance document on the equilibrium partitioning method as early as the fall of 1990.

The problem of metal contamination is also being addressed by the U.S. EPA. Recent evidence from studies with cadmium have indicated that bioavailability, and hence, toxicity of some metals is closely associated with the concentration of sulfide in the sediments (DiToro et al. 1989). Metals are bound to acid-volatile sulfide (AVS) in a molar ratio by *in situ* sediment processes. It has been found that once the AVS is completely bound by metals, additional metals are then bioavailable and cause toxicity. Use of this method to establish metal effects on biota is in the early stages of development and needs further field evaluation before it is established as a SQC determinant.

Another type of chemical-specific SQC developed at the Duluth EPA lab is toxicity identification evaluation (TIE). These procedures were designed to identify contaminants in complex effluent mixtures by associating toxicity with specific compounds (Mount and Anderson-Carnahan 1989a,b, and Mount 1989). These procedures have been successfully applied to sediments in other IJC areas of concern (Ankley et al. 1990). There are several problems with applying these procedures: they are relatively expensive when applied to large numbers of areas, and they are currently only applicable to sediments which show acute toxicity. However, despite these obstacles, the procedures are proving valuable in pinpointing exactly which chemicals are causing toxicity in a sediment, which can be extremely useful both in deciding appropriate remedial action and in identifying present or historical point sources of the contaminants. A guidance document describing the use of these procedures with sediments should be released soon.

Given the current state of information and research on the St. Louis River/Bay, it is impossible to apply any criteria other than the dredge disposal guidelines. With that in mind, we investigated criteria currently in use by the MPCA, WDNR, and Ontario Ministry of Environment (MOE). The most conservative criteria were selected for each parameter to determine degree of contamination, and are shown in Table 1.

The subcommittee compared three sets of criteria which are currently in use for characterizing the degree of sediment contamination:

1. Guidelines for pollutional classification of Great Lakes harbor sediment (U.S. EPA Region V 1977). (See Table 2)

2. Ontario Ministry of Environment bulk chemical guidelines for determining whether dredged material requires confined disposal.

3. Wisconsin interim guidelines for open water disposal of dredged material in Lake Superior. (See Table 3)

All of these guidelines are based upon bulk chemistry of the sediments only. The most conservative guidelines are given for each parameter in Table 1. These guidelines represent the most sensitive value from either the Ontario Ministry of Environment, the Wisconsin interim guidelines, or the 1977 EPA guidelines for the "moderately polluted" classification. IJC recommends that this type of criteria be exclusively used only for the <u>initial</u> assessment of sediment contamination, and not as the sole criterion upon which remediation is based. Upon reviewing the IJC recommended assessment procedures, the sediment subcommittee of the Toxics TAC recommends the following:

Immediate financial and technical support to complete current data summarization and graphical presentation of existing data.

Implementation of the IJC-recommended assessment strategies (i.e., toxicity tests, benthic surveys, and bulk chemical analyses) in the backwater and embayment areas likely to support most of the aquatic biota in the St. Louis River/Bay.

Investigation of other criteria (e.g., U.S. EPA) which may be applicable to the St. Louis River/Bay assessment.

Figure 1. Assessment strategy recommended by the IJC Sediment Subcommittee for sediments in Great Lakes areas of concern (from IJC 1988).

Table 1. Guidelines from the Ontario Ministry of Environment and Wisconsin DNR and EPA Region 5.

	Concentrations in mg/kg, dry weight	
<u>Organics</u>	<u>Non-polluted</u>	<u>Polluted</u>
PCB, total	< 0.05	≥ 0.05
Total 2,3,7,8-TCDD	< 1.0 pg/g	≥ 1.0 pg/g
Total 2,3,7,8-TCDD	< 10.0 pg/g	≥ 10.0 pg/g
Aldrin	< 0.01	≥ 0.01
Dieldrin	< 0.01	≥ 0.01
Chlordane	< 0.01	≥ 0.01
Endrin	< 0.05	≥ 0.05
Heptachlor	< 0.05	≥ 0.05
Lindane	< 0.05	≥ 0.05
Toxaphene	< 0.05	≥ 0.05
DDT	< 0.01	≥ 0.01
DDE	< 0.01	≥ 0.01
Benzo(a)pyrene	< 1.0	≥ 1.0
<u>Metals</u>		
Arsenic	< 3.0	≥ 3.0
Barium	< 20.0	≥ 20.0
Cadmium	< 1.0	≥ 1.0
Chromium	< 25	≥ 25
Copper	< 25	≥ 25
Lead	< 40	≥ 40
Mercury	< 0.1	≥ 0.1
Nickel	< 20	≥ 20
Selenium	< 1.0	≥ 1.0
Manganese	< 300	≥ 300
Zinc	< 90	≥ 90
Iron	< 10,000	≥ 10,000
<u>Other</u>		
Ammonia	< 75	≥ 75
Cyanide	< 0.1	≥ 0.1
Phosphorus	< 420	≥ 420
Total Kjeldahl Nitrogen	< 1,000	≥ 1,000
Oil and Grease	< 1,000	≥ 1,000
Chemical Oxygen Demand	< 40,000	≥ 40,000
Volatile Solids	< 50,000	≥ 50,000

Table 2. Guidelines for the Classification of Great Lakes Sediments

Table 3. Wisconsin DNR 1989 Proposed Interim Guidelines for In-Water Placement of Dredged Material

Contaminant	Maximum Concentration	
Organics	Lake Michigan	Lake Superior
PCB, Total	0.05 ug/kg	0.05 ug/kg
Total 2,3,7,8 TCDD	1.0 pg/g	1.0 pg/g
Total 2,3,7,8 TCDF	10.0 pg/g	10.0 pg/g
Aldrin	0.01 ug/kg	0.01 ug/kg
Dieldrin	0.01 ug/kg	0.01 ug/kg
Chlordane	0.01 ug/kg	0.01 ug/kg
Endrin	0.05 ug/kg	0.05 ug/kg
Heptachlor	0.05 ug/kg	0.05 ug/kg
Lindane	0.05 ug/kg	0.05 ug/kg
Toxaphene	0.05 ug/kg	0.05 ug/kg
DDT	0.01 ug/kg	0.01 ug/kg
DDE	0.01 ug/kg	0.01 ug/kg
Metals		
Arsenic	10 mg/kg	10 mg/kg
Barium	500 mg/kg	500 mg/kg
Cadmium	1.0 mg/kg	1.0 mg/kg
Chromium	75 mg/kg	100 mg/kg
Copper	50 mg/kg	100 mg/kg
Lead	50 mg/kg	50 mg/kg
Mercury	0.1 mg/kg	0.1 mg/kg
Nickel	50 mg/kg	100 mg/kg
Selenium	1.0 mg/kg	1.0 mg/kg
Zinc	100 mg/kg	100 mg/kg
Other		
Oil & Grease	1000 mg/kg	1000 mg/kg

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APPENDIX G

St. Louis River AOC
Natural Resource Parcels

APPENDIX G.

NATURAL RESOURCE PARCELS LISTED IN METROPOLITAN
INTERSTATE COMMITTEE 1985 REPORT:
"SUPERIOR-DULUTH HARBOR NATURAL RESOURCES MANAGEMENT PROGRAM"
(Updated for Remedial Action Plan, 1992)

1. WISCONSIN POINT
Approximate Size: 300 acres Ownership: Public (City of Superior, WDNR, and Corps of Engineers).
Zoning: Undeveloped; Floodplain.
Features: Beach dune and pine forest habitats and critical status plant species present. Important bird habitat and migratory bird route. Nesting and young rearing habitat for colonial/nesting birds (common terns and piping plovers). High recreational value.

2. ALLOUEZ BAY
Approximate Size: 600 acres Ownership: Public (City of Superior)
Zoning: Undeveloped; Floodplain; Navigable waters; Wetlands.
Features: Extensive wetlands and shallow water habitat. Important fish and wildlife habitat.

3. MOUTH OF NEMADJI RIVER
Approximate Size: 90 acres Ownership: Public (Douglas Co.) and Private (Burlington Northern).
Zoning: Wetlands; Floodway; Navigable Waters.
Features: Wetlands, fish habitat.

4. HOG ISLAND
Approximate Size: 120 acres Ownership: Public (Douglas Co).
Zoning: Heavy Industry and Wetlands; Navigable Waters; Wetlands.
Features: Wetlands, shallow water habitat.

5. BARKER'S ISLAND
Approximate Size: 14 acres. Ownership: Public (City of Superior) and Private Parcels.
Zoning: Heavy Industry; Shoreland; Floodway.
Features: Previously contained designated bird sanctuary. No longer provides nesting habitat for colonial nesting bird species (common tern, piping plover) because of vegetative growth and human disturbance.

6. MINNESOTA POINT (outer undeveloped portion)
Approximate size: 200 acres Ownership: Public (City of Duluth, City of Superior, and Corps of Engineers).
Zoning: Residential, Floodplain, Shoreland.
Features: Pine forest and beach-dune habitats and associated critical status plant species. Importance on migratory bird route. Recreational value.

APPENDIX G cont.

NATURAL RESOURCE PARCELS LISTED IN METROPOLITAN
INTERSTATE COMMITTEE 1985 REPORT:
"SUPERIOR-DULUTH HARBOR NATURAL RESOURCES MANAGEMENT PROGRAM"
(Updated for Remedial Action Plan, 1992)

7. HEARDING ISLAND
Approximate Size: 32 acres plus adjoining shallow waters (approx, 50 acres)
Ownership: Public (State of Minnesota)
Zoning: General Development Shorelands; Floodway; Designated Wildlife Management Refuge.
Features: Colonial bird nesting site.

8. INTERSTATE ISLAND AND ADJACENT WATERS
Approximate Size: 200 acres Ownership: Public (State of Minnesota) and private (Burlington Northern Railroad and C. Reiss Coal Co.). Private lands managed by Wisconsin DNR.
Zoning: Not zoned, Floodway; Shoreland.
Features: Colonial bird nesting site (common terns).

9. WISCONSIN GRASSY POINT (shallow waters)
Approximate size: 140 acres Ownership: Public (Douglas Co. and City of Superior) and public
Zoning: Heavy industry; Shoreland.
Features: Wetlands, shallow waters, primary northern pike spawning area, waterbird habitat.

10. MINNESOTA GRASSY POINT (and adjacent islands)
Approximate size: 100 acres Ownership: Public (tax forfeit) and private.
Zoning: Waterfront; Shoreland; Floodplain; Wetland.
Features: Wetlands, shallow waters, primary northern pike spawning area, waterbird habitat.

11. CLOUGH (Whiteside) ISLAND
Approximate size: 370 acres plus adjoining waters.
Ownership: Private.
Zoning: Forestry; Shoreland; Wetlands.
Features: Marshes and waters adjoining island relativey undisturbed, natural state.

12. SUPERIOR MUNICIPAL FOREST (portion of) and POKEGAMA BAY
Approximate Size: 4500 acres Ownership: Public (City of Superior)
Zoning: Forestry; Shoreland; Navigable Waters: Wetlands.
Features: Boreal forest habitat. Bays, wetlands. Importance to fish and wildlife.

13. MORGAN PARK MUDFLATS AND SPIRIT ISLAND AREA
Approximate Size: 260 acres Ownership: Public (City of Duluth and Corps of Engineers).
Zoning: Manufacturing, Shoreland, Floodplain, Wetlands.
Features: Wetlands, shallow waters, mudflats, colonial bird nesting sites.

APPENDIX G cont.

NATURAL RESOURCE PARCELS LISTED IN METROPOLITAN
INTERSTATE COMMITTEE 1985 REPORT:
"SUPERIOR-DULUTH HARBOR NATURAL RESOURCES MANAGEMENT PROGRAM"
(Updated for Remedial Action Plan, 1992)

14. SPIRIT LAKE POINT (and adjoining wetlands)
Approximate Size: 50 acres. Ownership: Public (city of Duluth).
Zoning: Industrial; Shoreland; Floodplain; Wetlands.
Features: Wetlands, maple-basswood forest.

15. MUD LAKE (and adjacent wetlands)
Approximate size: 230 acres. Ownership: Public (City of Duluth)
Zoning: Commercial; Shoreland; Floodplain; Wetland.
Features: Wetlands and shallow water habitat.

16. SOUTH SPIRIT LAKE MARSH
Approximate Size: 240 acres (70 wetland and 170 shallow water).
Ownership: Public (Douglas Co. and Village of Oliver).
Zoning: Special Use; Wetland; Shoreland; Floodway.
Features: Wetlands and shallow water habitat.

17. OLIVER BRIDGE MARSH/BEAR ISLAND
Approximate Size: 120 acres Ownership: Public (City of Duluth) and Private
Zoning: Residential; Shoreland; Floodplain; Wetlands.
Features: Wetlands and shallow water habitat.

18. SOUTH HORSESHOE ISLAND AREA
Approximate Size: 200 acres Ownership: Public (State of Wisconsin) and Private (Werco Wisconsin).
Zoning: Forestry, Shoreland; Floodway; Wetlands.
Features: Wetlands and shallow water habitat. Nekuk and Arnik Islands and nearby islet owned by State of Wlisconsin, managed for natural and undisturbed nature.

19. SWAMP LAKE (Olson's Pond)
Approximate Size: 10 acres Ownership: Public (State of Minnesota) and Private
Zoning: Commercial; Floodway; Shoreland; State Park.
Features: Wetland. Green heron colony.

20. FOND DU LAC SPAWNING GROUNDS
Approximate size: 1-2/3 miles of river
Ownership: Public (State of Minnesota, State of Wisconsin) and Private.
Zoning: Suburban; Floodplain; Shoreland.
Features: Walleye spawning area.

APPENDIX G cont.

SITES WITHIN ST. LOUIS ESTUARY RATED AS VALUABLE NATURAL AREAS BY WDNR SCIENTIFIC AREAS PROGRAM

ALLOUEZ BAY
Ownership: City of Superior
Description and Comments: Shallow bay. Emergent aquatic community, numerous submerged and floating leaved aquatics. Good interspersion of aquatics and open water, and numerous mud flats provide excellent waterfowl and shorebird habitat. A primary northern pike spawning area.

WISCONSIN POINT
Ownership: City of Superior
Description and Comments: Narrow sand spit into Lake Superior, about 2-1/2 miles long. Pine forest and open beach and dune communities. Critical plant species present.

DWIGHT'S POINT-KIMBALLS BAY AREA
Ownership: City of Superior
Description and Comments: Two mile peninsula into St. Louis River containing old-growth red and white pine among second growth mixed woodland. This is some of the best boreal forest remaining in the Lake Superior area. Long serpentine inland bays such as Kimballs and Pokegama Bays are unique in Wisconsin to this naturally flooded river mouth. Wetland lines much of the bays which is used extensively by waterfowl. This approximately 290-acre area has been given high protection priority by the Wisconsin DNR Natural Areas Program.

ST. LOUIS RIVER MARSH
Ownership: Private
Description and Comments: Area from Red River mouth to Pokegama River mouth. Submerged and emergent plant communities along St. Louis River, with some mud flats and shorebird habitat.

NEMADJI RIVER
Ownership: City of Superior, Private.
Description and Comments: River valley and extensively meandering river zone from below its confluence with the Black River to its mouth in Superior Bay. Sluggish river whose channel is deeply entrenched into red clay. The river fluctuates wildly and carries a heavy silt load. Adjacent swamp timber. Main value is erosion control and ecological corridor value.

POKEGAMA RIVER
Ownership: City of Superior
Description and Comments: Zone of emergent aquatics up to 350 ft. wide along each side of the Pokegama River near its drowned mouth. Current is slow and many floating leaved aquatics occur. This approximately 200-acre area is dominated by cattails, burreed, and wild rice.

ST. LOUIS RIVER AREA, NORTH AND WEST OF THE VILLAGE OF OLIVER
Very likely contains important endangered resources concerns. Systematic inventories of this area have not been conducted.

Source: MIC Report: Superior-Duluth Harbor Natural Resources Management Program, 1985.

Memo from R. Nicotera, Bureau of Endangered Resources, Wisconsin DNR to Bruce Bacon, November 1991.

APPENDIX I

Listing of Endangered Flora and Fauna
in the St. Louis River AOC

Appendix I. Endangered Plants

SPECIES NAME	COMMON NAME	RATING	COUNTY LOCATION
Adoxa moschatellina	Monchatel	Special Concern	Carlton\St. Louis
Allium Schoenoprasum (silibircum)	Wild Chives	Special Concern	Carlton\St. Louis
Ammophila breiligulata	Beach Grass	Threatened	St. Louis
Arethusa bulbosa	Dragon's-mouth	Special Concern	Carlton\St. Louis
Calamagrostis lacustris	Marsh Reedgrass	Endangered	St. Louis
Caltha natans	Floating Marsh Marigold	Endangered	St. Louis
Carex exilis	Sedge Species	Special Concern	St. Louis
Carex garberi	Garber's Sedge	Endangered	St. Louis
Carex katahinensis	Mount Katahdin Sedge	Endangered	St. Louis
Carex pallescens	Pale Sedge	Endangered	St. Louis
Carex rossii	Ross's Sedge	Endangered	Carlton\Pine
Cetraria aurescens	Lichen species	Special Concern	St. Louis
Cirsium hillii	Hill's Thistle	Special Concern	Pine
Cladium mariscoides	Twig-rush	Special Concern	Pine
Cladonia pseudorangiformis	Lichen Species	Special Concern	St. Louis
Claytonia caroliana	Carolina Spring-beauty	Special Concern	Carlton/St. Louis

Appendix I cont. Endangered Plants			
SPECIES	**COMMON NAME**	**RATING**	**COUNTY**
Cypripendium arietinum	Ram's-head Lady's-slipper	Endangered	Itasca
Decodon verticllatus	Water-willow	Special Concern	Pine
Deschampsia flexuosa	Slender Hairgrass	Special Concern	St. Louis
Elecharis pauciflora (fernaldii)	Few-flowered Spike-rush	Special Concern	St. Louis
Elocharis nitida	Neat Spike-rush	Endangered	St. Louis
Euphraia hudsoniana	Hudson Bay Eyebright	Special Concern	St. Louis
Hydrocotyle americana	American Water-pennywort	Special Concern	Pine
Juncus stygius (americanus)	Bog Rush	Special Concern	St. Louis
Listeria auriculata	Auricled Twayblade	Endangered	Carlton/St. Louis
Littorella americana	American Shore-plantain	Endangered	St. Louis
Lorbaria quercizans	Lichen Species	Threatened	St. Louis
Muhlenbergia uniflora	One-flowered Muhly	Threatened	St. Louis
Phacelia franklinii	Wild Heliotrope	Treatened	St. Louis
Platanthera clacellata	Club-spur Orchid	Special Concern	St. Louis
Poa paludigena	Bog Bluegrass	Endangered	Pine
Polygonum arifloium	Halberd-leaved Teardthumb	Special Concern	Pine

Appendix I cont. Endangered Plants			
SPECIES	**COMMON NAME**	**RATING**	**COUNTY**
Polydonum careyi	Carey's Smartweed	Endangered	Carlton
Polygonum viviparum	Alpine Bistort	Special Concern	St. Louis
Potamogeton vaaseyi	Vasey's Pondweed	Special Concern	St. Louis
Pseudocyphellaria crocata	Lichen Species	Endangered	St. Louis
Pyrola minor	Small Shinleaf	Special Concern	St. Louis
Rancunculus lapponicus	Lapland Buttercup	Special Concern	St. Louis
Rhynochospora fusca	Sooty Colored Beak-rush	Special Concern	St. Louis
Salix pellita	Satiney Willow	Special Concern	St. Louis
Sparganium golmeratum	Clustered Bur Reed	Endangered	St. Louis
Stricta fuliginosa	Lichen Species	Special Concern	St. Louis
Subularia aquatica	Awlwort	Endangered	St. Louis
Tillaea aquatica	Pigmyweed	Endangered	St. Louis
Tomenthypnum falcifolium	Moss Species	Special Concern	St. Louis
Triglochin palustris	Marsh Arrow-grass	Special Concern	St. Louis
Tsuga canadensis	Eastern Hemlock	Special Concern	Carlton/Pine/St.Louis
Utricularia gibba	Humped Bladderwort	Special Concern	St. Louis
Vaccinium vitis-idaea	Mountain Cranberry	Endangered	Douglas
Viola novae-angliae	New England Violet	Special Concern	Carlton/St. Louis

Appendix I cont. Endangered Plants			
SPECIES	**COMMON NAME**	**STATUS**	**COUNTY LOCATION**
Waldsteinia fragrioides	Barren Strawberry	Special Concern	Pine/St. Louis
Xyris montana	Yellow-eyed Grass	Special Concern	St. Louis

Appendix I. Endangered Animals

SPECIES	COMMON NAME	STATUS	COUNTY LOCATION
Acipenser fulvescens	Lake Sturgeon	Special Concern	Pine\St. Louis
Bartramia longicauda	Upland Sandpiper (Plover)	Special Concern	Itasca\St. Louis
Botaurus lentiginosus	American Bittern	Special Concern	St. Louis
Buteo liniatus	Red-Shouldered Hawk	Special Concern (MN) Threatened (WI)	Pine Douglas
Canis lupus	Gray Wolf	Threatened (MN) Endangered (WI)	Carlton\Itasca\Pine\St.Louis Douglas
Casmerodius albus	Great Egret	Threatened	Douglas
Charadrius melodus	Piping Plover	Endangered	St. Louis\Douglas
Chelydra serpintina	Snapping Turtle	Special Concern	Carlton\Itasca\Pine\St.Louis
Cicindela denkikei	Tiger Beetle	Endangered	St. Louis
Cicindela hirticollis shermani	Tiger Beetle	Special Concern	St. Louis
Cicindela petruela petruela	Tiger Beetle	Threatened	Pine
Clemmys insculpta	Wood Turtle	Threatened	Pine\St. Louis\Douglas
Clossiana freija	Frija Frillary	Special Concern	Carlton\Itasca\Pine\St.Louis
Clossiana frigga saga	Frija Frillary	Special Concern	Pine\St. Louis

Appendix I cont. Endangered Animals			
SPECIES	**COMMON NAME**	**STATUS**	**COUNTY LOCATION**

Cygnus buccinator	Trumpeter Swan	Endangered	Douglas
Elaphe vulpina	Fox Snake	Special Concern	Pine
Emydoidea blandingii	Blanding's Turtle	Threatened	Pine\Douglas
Epidemia dorcas dorcas	Dorcas Copper	Special Concern	Carlton\Itasca\Pine\St.Louis
Elaphe epixaphe michoganesis	Bog Copper	Special Concern	Carlton\Itasca\Pine\St. Louis
Erebia disa manicnus	Disa Alpine	Special Concern	St. Louis
Erebia discoidalia	Red-disked Alpine	Special Concern	Carlton\Itasca\Pine\St.Louis
Falco peregrinus	Peregrin Falcon	Endangered	Douglas\St. Louis
Grus cana densis	Sandhill Crane	Special Concern	Pine
Haliaetus Leucocephalus	Bald Eagle	Threatened	Carlton\Itasca\Pine\St.Louis\Douglas
Heterodon plarhinos	Eastern Hognose Snake	Special Concern	Pine
Lanius ludovicianus	Loggerhead Shrike	Threatened Endangered	St. Louis Douglas
Lycaeides idas	Northern Blue Butterfly	Endangered	Douglas
Lynx canadensis	Canada Lynx	Endangered	Douglas
Marpissa grata	Jumping Spider	Special Concern	Carlton
Martes americana	Marten	Special Concern	St. Louis
Mircotus chrotorrhinus	Rock Vole	Special Concern	St. Louis
Myotis septentrionalis	Northern Myotis	Special Concern	Itasca\Pine\St. Louis
Odocoileus hemionus	Mule Deer	Special Concern	Itasca
Oeneis Jutta ascerta	Jutta Arctic	Special Concern	Carlton\Pine\St. Louis
Pandion haliatus	Osprey	Special Concern (MN) Threatened (WI)	Itasca\Pine\St. Louis Douglas
Phenacomys intermedius	Heather Vole	Special Concern	St. Louis
Pipistrellus subflavus	Eastern Pipistrelle	Special Concern	St. Louis

Appendix I cont. Endangered Animals			
SPECIES	**COMMON NAME**	**STATUS**	**COUNTY LOCATION**
Podiceps grisegena	Red-necked Grebe	Threatened	Douglas
Proclossiana eunomia dawsoni	Bog Fritillary	Special Concern	St. Louis
Rangifer tarandus	Caribou	Special Concern	St. Louis
Seiurus motacilla	Louisiana Waterthrush	Special Concern	Pine
Spilogale putorius	Eastern Spotted Skunk	Special Concern	Itasca\Pine\St. Louis
Sterna caspia	Caspian Tern	Endangered	Douglas
Sterna hirundo	Common Tern	Special Concern Endangered	St. Louis Douglas

APPENDIX J

Part A

Compilation of Documented Spills and/or Accidental Releases
into the St. Louis River Drainage Basin
for the State of Minnesota

Appendix J. Documented Spills in Minnesota

DATE	RESPONSIBLE PARTY	LOCATION	SPILL	CAUSE	AMOUNT
10/17/90	WLSSD	Duluth/Endion	Wastewater	Mod. Rain	*
8/31/90	WLSSD	Duluth/Endion	Sewage	Heavy Rain	20,000 g
8/25/90	WLSSD	Duluth/Becks Rd.	Foam	Seal Failure	*
8/25/90	WLSSD	Duluth Plant	Wastewater	Heavy Rains	*
8/25/90	WLSSD	Duluth/Endion	Wastewater	Heavy Rains	110,000 g
8/25/90	WLSSD	Duluth/Endion	Wastewater	Lighting	840,OO0 g
4/29/90	WLSSD	Duluth Plant	Wastewater	Pump Repairs	600,000 g
4/27/90	WLSSD	LSPI Station	Wastewater	Failed Alarm	*
4/26/90	WLSSD	Duluth/77th A.W.	Sewage	Vandalized	350,000 g
12/19/89	Duluth	*	Petroleum	Overfill	80 g
10/25/89	Viking Explosives	Aurora	Fuel Oil	AST	*
10/24/89	City of Duluth	Duluth	Fuel Oil	UST	6 g
10/16/89	USX Corporation	Mt. Iron	Fuel Oil	UST	*
10/11/89	Skubick Bros.	Virginia	Waste Oil	UST	*
10/10/89	Curtis Oil	Hermantown	Gasoline	UST	*
10/10/89	Lampert Lumber Center	Hibbing	Fuel Oil #2	UST	*
10/05/89	Northern Engine Supply	Proctor	Fuel OIl	UST	*
10/04/89	Minnesota Power	Thomson	Gasoline	UST	*

Appendix J cont. Documented Spills in Minnesota

DATE	RESPONSIBLE PARTY	LOCATION	SPILL	CAUSE	AMOUNT
9/29/89	Miller Homes	Duluth	Petroleum	UST	*
9/26/89	*	Duluth	Oil	Spill	*
9/26/89	Azcon Corp.	Duluth	Petroleum	Spill	*
9/26/89	Century Mercury Motor Freight	Duluth	Gasoline	UST	*
9/26/89	Century Mercury Motor Freight	Duluth	Gasoline	UST	*
9/25/89	Ship	Duluth	Fuel Oil #5/6	Ship	*
9/25/89	Duluth Harbor	Duluth	Petroleum	UST	*
9/25/89	WC Ship	Duluth	Fuel Oil #5	Ship	*
9/23/89	Amoco	Hibbing	Gasoline	UST	*
9/20/89	Yellow Freight	Duluth	Petro/Soil	UST	250 yards
9/13/89	US West Communications	Duluth	Fuel Oil	UST	*
9/12/89	Spirit Valley Little Store	Duluth	Petro/Soil	UST	*
9/11/89	US West Communications	Duluth	Fuel Oil	UST	*
9/07/89	Eddies Supper Club	Proctor	Petroleum	UST	*
9/06/89	US West Communications	Cloquet	Fuel Oil	UST	*
8/31/89	Potlatch	Cloquet	Lime Slurry	Pump Failure	20 g
7/12/89	Cutler Magner Co.	Duluth	Gasoline	UST	*
7/11/89	Amoco	Duluth	Gasoline	Overfill	*

Appendix J cont. Documented Spills in Minnesota

DATE	RESPONSIBLE PARTY	LOCATION	SPILL	CAUSE	AMOUNT
7/10/89	Richard Barry	Virginia	Petroleum	UST	*
6/29/89	*	West Duluth	Explosives	Fireworks Fact.	*
6/28/89	Trico Oil Co.	Two Harbors	Petroleum	UST	*
6/13/89	Seven-Eleven	Duluth	Gasoline	Dispenser Accident	10 g
6/10/89	*	Aurora	Gasoline	Car Accident	20 g
6/08/89	Mariner Canadian Ship	Duluth	Oil Base Paint	Spill	1 g
6/07/89	Bank	Hibbing	Fuel Oil	UST	*
6/06/89	Cliff Knutson	Biwabik	Fuel Oil	AST	150 g
6/01/89	Virginia Public Utilities	Virginia	Askaral	Spill	1/2 cup
5/23/89	Minnesota Power	Duluth	Hydraulic Oil	Truck	20 g
5/16/89	WLSSD	Duluth	Sewage	Sewer Break	*
5/15/89	MNDOT	Cromwell	Fuel Oil	UST	*
5/09/89	Union Carbide Plant	Duluth	Fuel Oil	UST	*
5/05/89	Holmes Construction Inc.	Cloquet	Gasoline	UST	*
4/14/89	Jack & Don’s	Hibbing	Waste Oil	Salvage Runoff	*
4/07/89	City of Duluth	Duluth	Petroleum	UST	*
4/05/89	Hanna Mining	Nashwauk	Hydraulic Fluid	Back Hoe Accident	100 g
3/27/89	Tire Cycle	Babbitt	Fuel Oil	UST	*

Appendix J cont. Documented Spills in Minnesota

DATE	RESPONSIBLE PARTY	LOCATION	SPILL	CAUSE	AMOUNT
3/18/89	Como Oil Co.	Duluth	Fuel Oil	Fuel Delivery	30 g
3/14/89	City of Duluth	Duluth	Gasoline	UST	*
3/09/89	Wehr Jerrod	Cloquet	Fuel Oil	Fuel Transfer Accident	50 g
3/03/89	Jon Widen	Duluth	Fuel Oil	UST	200 g
2/15/89	WLSSD	Duluth LS 37th	Sewage/Wastewater	Valve Failure	*
2/15/89	WLSSD	Duluth	Wastewater	Valve Failure	*
2/15/89	*	Aurora	Fuel Oil	UST	*
2/08/89	Proctor City	Proctor	Sewage	Clogged Sewer	3000 g
2/07/89	Como Oil Co.	Duluth	Fuel Oil	Equipment Failure	10 g
1/25/89	Domex	Hibbing	Petroleum	Spill	*
1/23/89	St. Louis Co. Federal	Duluth	Fuel Oil	UST	*
1/20/89	Indianhead Truck Line	Virginia	Gasoline	Valve Left Open	8600 g
1/17/89	DM&IRR	Proctor	Gasoline	Line Leak	50 g
1/11/89	MNDOT	Duluth	Fuel Oil	UST	1600 g
1/10/89	Equipoise Leasing Co.	Duluth	Fuel Oil	Truck Accident	100 g
1/02/89	WLSSD	Scanlon	Sewage	Power Failure	500000 g
1/02/89	WLSSD	Scanlon	Sewage/Wastewater	Pump Failure	500000 g
12/29/88	WLSSD	Cloquet	Sewage/Wastewater	Power Failure	401000 g

Appendix J cont. Documented Spills in Minnesota

DATE	RESPONSIBLE PARTY	LOCATION	SPILL	CAUSE	AMOUNT
6/13/88	Potlatch	Cloquet	Liquid Ammonia	Clogged Hose	600 g
5/11/88	*	Proctor	Fuel Oil	UST	*
5/09/88	Security Oil Co.	Cloquet	Leaded Gasoline	UST	1000 g
5/06/88	WLSSD	Duluth	Diesel	Truck Accident	50 g
4/15/88	US Steel	Mt. Iron	Fuel Oil #2	Overfill	7000 g
4/05/88	Gambucci Hardware	Habbing	Gasoline	UST	*
3/25/88	National Steel Pellet Co.	Keewatin	Transformer Oil	Spill	50 g
3/09/88	Wherley Moving & Storage	Hibbing	Diesel Oil	Truck	100 g
3/04/88	MNDOT	Duluth	Hydraulic Oil	Leak	*
2/26/88	Road Machinery Service	Virginia	Hydraulic Oil	Truck	50 g
2/15/88	NECA	Hibbing	Mineral Oil	Transformer	1 g
2/05/88	MP&L	Duluth	Mineral Oil	Transformer	159 g
2/04/88	Dahlen Transport	Duluth	Gasoline	Truck	15 g
1/15/88	Louisiana Pacific Waferboard	Two Harbors	Waste Chemical	Dumping	16500 g
1/06/88	Virginia Public Utility	Virginia	Mineral Oil	Transformer	2 g
12/18/87	Minntac	Mt. Iron	Diethylene Glycol	AST	12000 g
12/18/87	Buckley Bros.	Cloquet	Ammonia Hydroxide	Truck Accident	1500 g
11/10/87	Superwood	Duluth	Waste Oil	Valve Failed	50 g

Appendix J cont. Documented Spills in Minnesota

DATE	RESPONSIBLE PARTY	LOCATION	SPILL	CAUSE	AMOUNT
10/15/87	Jacks Mobile	Duluth	Gasoline	UST	*
8/17/87	WLSSD	Scanlon/Div E	Sewage/Wastewater	*	19.3 mg
8/01/87	Marine Fueling	Two Harbor	Fuel Oil	Hose Problem	10000 g
7/28/87	ICO	Duluth	Fuel Oil	Overfill	37 g
7/23/87	Edwards Oil	Virginia	Fuel Oil	Mone Tank	230 g
7/16/87	Minnesota Power	Babbitt	Mineral Oil	Transformer	40 g
7/13/87	Virginia Public Utility	Virginia	PCB	Transformer	1 g
5/18/87	Minntac	Mt. Iron	Mineral Oil	Transformer	100 g
5/15/87	Great Lakes Gas	Cloquet	PCB	Inverter Failed	*
5/08/87	Stock Tire	Cloquet	Fire Water	Fire	*
5/05/87	WLSSD	Duluth	Wastewater	Overflow	750000 g
3/26/87	Potlatch	Cloquet	Wastewater	Line Leak	1000 g
3/07/87	Erickson Dairy	Scanlon	Diesel	Truck	30 g
2/19/87	WLSSD	Scanlon/Div E	Sewage/Wastewater	Installation	*
2/06/87	WLSSD	LS #12	Wastewater	Line Replaced	300000 g
2/04/87	WLSSD	Duluth LS 49th	Sewage	Clogged w Debris	*
2/03/87	Security Service	Hibbing	Gasoline	UST	*
1/16/87	David Ang	Duluth	Fuel Oil	AST	200 g

Appendix J cont. Documented Spills in Minnesota

DATE	RESPONSIBLE PARTY	LOCATION	SPILL	CAUSE	AMOUNT
1/06/87	Halvor Lines	Duluth	Diesel Fuel	Saddle Tank Spill	50 g
1/03/87	Koch Services	Duluth	Gasoline	Overfill	400 g
12/29/86	*	Duluth	Gas/Oil	Truck	20 g
12/19/86	*	Chisholm	Fuel Oil	Sewer	*
12/16/86	Food-n-Fuel	Duluth	Gasoline	Overfill	5 g
11/26/86	Hanna Mining Corp.	Keewatin	Mine Tailings	Vavle Leak	75000 g
11/24/86	Eveleth Mines	Eveleth	PCB Oils	Transformer	*
11/13/86	*	Duluth	Waste Oil	Dumped	2 g
10/31/86	Potlatch	Cloquet	Hydraulic Oil	Equipment Failure	17 g
10/19/86	McKinney	Cloquet	Fuel Oil	AST	5000 g
10/15/86	ICO	Duluth	Gasoline	UST	*
10/02/86	WLSSD	Duluth/Endion	Wastewater	Cleansing Line	24000 g
9/30/86	WLSSD	Duluth/Endion	Wastewater	Cleansing Line	132500 g
9/24/86	WLSSD	Duluth/Endion	Wastewater	Cleansing Line	82500 g
9/22/86	Mike Vesapovich	Eveleth	Diesel	Truck Spill	100 g
9/22/86	Todd Pietrowski	Duluth	Diesel	*	15 g
9/11/86	Kayo	Cloquet	Gasoline	UST	*
8/29/86	Redwood Falls	Duluth	Diesel	Truck Spill	100 g

Appendix J cont. Documented Spills in Minnesota

DATE	RESPONSIBLE PARTY	LOCATION	SPILL	CAUSE	AMOUNT
8/29/86	Safety Kleen	Duluth	Mineral Spirits	Truck Spill	4 g
8/29/86	J & H Foods	Duluth	Diesel	Truck Spill	100 g
8/12/86	Minnesota Power	Cloquet	Hydraulic Fluid	Derrick Spill	50 g
7/30/86	DM&IRR	Proctor	Fuel Oil	Locomotive	150 g
7/30/86	Hallett Dock	Duluth	Waste Oil	Vandals/AST	200 g
7/21/86	Superwood	Duluth	Waste Oil	Valve Problem	250 g
7/14/86	USG	Cloquet	Petroleum	Transformer	*
7/11/86	Curtis Oil Co.	Duluth	Diesel	Overfill	50 g
7/11/86	Mrs. McKay	Duluth	Diesel	Leak	15 g
6/21/86	WLSSD	Scanlon	Wastewater	Power Failure	2 mg
6/21/86	Hibbing Taconite	Hibbing	Diesel	*	750 g
6/20/86	US Steel Corp.	Mt. Iron	PCB Oils	Transformer	21 g
6/19/86	Amoco	Grand Marais	Gasoline	Overfill	*
6/19/86	US Forest Service	Eveleth	2,4 D	Spill	Barrel - 50 g
6/16/86	ICO	Gilbert	Fuel Oil	UST	*
6/14/86	*	Mt. Iron	Gasoline	*	2 g
6/13/86	*	Duluth	Drain Oil	Tipped Bucket	2 g
6/13/86	US Steel Mintac	Mt. Iron	Mineral Oil	Transformer Spills	40 g

Appendix J cont. Documented Spills in Minnesota

DATE	RESPONSIBLE PARTY	LOCATION	SPILL	CAUSE	AMOUNT
6/10/86	Edwards Oil	Virginia	Gasoline	UST	966 g
6/03/86	Babbitt School Dist.	Babbitt	Fuel Oil #5	UST	*
6/01/86	WLSSD	Duluth/Endion	Wastewater	Televising/Inspections	250000 g
5/28/86	Minnesota Power	Cloquet	Lube Oil	Assoc. w/Hydro Dam	50 g
5/13/86	Potlatch	Cloquet	Process Water	Seepage	1 g
5/13/86	James Anderson	Duluth	Waste Oil	Barrel Tipped	27 g
5/13/86	WLSSD	Duluth	Wastewater	Bypass	140000 g
5/13/86	North City Aviation Inc.	Duluth	Aviation Fuel	Overfill	50 g
5/07/86	Phillips 66	Virginia	Gasoline	UST	*
5/05/86	WLSSD	Esko	Wastewater	Pipeline Relocation	6.8 mg
5/05/86	WLSSD	Scanlon	Wastewater	Pipeline Replacement	28. mg
4/28/86	WLSSD	Esko	Wastewater	Pipeline Replacement	8. mg
4/28/86	WLSSD	Esko	Wastewater	Pipeline Relocation	1 mg
4/18/86	*	Hibbing	Oil	Well	*
4/08/86	DM&IRR	Proctor	Crank Case Oil	Assoc. w/Locomotive	150 g
4/02/86	Minnesota Hospital	Moose Lake	Gasoline	UST	*
4/01/86	Great Lakes Gas	Cloquet	Waste Oil	Facility	20 g
3/31/86	WLSSD	Duluth/Endion	Wastewater	Pump Failure	1.5 mg

Appendix J cont. Documented Spills in Minnesota

DATE	RESPONSIBLE PARTY	LOCATION	SPILL	CAUSE	AMOUNT
3/31/86	WLSSD	Hermantown	Wastewater	Snowmelt Runoff	1.8 mg
3/28/86	McKevitt Trucking	Carlton	Diesel	Assoc. w/ Truck	*
3/10/86	WLSSD	Duluth	Wastewater	Overflow	200 g
3/07/86	ICO	Gilbert	Fuel Oil	Leak	*
3/07/86	ICO	Gilbert	Fuel Oil	Leak	*
2/07/86	PM Company	Hibbing	Fuel Oil #1 & #2	Line Problems	*
1/09/86	United Power Assoc.	Two Harbors	Mineral Oil	*	34 g
1/09/86	United Power Assoc.	Two Harbors	Mineral Oil	Transformer	34 g
1/08/86	Petro Supply	Hibbing	Fuel Oil	Assoc. w/ Truck	2 g
11/30/85	WLSSD	Duluth	Wastewater	Overflow	45000 g
10/23/85	Spur Station	Eveleth	Gasoline	Overfill	20 g
10/22/85	Spur Station	Eveleth	Gasoline	Overfill	20 g
10/14/85	Frank's 66	Duluth	Gasoline	UST	*
10/14/85	Walt's Union 76	Virginia	Gasoline	UST	*
10/14/85	DM&IRR	Duluth	Hydraulic Oil	Hose Leak	30 g
9/16/85	MP&L	Aurora	Coal Pond Water	*	*
9/13/85	Taconite Oil	Virginia	Lube Oil	Fire	*
9/11/85	Taconite Oil	Virginia	Lube Oil	Fire	*

Appendix J cont. Documented Spills in Minnesota

DATE	RESPONSIBLE PARTY	LOCATION	SPILL	CAUSE	AMOUNT
9/03/85	WLSSD	Esko	Wastewater	Power Failure	30 mg
8/30/85	WLSSD	Duluth	Sewage	Plugged Manhole	420000 g
8/30/85	Zenith Terrace Mobile Home	Duluth	Fuel Oil	Spilled in Sewer	100 g
8/06/85	US Steel Corp.	Mt. Iron	PCB Oils	Transformer Spills	10 g
7/19/85	*	Duluth	Drain Oil	Barrel	50 g
6/27/85	Hanna Mining	Keewatin	Mineral Oil	Transformer	185 g
6/25/85	Ordean Junior High School	Duluth	PCB Oils	Transformer	*
6/18/85	Safety Kleen	Cloquet	Solvent	*	*
6/12/85	Doug Hoffbaur	Hermantown	Lasso	Sprayer	25 g
6/10/85	Hanna Mining	Keewatin	Lube Oil	Broken Line	700 g
5/21/85	City of Proctor	Proctor	Gasoline	Truck Tank	40 g
5/14/85	MP&L	Duluth	Oil	Blowout	25 g
5/10/85	Lakeland Oil Co.	Cloquet	Gasoline	UST	*
5/07/85	Potlatch	Cloquet	Hydraulic Oil	Hose	50 g
5/06/85	Mational Steel Pelley Co.	Keewatin	Mineral Oil	Transformer	100 g
4/24/85	Potlatch	Cloquet	Mineral Oil	Transformer	1 g
4/18/85	US Coast Guard	Duluth	Diesel	Pump Failed	15 g
4/18/85	Como Oil Co.	Duluth	Fuel Oil	Overfill	5 g

Appendix J cont. Documented Spills in Minnesota

DATE	RESPONSIBLE PARTY	LOCATION	SPILL	CAUSE	AMOUNT
4/18/85	Potlatch	Cloquet	PCB	*	1 qt
4/10/85	Ania Gift Shop	Duluth	Gasoline	UST	*
4/04/85	*	Mt. Iron	Gasoline	UST	*
3/25/85	Willers Truck Service	Twig	Diesel	Truck	60 g
3/18/85	Conoco	Wrenshall	Gasoline	Pump Gasket	44 bl
3/18/85	Edwards Oil	Hibbing	Gasoline	AST	63 g
3/06/85	Curtis Oil Co.	Duluth	Diesel	Overfill	50 g
2/28/85	Park Construction	Duluth	Motor Oil	*	*
2/27/85	Transport Inc.	Mt. Iron	Gasoline	Overfill	600 g
2/27/85	Potlatch	Cloquet	Gasoline	Line	20 g
2/15/85	Lakehead Oil Co.	Duluth	Fuel Oil	Overfill	*
1/25/85	Conoco	Wrenshall	JP4	Filter Leak	409 bl
1/11/85	Inland Steel Mining Co.	Virginia	Mineral Oil	Transformer	*
11/29/84	*	Duluth	Paint Stripper	*	*
11/29/84	*	Duluth	Gasoline	Spill	*
11/29/84	Virginia Public Utility	Eveleth	Mineral Oil	Truck	1 g
11/29/84	PRVI-FEBRUARY	Duluth	Oil	Ship	*
11/29/84	Air National Guard	Duluth	Jet Fuel	Spill	*

Appendix J cont. Documented Spills in Minnesota

DATE	RESPONSIBLE PARTY	LOCATION	SPILL	CAUSE	AMOUNT
11/28/84	WM Pipeline	Duluth	Gasoline	*	*
11/27/84	Vintage Acres Mobile Homes	Duluth	Fuel Oil	Line	*
11/19/84	WLSSD	Duluth	Sewage	Bypass	1,500,000 g
11/15/84	WLSSD	Duluth	Wastewater	Heavy Rain	45,000 g
11/15/84	Potlatch	Cloquet	Soap Wood Slurry	Overflow	20,000 g
11/15/84	Superwood	Duluth	Molasses	Dike Vakve	6000 lbs
11/06/84	Mobil One Stop	Cloquet	Fuel Oil	Overfill	50 g
10/30/84	Indianhead	Twig	Fuel Oil	Truck Accident	*
10/26/84	Erickson Petroleum	Hibbing	Gasoline	*	*
10/24/84	US Steel Corp.	Mt. Iron	Mineral Oil	Transformer	40 g
10/07/84	*	Cloquet	Diesel	Truck	100 g
9/26/84	Hibbing Taconite	Hibbing	Diesel	Overfill	500 g
9/13/84	Potlatch	Cloquet	Hydraulic Oil	*	*
9/07/84	Hanna Mining	Nashwauk	PCB	Transformer	*
8/24/84	MN Power	Fond du Lac	Oil	*	1 g
8/15/84	Holiday Transport	Virginia	Gasoline	Truck	*
8/07/84	Potlatch	Cloquet	Effluent	*	*
7/30/84	Standard Brick & Supply	Duluth	Asphalt	Overfill	560 g

Appendix J cont. Documented Spills in Minnesota

DATE	RESPONSIBLE PARTY	LOCATION	SPILL	CAUSE	AMOUNT
7/25/84	MN Power	Duluth	Mineral Oil	Transformer	*
7/12/84	Great Lakes Towing Co.	Duluth	Oil	Barge	*
6/28/84	ICO	Gilbert	Gasohol	Overfill	*
6/14/84	Potlatch	Cloquet	Wax Emulsion	*	500 g
6/10/84	WLSSD	Duluth/52 A E	Sewage	Heavy Rain	10,000 g
6/10/84	WLSSD	Duluth/77th A W	Sewage	Heavy Rain	*
6/10/84	WLSSD	Proctor	Sewage	Heavy Rain	*
6/10/84	WLSSD	Duluth	Sewage	Heavy Rain	*
12/25/83	WLSSD	Cloquet	Wastewater	Line Clogged	*
12/16/83	WLSSD	Duluth	Sewage	Backline Break	750,000 g
11/20/83	WLSSD	Proctor	Wastewater	Line Failure	71,000 g
11/20/83	WLSSD	Duluth	Sewage	Line Clogged	337,000 g
11/08/83	WLSSD	Duluth/Endion	Wastewater	Construction	80,000 g
10/28/83	WLSSD	Duluth	Ethylene glycol	Spill	100 g
8/30/83	WLSSD	Duluth/Endion	Wastewater	Power Failure	235,000 g
6/02/83	WLSSD	Duluth/52 A E	Sewage	Planning Error	5000 g
12/28/82	WLSSD	Duluth Plant	Liquor Foam	Human Error	2500 g
12/26/82	WLSSD	Scanlon	Sewage/Wastewater	Line Repair	6,000,000 g

Appendix J cont. Documented Spills in Minnesota

DATE	RESPONSIBLE PARTY	LOCATION	SPILL	CAUSE	AMOUNT
12/13/82	WLSSD	Proctor	Wastewater	Line Clogged	36,000 g
11/22/82	WLSSD	Carlton	Wastewater	Power Failure	69,000 g
3/05/82	WLSSD	Duluth/11th A W	Wastewater	Line Repaired	98,000 g
3/04/82	WLSSD	Duluth Plant	Calcium Hydroxide	Transfer	3500 g
6/16/81	WLSSD	Duluth/Endion	Sewage/Wastewater	Demonstration	300,000 g
3/03/81	WLSSD	Scanlon	Sewage/Wastewater	Main Break	180,000 g
3/03/81	WLSSD	Cloquet	Sewage/Wastewater	Main Break	22,500,000 g
3/03/81	WLSSD	Esko	Sewage/Wastewater	Main Break	100,000 g
1/30/81	WLSSD	Duluth/Endion	Sewage	Televising	50,000 g
1/19/81	WLSSD	Proctor	Wastewater	Line Break	300,000 g
12/02/80	WLSSD	Esko	Sewage/Wastewater	Line Repaired	180,000 g
12/02/80	WLSSD	Scanlon	Sewage/Wastewater	Line Repaired	300,000 g
12/02/80	WLSSD	Cloquet	Sewage/Wastewater	Line Repaired	30,000,000 g
11/24/80	WLSSD	Scanlon	Sewage/Wastewater	Electric Failure	250,000 g
5/15/80	WLSSD	Cloquet	Sewage/Wastewater	Crane Crash	767,000 g

KEY: g = Gallon
mg = Million Gallons
qt = Quart
bl = Barrel

tsp = Teaspoon
yds = Yards
lbs = Pounds
jp = Jet Petroleum/Fuel
UST = Underground Storage Tank
AST = Above Ground Storage Tank
* = Information Not Available

Appendix J

Part B

Compilation of Documented Spills and/or Accidental Releases
into the St. Louis River Drainage Basin
for the State of Wisconsin

Appendix J. Documented Spills in Wisconsin

DATE	RESPONSIBLE PARTY	LOCATION	SPILL	CAUSE	AMOUNT
1/09/91	Murphy Oil	Superior	Gas Additive	Valve Failure	25 g
1/08/91	Rod McKenzie	Superior	Fuel Oil #1	Tank Failure	140 g
1/03/91	Murphy Oil	Superior	Fuel Oil #1	Line Punctured	1550 g
12/20/90	J. R. Jensen	Superior	Fuel Oil	UST	*
12/12/90	Superior Senior High School	Superior	Fuel Oil	Tank Overflow	25 g
11/14/90	Murphy Oil	Superior	Sulfur	Overloaded Car	500 g
10/25/90	Carlson Fuels	Superior	Diesel	UST	*
10/24/90	Burlington Northern RR	Superior	Motor Oil	Drain Tile Leak	200 g
10/01/90	Cronstrom Rentals	Superior	Gasoline	UST	*
9/14/90	Murphy Oil	Superior	Gasoline	Tank Leak	800 g
8/24/90	*	Superior	Mineral Oil/PCB	Dumping	5 g
7/24/90	Murphy Oil	Superior	Fuel Oil #5	Leaking Line	25 g
7/18/90	United Purification	Superior	Used Oil	Overflow	100 g
7/14/90	Murphy Oil	Superior	Fuel Oil #6	Line Failure	850 g
7/14/90	Murphy Oil	Superior	Crude Oil	Valve Opened	4500 g
6/27/90	Unocal Corporation	Superior	Sludge/Gasoline	UST	100000 g
6/20/90	Barko Hydraulics	Superior	Gear Lube	Barrel Crushed	55 g
6/18/90	Koppers Industries	Superior	Creosote	Leaking Tank	20 g

Appendix J cont. Documented Spills in Wisconsin

DATE	RESPONSIBLE PARTY	LOCATION	SPILL	CAUSE	AMOUNT
6/11/90	Indianhead Truck Lines	Superior	Gasoline	Overfill	115 g
5/24/90	Murphy Oil	Superior	Fuel Oil #2	Gauge Failure	50 g
5/04/90	Highgate Court	Superior	Fuel Oil	UST	*
4/20/90	Lakehead	Superior	Diesel	UST	*
4/18/90	Murphy Oil	Superior	Fuel Oil #1	Leak in Pipe	250 g
4/17/90	Murphy Oil	Superior	Asphalt	Bad Valve	6500 g
3/29/90	Murphy Oil	Superior	Gas/Oil	Leaking Tank	300 g
3/25/90	Murphy Oil	Superior	Crude Oil	Valve Froze	100 g
3/15/90	Koppers Industries	Superior	Creosote	Leaking Tank	40 g
3/16/90	Soo Line RR	Superior	Diesel	Leaking Valve	400 g
3/09/90	Koppers Industries	Superior	Mineral Oil	Transformer	1 g
3/08/90	Murphy Oil	Superior	Waste Oil	UST	*
12/15/89	Peavy Globe Elevator	Superior	Fuel Oil	UST	*
12/15/89	Hammond Presbyterian Church	Superior	Fuel Oil #2&6	UST	*
12/15/89	Murphy Oil	Superior	Fuel Oil #2	Valve Opened	625 g
11/08/89	Amoco Oil	Superior	Waste Oil	UST	*
11/05/89	Burlington Northern RR	Superior	Benzene & Toluene	Valve Leaked	28000 g
11/11/89	United Purification	Superior	Petroleum	UST	*

Appendix J cont. Documented Spills in Wisconsin

DATE	RESPONSIBLE PARTY	LOCATION	SPILL	CAUSE	AMOUNT
11/01/89	Figgens Transport LTD	Superior	Fuel Oil	Truck Accident	200 g
10/26/89	Koppers Industries	Superior	Creosote/Petrol	Tank Overflow	2.5 g
10/20/89	Superior Water, Light & Power	Superior	Gasoline	Line Punctured	5 g
10/14/89	Murphy Oil	Superior	Asphalt	Tank Overfill	500 g
10/05/89	*	Superior	Fuel Oil	Tank Overfill	*
9/28/89	Murphy Oil	Superior	Crude Oil	Valve Open	500 g
9/08/89	Chicago North Western RR	Superior	Soda Ash	Spill	500 g
9/03/89	Murphy Oil	Superior	Asphalt	Transfer Spill	840 g
8/25/89	Murphy Oil	Superior	Fuel Oil #3	Tank Overfill	80 g
8/21/89	Seven Eleven Broadway	Superior	Gasoline	UST	*
8/18/89	Murphy Oil	Superior	Asphalt	Tank Gauge Fail	20 g
8/10/89	Murphy Oil	Superior	Gasoline	Tank Leak	150 g
8/02/89	Murphy Oil	Superior	Fuel Oil #1	Tank Overfill	200 g
7/28/89	Murphy Oil	Superior	Crude Oil	Open Valve	500 g
7/25/89	Garon Knitting Mills	Superior	Diesel	UST	*
7/25/89	Milkhouse Convenience Store	Superior	Gasoline	UST	*
6/20/89	Murphy Oil	Superior	Waste Oil	Leaky Seal	80 g
6/09/89	ABC Rail Corporation	Superior	Gasoline	UST	*

Appendix J cont. Documented Spills in Wisconsin

DATE	RESPONSIBLE PARTY	LOCATION	SPILL	CAUSE	AMOUNT
5/11/89	Amoco Oil Terminal	Superior	Fuel Oil	Separator Tank	*
5/02/89	Hardees	Superior	Gasoline	UST	*
1/21/89	Murphy Oil	Superior	Fuel Oil #2	Bad Gauge	4000 g
1/7/89	Murphy Oil	Superior	Gasoline	Valve Malfunction	150 g
12/19/88	Murphy Oil	Superior	Fuel Oil #2	Frozen Valve	200 g
11/8/88	Murphy Oil	Superior	Fuel OIl #6	Overfilled	84 g
10/28/88	Quickie Transport	Superior	Fuel Oil	UST	12500 g
10/27/88	Jacobson Trucking	Superior	Asphalt	Valve Cracked	3000 g
10/24/88	Corbin Bar	Superior	Fuel Oil #1	Tank Leak	15 g
9/28/88	Murphy Oil	Superior	Crude Oil	Open Tank	151200 g
8/15/88	Murphy Oil	Superior	Naptha	Open Valve	280 g
8/10/88	Murphy Oil	Superior	Asphalt	Loading Spill	50 g
7/8/88	Murphy Oil	Superior	Crude Oil	Gasket Blew	210 g
6/09/88	Koppers Industries	Superior	Creosote/Oil	Valve Leak	1500 g
6/01/88	Koppers Industries	Superior	Creosote	Leaking Hose	100 g
5/27/88	Murphy Oil	Superior	Liquid Asphalt	Leaking Tank	4500 g
5/22/88	Halvor Lines	Superior	Fuel Oil #2	Truck Accident	50 g
5/21/88	Halvor Lines	Superior	Fuel Oil #2	Truck Accident	20 g

Appendix J cont. Documented Spills in Wisconsin

DATE	RESPONSIBLE PARTY	LOCATION	SPILL	CAUSE	AMOUNT
5/18/88	Murphy Oil	Superior	Fuel Oil #1	Leak in Pipe	190 g
5/01/88	Murphy Oil	Superior	Liquid Asphalt	UST	4500 g
2/15/88	*	Superior	PCB Oil	Transformer	30 g
1/28/88	Unocal Corporation	Superior	Fuel Oil/Gasoline	UST	*
1/11/88	Lakehead Pipeline	Superior	Crude Oil	Valve Failed	175 barrels
1/05/88	*	Superior	Fuel Oil #2	Dumping	500 g
1/04/88	O'Brien Oil Co.	Superior	Fuel Oil #2	Truck Accident	400 g
9/16/87	*	Superior	Pesticide	Dumping	200 g
5/12/87	Murphy Oil	Superior	Tar	Bad Gauge	Unknown
5/12/87	Murphy Oil	Superior	Petroleum product	Bad Gauge	210 g
4/25/87	Murphy Oil	Superior	Asphalt	Open Valve	3150 g
4/25/87	Murphy Oil	Superior	Tar	Open Valve	3780 g
1/7/87	Murphy Oil	Superior	Fuel Oil	Leak in Pipe	8000 g
6/14/86	Murphy Oil	Superior	Unknown	Auto Gauge Off	100 g
3/21/86	Murphy Oil	Superior	Asphalt	Overfilled Tank	300 g
2/5/86	Murphy Oil	Superior	Asphalt	Faulty Gauge	>840 g
11/14/85	Murphy Oil	Superior	Fuel Oil #1	Leaking Line	100 g
6/27/85	Soo Line RR	Superior	Fuel Oil #2	Tank Ruptured	1000 g

Appendix J cont. Documented Spills in Wisconsin

DATE	RESPONSIBLE PARTY	LOCATION	SPILL	CAUSE	AMOUNT
3/21/85	Murphy Oil	Superior	Fuel Oil	Leaking Tank	250 g
4/24/84	Boswell's Spur	Superior	Gasoline	Leaking Tank	300 g
10/07/83	Maple Services	Superior	Fuel Oil #2	Hose Ruptured	75 g
11/01/82	Chicago & NWRR	Superior	Fuel Oil #2	Overfill	500 g
7/03/82	Soo Line RR	Superior	Fuel Oil #2	Tank Ruptured	3000 g
10/08/81	*	Superior	Fuel Oil #1	Tank Ruptured	150 g

APPENDIX K

Estimated 1989 Toxic Air Emissions Reported Under SARA 313
for Facilities within the St. Louis River Watershed

Appendix K. Estimated 1989 Toxic Air Emissions Reported Under SARA 313 for Facilities within the St. Louis River Watershed

FACILITY, LOCATION	SUBSTANCE	FUGITIVE AIR (POUNDS)	STACK AIR (POUNDS)
ABC RAIL CORPORATION SUPERIOR, WI	MANGANESE	250	250
BRANCOR VIRGINIA, MN	FORMALDEHYDE	-	250
	PHENOL	-	250
D.B. WESTERN VIRGINIA, MN	FORMALDEHYDE	250	250
DULUTH BRASS & ALUMINUM DULUTH, MN	COPPER & COMPOUNDS	250	750
HAARMAN & REIMER CORP. DULUTH, MN	MALEIC ANHYDRIDE		3
KOPPERS COMPANY, INC. SUPERIOR, WI	ANTHRACENE	17	19
	DIBENZOFURAN	29	43
	NAPHTHALENE	278	333
M.E. INTERNATIONAL DULUTH, MN	ALUMINUM OXIDE (FIBROUS)	1040	250
	CHROMIUM & COMPOUNDS	250	250
	MANGANESE & COMPOUNDS	250	250
	1,1,1-TRICHLOROETHANE	96200	-
MURPHY OIL USA, INC. SUPERIOR, WI	ALUMINUM OXIDE	-	37421
	BENZENE	2568	1193
	CUMENE	-	250
	CYCLOHEXANE	2087	402

Appendix K cont. Estimated 1989 Toxic Air Emissions Reported Under SARA 313 for Facilities within the St. Louis River Watershed

FACILITY, LOCATION	SUBSTANCE	FUGITIVE AIR (POUNDS)	STACK AIR (POUNDS)
MURPHY OIL USA, INC. continued	ETHYL BENZENE	1691	7830
	ETHYLENE	2483	1176
	NAPTHALENE	-	211
	PROPYLENE	12563	2288
	TOLUENE	7550	20336
	XYLENES (MIXED ISOMERS)	5468	53003
	1,2,4-TRIMETHYLBENZENE	-	2974
NORTH STAR STEEL MINNESOTA DULUTH, MN	CHROMIUM & COMPOUNDS	250	-
POTLATCH CORPORATION CLOQUET, MN	AMMONIA	21000	-
	CHLORINE DIOXIDE	250	19000
	HYDROCHLORIC ACID	-	180000
	METHANOL	20000	130000
	SULFURIC ACID	-	19000
SUPERIOR FIBER PRODUCTS SUPERIOR, WI	XYLENE	-	59295

Source: MN Dept. of Public Safety, 1990
WI DNR, 1990