WMRC Reports

Waste Management and Research Center

Pollutant Transport to Lake Calumet and Adjacent Wetlands and an Overview of Regional Hydrology

William P. Fitzpatrick,
Nani G. Bhowmik

Illinois State and Water Survey

RR-E50
September 1990
Electronic Version

About WMRC's Electronic Publications:

This document was originally published in a traditional format

It has been transferred to an electronic format to allow faster and broader access to important information and data

While the Center makes every effort to maintain a level of quality during the transfer from print to digital format, it is possible that minor formatting and typographical inconsistencies will still exist in this document.

Additionally, due to the constraints of the electronic format chosen, page numbering will vary slightly from the original document

The original, printed version of this document may still be available

Please contact WMRC for more information

WMRC
One E. Hazelwood Drive
Champaign, IL 61820
217-333-8940 (phone)

www.wmrc.uiuc.edu

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

WMRC is a division of the Illinois Department of Natural Resources

HAZARDOUS WASTE RESEARCH & INFORMATION CENTER
One East Hazelwood Drive
Champaign, Illinois 61820
(217)333-8940

HWRIC RR-050

Pollutant Transport ot Lake Calumet and Adjacent Wetlands and an Overview of Regional Hydrology

by

William P. Fitzpatrick
and
Nani G. Bhowmik

Illinois State Water Survey
Champaign, Illinois

September 1990
Reprinted May 1991

Illinois Department of Energy and Natural Resources

HWRIC RR-050

POLLUTANT TRANSPORT TO LAKE CALUMET AND ADJACENT WETLANDS AND AN OVERVIEW OF REGIONAL HYDROLOGY

by

William P. Fitzpartrick and Nani G. Bhowmik
Illinois State Water Survey
2204 Griffith Drive
Champaign, IL 61920-7495

Prepared for
the Illinois Hazardous Waste Research and Information Center
HWRIC Project 88/89-049

Printed September 1990
Reprinted May 1991

Printed by authority of the State of Illinois 91/200

ACKNOWLEDGMENTS

The authors would like to express their thanks to the laboratory personnel: Loretta M. Skowron and Mark Peden of the Illinois State Water Survey (ISWS) Analytical Chemistry Laboratory; Carolyn Hohenboken, John Helfrich, and Eleanor Hopke of the ISWS Aquatic Chemistry Laboratory; Mike Miller, Jim Ploetz, and Becky Roeper of the Inter-Survey Geotechnical Laboratory; and LouAnn C. Burnett of the Illinois Natural History Survey (INHS) Aquatic Biology Laboratory.

In addition, appreciation is expressed to Claudia Washburn and Gary Miller of the Hazardous Waste Research and Information Center for their technical assistance and guidance. Mike Demissie and Rodger Adams provided many helpful suggestions and comments throughout the project, and Edward Delisio provided field assistance. Becky Howard typed the camera-ready copy of this report, Gail Taylor edited the report, and Linda Riggin prepared the figures.

CONTENTS

CONTENTS (concluded)

TABLES

FIGURES

ABSTRACT

The transport of pollutants to Lake Calumet and adjacent wetlands was investigated by reviewing existing data and conducting field sampling and measurements. The regional hydrology and interactions with Lake Michigan were investigated to assess the impact of pollutants in the Lake Calumet environment on regional water resources. These studies were funded by the Illinois State Water Survey and the Hazardous Waste Research and Information Center.

Five sources of inflow to Lake Calumet and the wetlands east of the lake were selected for detailed measurements of water discharge and sampling for laboratory analysis of suspended sediment, organic carbon, organic halides, arsenic, cadmium, chromium, lead, and zinc concentrations. Sampling and measurements were performed on approximately a monthly basis for one year.

Principal findings of this study are: 1) The watersheds of Lake Calumet and the adjacent wetlands have been extensively altered by dredging, filling, and solid and liquid waste disposal activities. Shallow lakes and wetlands, once a prominent feature of the area, have been reduced to a few remaining areas. 2) Previous studies of the sediments of the lake and wetlands have shown concentrations of toxic metals and organic chemicals well above expected background levels and higher than those in nearby water bodies. Single species bioassay tests of the sediments have shown highly toxic responses at half of the sampling sites. 3) Water samples from tributaries of the lake and wetlands have shown levels of metals as high as 98 milligrams per liter (mg/l) zinc (well in excess of general use, secondary contact, and public water supply standards) and 65 mg/l chromium (well above the public water supply standard). 4) The inflow of toxic metals to the wetlands northeast of the lake was as high as 322 pounds per hour; over 99% of the total was from the sludge drying beds of the Metropolitan Water Reclamation District of Greater Chicago. 5) A site conveying discharge from a sewer and overland flow was measured as delivering 22,000 pounds per hour of sediment and over 7 pounds per hour of toxic metals to the lake. 6) Drainage from I-94 and adjacent landfill and roadside areas was the largest measured source of arsenic, lead and chromium to the lake, totaling over 4 pounds per hour on one date. 7) Composite toxicity bioassay results from four tributaries of the lake and wetlands indicate that three sites were rated highly toxic and one site extremely toxic. 8) Illegal dumping in the area is a threat to the water resources as well as to humans and native and migratory wildlife. 9) Present levels of water pollution generated in the area may threaten the quality of Lake Michigan.

The effects of past pollution in the form of contaminated water, sediment, and soils in the region are continuing threats to the environment. Land and water pollution in the Lake Calumet area is a threat to humans who work, recreate, hunt, and fish in the area as well as to native and migratory fish and wildlife. Current evidence suggests that pollutants from Lake Calumet may be delivered to Lake Michigan, the sole water supply source of millions of people in Illinois and bordering states.

Tighter control of water pollution from landfills, sludge beds, and sewer outfalls must be implemented. Illegal dumping of solid and liquid wastes in the area must be stopped. Remaining wetland areas should be managed for the benefits of flood control, water quality, and wildlife habitat. Ignoring the continuing pollution of water resources in the area will further threaten the environment and humans in the region as well as increasing the eventual cost of correcting the problem. Therefore, in addition to more diligent enforcement of existing regulations, further research is warranted to determine the magnitude of present water pollution in the Lake Calumet area, the effects of past pollution, and the impact on regional water resources including Lake Michigan.

EXECUTIVE SUMMARY

Lake Calumet is located in the southeastern portion of Chicago, Illinois, along the southwestern shore of Lake Michigan and forms the extreme southwestern edge of the Great Lakes Basin. Lake Calumet and adjacent wetlands are remnants of an extensive area of shallow lakes, rivers, and wetlands that dominated the region in pre-settlement times. The land and water resources of the area have been extensively altered by dredging, filling, and waste disposal activities. Large tracts of the area were filled for industrial and commercial siting beginning in the mid-19th century. Rivers were excavated for commercial navigation and interbasin transfer of water from the Great Lakes Basin to the Illinois River/Mississippi River Basin. The land currently is used primarily for residences, industry, commerce, waste disposal, transportation, and recreation.

This study was undertaken to examine the role of surface water in transporting pollutants to Lake Calumet and adjacent wetlands. Five drainage channels, tributary to Lake Calumet and the wetlands, were selected for monitoring of water discharge and pollutant loading on approximately a monthly basis for one year. Detailed measurements of water discharge and sampling for laboratory analysis of suspended sediment, organic carbon, organic halides, arsenic, cadmium, chromium, lead, and zinc concentrations were performed. The regional hydrology and interactions with Lake Michigan were briefly investigated to assess the potential impact of pollutants in the Lake Calumet area on regional water resources. These studies were funded by the Illinois State Water Survey and by a research contract with the Hazardous Waste Research and Information Center.

In 1987 the Illinois legislative Joint Committee on Hazardous Waste in the Lake Calumet Area, chaired by Senator Emil Jones and Representative Sam Panayotovich, determined that "Lake Calumet is affected not only by hazardous waste, but also by air, soil and water pollution and the growing crisis of solid waste management." The committee also referred to early waste disposal practices in the area: "Originally, the plant operators simply poured their industrial wastes into the lakes and rivers; in fact, one of the major attractions of the area was easy access to waste disposal. As industrial activity in the Calumet area increased, so did uncontrolled dumping of waste. . . . In addition to the effects of past contamination, Lake Calumet is currently impacted by a variety of nonpoint toxicant sources; leaching and dispersal from sediments; highway runoff, including spills; and surface runoff from the industrial properties contiguous to the lake. There is also seepage of contaminated groundwater from dumps, landfills, waste lagoons, underground storage tanks and, perhaps, illegal dumping."

With at least thirty-one solid and liquid waste landfills in the area, the region has one of the highest concentrations of solid and liquid waste disposal sites in the nation.

A 1965 study of water quality determined that all of the Calumet area streams were polluted and contaminated by toxic waste, differing only in degree and the nature of the pollutants. A 1977 study classified all river monitoring stations as moderately to severely polluted. Other studies described pollutants in the rivers of the region as including PCBs, sewage plant discharges, pickle liquors, heavy metals, fecal coliform, oily waste, ammonia, cyanide, and phenolic materials. Estimates of the source of pollution in the major rivers have indicated that the combined-sewer overflows in the area account for 45% of the total.

A 1988 study of the sediments of Lake Calumet showed levels of toxic metals and organic chemicals well above expected background levels and higher than those in nearby water bodies. This study examined the toxicity of the sediments to aquatic organisms and found that 90% of the sites sampled produced Microtox^{TM} values that were moderately to extremely toxic.

Lake Calumet and the adjacent wetlands are hydrologically interrelated to Lake Michigan and the Calumet River. Pollutants delivered to the Calumet River and Lake Calumet may be carried into Lake Michigan, the sole water supply source of millions of people in Illinois and bordering states. In addition, at times of extreme flood flows, the combined-sewer systems of Chicago and other adjacent communities in Illinois and Indiana overflow into the various rivers of the region and eventually discharge into Lake Michigan.

This study found concentrations of toxic metals in water samples as high as 98 milligrams per liter (mg/l) zinc, 65 mg/l chromium, 4.4 mg/l cadmium, and 12.5 mg/l lead. These values are well above established water quality standards for general use, secondary contact, and public water supply. The most contaminated measured source of water pollution in the area was drainage from the sludge drying beds of the Metropolitan Water Reclamation District of Greater Chicago. On one date during a heavy rainstorm, the flow coming off the beds at 107th Street and Stony Island Avenue was measured to have a sediment concentration of 33,000 mg/l, indicating that 59,600 pounds per hour of solids were flowing into the wetlands east of the lake. The metal discharge from the sludge beds to the wetlands was measured as 176, 117, 22, and 7.9 pounds per hour of zinc, chromium, lead, and cadmium respectively.

Drainage to the western side of Lake Calumet from Pullman Creek was determined to be the largest measured direct source of arsenic, lead, and chromium to the lake. On August 10, 1988, over 2,600 pounds per hour of sediment and over 4 pounds of toxic metals per hour were measured flowing to the lake from this source. Pullman Creek receives drainage from Interstate 94, nearby landfills, and roadside ditches. Pullman Creek drainage was sampled on four dates for bioassay toxicity testing. A composite index of toxicity, averaging the results of the Microtox^{TM} and *P. redivivus* techniques, indicated that drainage from this source was highly toxic.

Drainage to the eastern side of the lake was monitored at a storm sewer outfall site. Water discharged to the lake from this site has exceeded the established water quality standards for chromium, lead, and zinc. On August 10, 1988, a channel carrying the combined drainage from the sewer and overland flow was measured to have been delivering 22,000 pounds per hour of sediment and over seven pounds per hour of toxic metals. Results of three bioassay toxicity tests using the Microtox™ technique indicated that all samples were extremely toxic. The results of three tests employing the *P. redivivus* technique indicated that the water from this site was highly toxic.

This study did not examine the effect of drainage from known toxic and hazardous waste dumps in the area. The quantity of contaminants drained from these areas and the effects on the local and regional water resources are unknown at this time. This study is only a first step in an effort to quantify the level of pollution in the area since only a few of the many sources were examined to assess if pollution is continuing. This study produced evidence showing that pollution is continuing and poses a potential threat to the environment and to the health of humans who work, recreate, hunt, and fish in the area, as well as to native and migratory fish and wildlife.

Tighter controls of water pollution from landfills, sludge beds, and sewer discharges must be implemented. Further research is needed to quantify the present levels of pollution in water resources of the Lake Calumet area. In addition, pollutant transport out of the area to Lake Michigan and the Illinois River Valley should be investigated. The local and regional importance of Lake Michigan for water supply, recreation, and wildlife warrants immediate concern regarding contamination from pollutants generated in the Calumet region.

CHAPTER 1
INTRODUCTION

Project Description

This project was undertaken to examine the role of surface water in transporting pollutants to Lake Calumet and adjacent wetlands (Figure 1). Five drainage channels, tributary to Lake Calumet and the wetlands, were selected for monitoring of water discharge and pollutant loading on approximately a monthly basis for one year. The interrelationships of Lake Calumet with the major rivers of the region and Lake Michigan were also examined.

The specific objectives of this project were:

- Investigate the surface flow pattern in the study area.
- Investigate the instantaneous quantities of selected pollutants (suspended sediment, organic carbon, organic halides, arsenic, chromium, cadmium, lead, and zinc) carried by runoff at five sites on a once per month basis for approximately one year.
- Investigate the possible sources of pollutants measured at the monitoring sites and identify the receiving waters of these pollutants.
- In cooperation with the Illinois State Natural History Survey, obtain water samples for toxicological bioassay analyses.

Overview of the Greater Lake Calumet Area

Prior to modern development, the greater Lake Calumet area on the southwestern shores of Lake Michigan was dominated by extensive wetlands, sluggish rivers, and shallow lakes. The topography was relatively flat and level. Lake Calumet, the largest of the shallow lakes, covered an area nearly twice its present size. The surface geologic characteristics of the area are the result of glacial and fluvial actions. Following the retreat of the Wisconsinan glaciers, a vast lake covered much of northeastern Illinois and northwestern Indiana. This lake receded into present-day Lake Michigan and exposed a flat and poorly drained lakebed. The greater Lake Calumet area now occupies this former lakebed. In reporting the regional environment of the early and mid-19th century, Colten (1985) described Lake Calumet as having indistinct boundaries which fluctuated with each rise and fall in the level of Lake Michigan. He referred to surveying records which described the marshes which surrounded the lake as impassable. Colten quoted from Corps of Engineer records which reported the Calumet River and the land through which it flowed as being very low and swampy and, during rainy seasons, covered with water. The banks of the river were described as being poorly defined and surrounded by wetlands.

Since development and modification of the river and lakes for navigation and flood control, the hydrology of the area has become complex. For example, the Calumet River is under the control of the O'Brien Lock and Dam, and the river can be made to

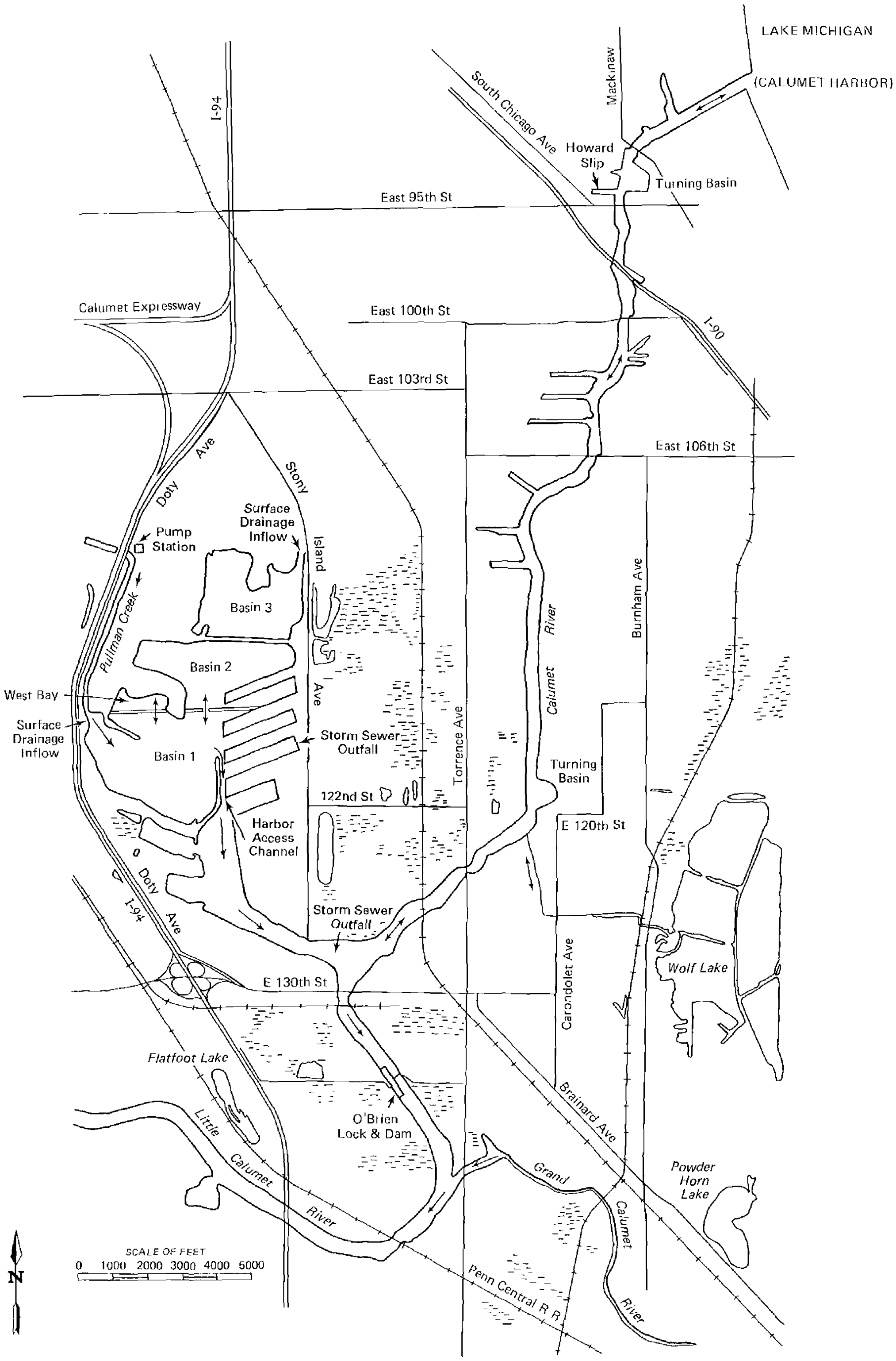


Figure 1. Greater Lake Calumet Region

flow either north to Lake Michigan or south to the Little Calumet River, and then to the Calumet-Sag Channel and the Illinois River of the Mississippi River Basin. Major rivers of the area (the Calumet, Grand Calumet, and Little Calumet Rivers) are capable of flowing in either direction and eventually discharging into either or both the Lake Michigan or Mississippi River basins.

Figure 2 shows the overall watershed of the Calumet River system. The primary outlets for drainage for the Calumet River system are the Calumet, Grand Calumet, and Little Calumet Rivers in Illinois, and Burns Ditch and the Indiana Ship Canal in Indiana. Drainage flows out of the area and into Lake Michigan through the Calumet River, the Indiana Ship Canal, and Burns Ditch, or to the Illinois River through the Calumet-Sag Channel.

Industrial and commercial development began in the mid-19th century. Metals processing, building material manufacturing, food processing, chemical and petroleum facilities, and other industries were located in the area. Modification of the land and water resources for site development, navigation, and waste disposal began at this time and continues to the present. Prior to modern environmental regulations, solid and liquid waste disposal consisted of dumping the materials on the ground or into the rivers, lakes, and wetlands of the area. Principal attractions of the area were its proximity to Lake Michigan and the presence of large undeveloped tracts and convenient waste disposal sites.

Presently the area is extensively developed and the land is used principally for residences, industry, commerce, waste disposal, transportation, and recreation. In addition, several forest preserves and conservation areas are located in this area. Table 1 lists some of the resources of the greater Lake Calumet area as compiled from U.S. Geological Survey (USGS) 7.5-minute series topographic maps and Illinois Department of Transportation (IDOT) state highway maps.

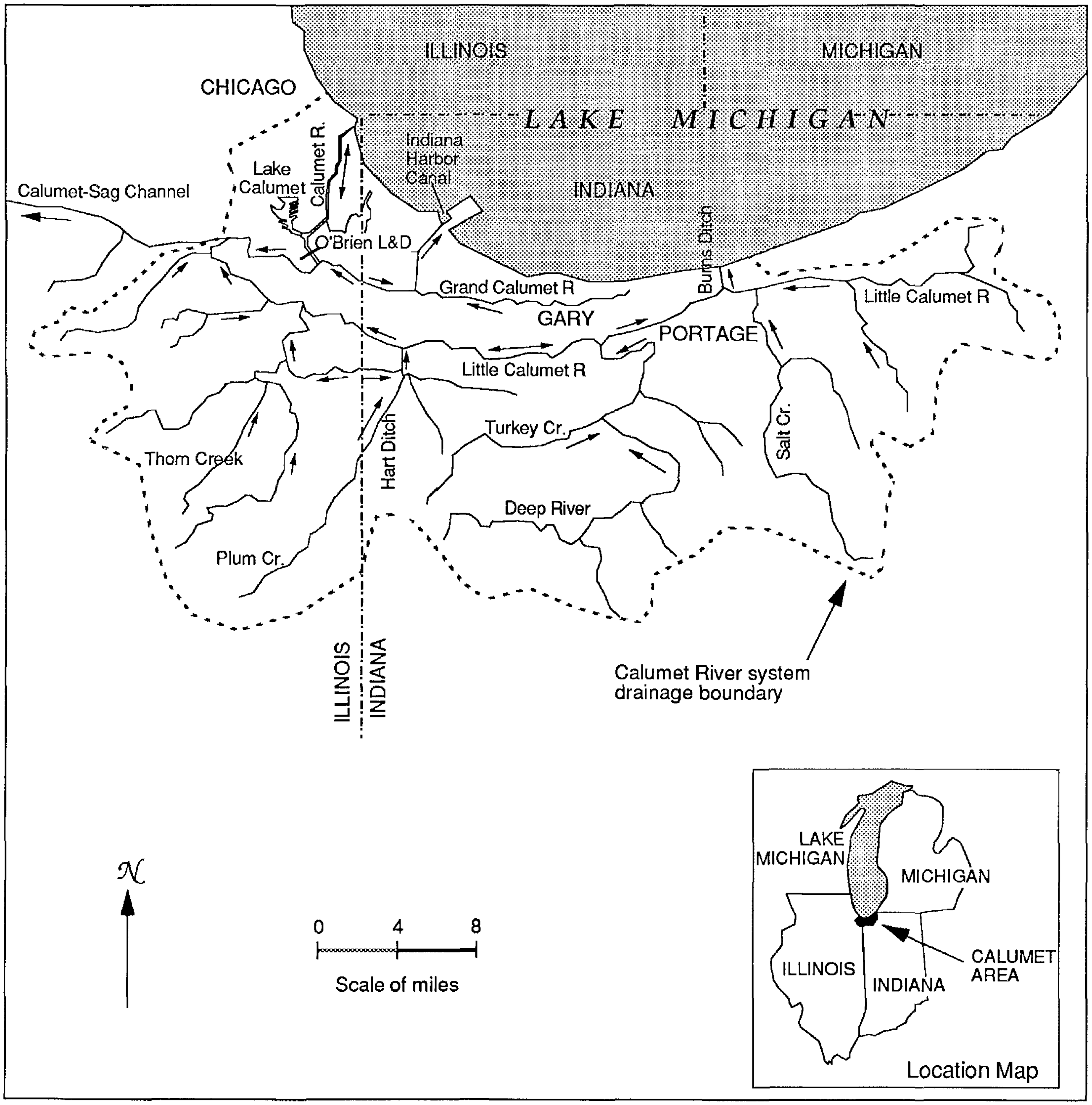


Figure 2. Streams, Lakes, and Drainage Patterns in the Calumet Area

Table 1 Overview of the Greater Lake Calumet Area

General

Boundaries of the Greater Lake Calumet Area
North - 95th Street
South - 146th Street
East - state line
West - State Street

Area
33 square miles

*Communities**	*Population* (approximate)
Burnham	4,000
Calumet City	40,000
Chicago	3,000,000
Dolton	25,000
Riverdale	13,000

Water Resources

Major Rivers and Canals	*Commercial Navigation*	*Recreation*	*Municipal Water Supply*
Calumet River	X	X	
Little Calumet River	X	X	
Grand Calumet		X	
Calumet-Sag Channel	X	X	
Lakes			
Michigan	X	X	X
Calumet	X		
Wolf		X	
Flatfoot		X	
Powder Horn		X	
Cottage Grove		X	

Wetlands
Twenty-eight major areas publicly and privately owned identified by USACE, encompassing over 600 acres (USACE, 1988)

Parks and Preserves

Wm W Powers State Conservation Area
Burnham Woods
Palmer Park
Rowan Park
Abbot Park
Bensley Park
Luella Park
Beaubinen Woods Forest Preserve
Eggers Woods Forest Preserve
Trumbull Park
Veterans Park
Calumet Park
Mann Park
Carver Park
Kensington Park

* The Greater Lake Calumet area encompasses portions of the communities listed

CHAPTER 2

BACKGROUND

Land Use Development and Waste Disposal

The Calumet region was altered greatly over the period 1869 to 1921, primarily because of modifications to the environment by the dredging and filling operations of the U.S. Army Corps of Engineers and industrial site developers, and by the indirect effects of industrial waste disposal (Colten, 1985). Following the dredging of the mouth of the Calumet River in the 1870s, the potential development of a harbor and the existence of open lands attracted many industries to the region. Wholesale wetland filling, waterfront dredging, and dumping of untreated industrial waste into streams, rivers, lakes, and wetlands of the region accompanied industrial development.

Colten (1985) reported that hundreds of acres of land were built up by the dumping of steel slag, dredge spoil, and other solid wastes to improve industrial sites. Manufacturers viewed the marshes of the region as convenient and inexpensive sites for solid waste disposal. From the late 19th century to the early 20th century, liquid wastes were discharged directly into nearby bodies of water. Lake Calumet, Lake Michigan, and the Calumet, Grand Calumet, and Little Calumet Rivers received direct industrial discharges. Colten (1985) described the frustration of the Army Corp of Engineers commander at attempts in 1893 to maintain the navigation channel of the Grand Calumet. The channel was filling up with slaughterhouse refuse, manufacturing waste, and sewer discharges as quickly as it could be excavated.

The following three-paragraph summary of early waste disposal practices was compiled from Colten (1985), JCHWLCA (1987), IEPA (1986), and Ross et al. (1988a). Early concerns over sewage and waste disposal centered on biological waste and the known link between recurring cholera and typhoid epidemics and tainted water supplies. For this reason, construction of the Sanitary and Ship Canal and the Calumet-Sag Channel was begun to divert the polluted Calumet and Chicago Rivers away from Lake Michigan. Reversal of the rivers toward Lake Michigan occurred during heavy rainstorms, and the epidemics continued through the early portion of the twentieth century until chlorine-based water treatment processes were developed. Bacterial pollution was the principal concern of early pollution control efforts, and little attention was given to the health effects of discharges that entered the rivers and lakes of the region from steel mills, paint manufacturers, distilleries, and other types of industries. Contaminated solid wastes were disposed of on-site, by dumping in wetlands, or at municipal dumps in the region. Materials dredged from the rivers were dumped on the river banks, used as fill for industrial sites, dumped in the marshes, or hauled down the river and dumped into Lake Michigan.

The period from the 1920s to the 1940s was a time of increasing concern over the detrimental effects of waste disposal, especially the effects on the water supply from Lake Michigan. Regulatory actions required manufacturers to provide basic treatment and control of their discharges. In the 1930s treatment facilities were installed in some industries. The Great Depression slowed industrial production and temporarily reduced waste discharge.

During the period from the 1940s through the 1970s, landfills were developed in the Calumet area for solid waste disposal. In 1948 the Clean Water Act directed manufacturers to treat their wastes or to dispose of them on land. Although the act somewhat reduced discharges into the waterways, the emphasis of waste disposal turned to land disposal. Industrial waste, municipal garbage, sludge from treatment plants, and dredging spoil were disposed of on the wetlands and low-lying areas of the region. The act's effort to clean the waterways resulted in the further destruction and pollution of wetlands in the area.

In 1940 the city of Chicago built a dike across the northern one-quarter of Lake Calumet (±300 acres) to drain it and use it as an open municipal dumping ground. Residents of the area complained about odors, rats, blowing trash, and fires constantly occurring at the dump. The area was finally closed in the late 1950s with the opening of the city's incinerator at 103rd Street at the northern end of the dump. However, unauthorized dumping continues throughout the area, especially in the immediate vicinity of Lake Calumet along Doty Avenue on the western shore and along Stony Island Avenue on the eastern shore. Garbage, construction debris, and other waste are dumped with such frequency that at times Stony Island Avenue is impassable to vehicles. Trucks en route to the landfills along the southeastern shore of the lake have overturned on Stony Island Avenue while attempting to drive through the piles on the road surface. Doty and Stony Island Avenues are periodically plowed by bulldozers to open the roads to traffic. However, the dumped materials are pushed into the roadside ditches, wetland areas, and drainage channels, thus adding further to the pollutant load in the lake and wetland environments.

Thirty-one known waste disposal landfills are currently operating in the southeast Chicago area (IEPA, 1986). Many other landfill sites were used in the past. Two of the known landfills have been closed and are under investigation by the Illinois Environmental Protection Agency (IEPA), the United States Environmental Protection Agency (USEPA), and the Illinois Attorney General's Office because of unauthorized dumping of toxic waste. The U.S. Scrap Corporation site, three-quarters of a mile from Lake Calumet, had an underground fire in 1985 that threatened the evacuation of residents of the area due to toxic smoke fumes (Ecology and Environment, Inc., 1986). The fumes were a result of the dumping of tens of thousands of gallons of pesticides, herbicides, benzenes, toluenes, and other chemicals directly onto the ground and into unlined pits that were later covered (Ecology and Environment, Inc., 1986). Operators of the site are suspected of being responsible for drums of liquid chemicals that were discovered buried on adjoining railroads, on Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) properties, and on public rights-of-way (Ecology and Environment, Inc., 1986). Although the presence of authorized and properly operated waste disposal landfills is not necessarily a cause of concern in itself, the long history of unregulated filling and dumping and the high density of both authorized and unauthorized dumps in this area indicate the need for close scrutiny of aquatic systems and the regional surface water resources of the area.

Previous Studies

The Illinois legislative Joint Committee on Hazardous Waste in the Lake Calumet Area determined that "Lake Calumet is affected not only by hazardous waste, but also by air, soil, and water pollution and the growing crisis of solid waste management" (JCHWLCA, 1987). The committee also referred to early waste disposal practices in the area: "Originally, the plant operators simply poured their industrial wastes into the lakes and rivers; in fact, one of the major attractions of the area was easy access to waste disposal. As industrial activity in the Calumet area increased, so did uncontrolled dumping of waste. Liquid wastes were directed into nearby water; these wastes were usually not treated, although they were sometimes diluted with waste waters." The Committee noted the practice of dumping slag, ash, contaminated spoil, and other solid waste in the wetlands of the area. The Committee also reviewed the historical changes that have occurred in the region since development and the present condition of water resources: "The east side of the lake [Lake Calumet] is currently populated with waste disposal facilities while the west side is bordered by the busy Calumet Expressway and a ditch filled with runoff from the expressway and nearby industries. In addition to the effects of past contamination, Lake Calumet is currently impacted by a variety of nonpoint toxicant sources; leaching and dispersal from sediments; highway runoff, including spills; and surface runoff from the industrial properties contiguous to the lake. There is also seepage of contaminated groundwater from dumps, landfills, waste lagoons, underground storage tanks and, perhaps, illegal dumping." The proximity of the Lake Calumet area to Lake Michigan, the regional water supply of Chicago and hundreds of other communities, and the possibility of contamination were of great concern to the Committee: "The state needs full assurance that the Lake Calumet area is not harming the quality of the valuable waters of Lake Michigan."

The Illinois Department of Public Health published a study of cancer mortality in the Lake Calumet area (IEPA, 1986). This study concluded that there was excessive mortality for all cancers in the area compared with the national averages. The study found excessive instances of lung and prostate cancer in white males and excessive bladder cancer in white females of the area. This study, which examined only cancers which resulted in death and not all occurrences, speculated that the possible causes could be attributed to occupational and environmental exposure.

Past and present land use and pollutant discharges to rivers and lakes in the region have resulted in severe aquatic pollution. Bottom sediments from Lake Calumet and the Calumet River are known to have dangerous levels of metals and organic chemicals (Ross et al., 1988a). A study of the toxicity to aquatic organisms in bottom sediments of Lake Calumet has shown that most areas of the lake (90% of the sites sampled) have levels of pollutants that produce Microtox™ values that indicate moderate to extreme toxicity (Ross et al., 1988a). The report of the Joint

Committee on Hazardous Waste in the Lake Calumet Area recognized that "various samples taken from soil and water in the area have indicated potential contamination from undetermined industrial sources (1987)." A recent study of Lake Calumet sediments found concentrations of lead, cadmium, chromium, and mercury in excess of human toxicity levels (Ross et al, 1988a).

A U.S. Department of Health, Education and Welfare report on pollutant problems in the area noted that the "streams of the Calumet area are grossly polluted by fecal contamination" (USHEW, 1965). It described serious pollution problems from municipal sewage treatment plant discharges and from industrial discharges of oily waste, pickle liquors, ammonia, cyanide, and phenolic materials. Bottom sediments of the Little Calumet and Calumet Rivers were described as composed of ooze and organic debris, with strong sewage and petroleum odors. All the streams of the Calumet area were described as polluted and contaminated by toxic waste, differing only in the degree and the nature of the pollutants.

These observations were essentially the same as those made in a Northeastern Illinois Planning Commission study conducted under Federal Water Pollution Control Act 92-500 (NIPC, 1977), in which all river monitoring stations were classified as moderately to severely polluted. Grand Calumet River sediments were characterized by Hydro Qual Inc. (1985) as contaminated with heavy metals and PCBs. Similar results were reported by the Corps of Engineers in 1983 (USACE, 1983), which found the water quality of the Little Calumet River and its tributaries to be of poor quality due to high biological oxygen demand (BOD), fecal coliform bacteria, and other pollutants.

Past polluted discharges to the rivers and lakes of the region have contaminated not only the waters but also the sediments and bottom materials to such a degree that they are unsuitable for open water disposal during maintenance dredging operations. These polluted sediments are a source of contamination to overlying waters and in addition, when scoured by streamflow, they contribute significant quantities of pollutants to receiving water bodies (Ross et al., 1988a).

Recent data on the water quality of the rivers of the region show a vast improvement over the past 30 years. Industrial discharges from point sources are regulated and monitored by the IEPA and the MWRDGC. However, sewer overflows that occur approximately 100 times a year (City of Chicago, 1976; MWRDGC, 1988) are also a major concern. They are a result of the relatively antiquated sewer system that handles both sanitary and storm waters. During storm events the sewer system overloads, and to prevent sewage backup into homes and businesses, raw sewage is pumped into the Calumet and Grand Calumet Rivers at 122nd Street, 130th Street, 138th Street, and the Howard Slip at 95th Street, less than one mile from Lake Michigan (City of Chicago, 1976).

The City of Chicago and the MWRDGC are aware of the deficiencies of the current system and have been working on several plans to eliminate sewer discharges into Lake Michigan, including new sewer pump stations, connector mains, and the Tunnel and Reservoir Plan.

The USEPA has classified sediments from the Calumet area of Lake Michigan and the rivers of the region as hazardous and unsuitable for open water disposal (USACE, 1982). Therefore materials dredged to maintain navigation require special confinement to isolate the contaminants. Romano et al. (1977) indicated that over 40 tons per year of zinc and 121 tons per year of iron are discharged into Lake Michigan from the Grand Calumet River. They believed that the Calumet River system is a major source of fluvial metals in Lake Michigan. Shimp et al. (1971) showed that arsenic, lead, bromine, copper, chromium, mercury, zinc, and organic carbon are accumulating in southern Lake Michigan. Little research has been conducted to determine the relative contribution of pollutant loads by the tributaries in the southern Lake Michigan basin. The abundance of various anthropogenic elements in the sediments of the southern basin do imply a source or sources in the vicinity of the depositional area.

Water Resources

Regional Drainage and Pollutant Transport

Figures 1 and 2 illustrate the principal rivers, lakes, and wetlands of the greater Lake Calumet region. This area is drained by three major rivers: the Calumet, Little Calumet, and Grand Calumet. Flow directions and drainage patterns are controlled, to a certain extent, by the O'Brien Lock and Dam located approximately eight miles south of Lake Michigan on the Calumet River and one-half mile north of the junction of the Little Calumet and Grand Calumet Rivers (Figure 1). The lock and dam were constructed in 1960 to divert runoff and pollutants from the Little Calumet and Grand Calumet Basins away from the Calumet River and Lake Michigan. During low and moderate runoff events, drainage from the Little Calumet and Grand Calumet is diverted west to the Calumet-Sag Channel, which conveys the drainage to the Des Plaines River of the Illinois/Mississippi River Basin. The O'Brien Lock and Dam therefore functions, at times, as a subcontinental drainage divide separating waters of the Mississippi Basin which flow to the Gulf of Mexico from the waters of the Great Lakes which flow to the Atlantic Ocean.

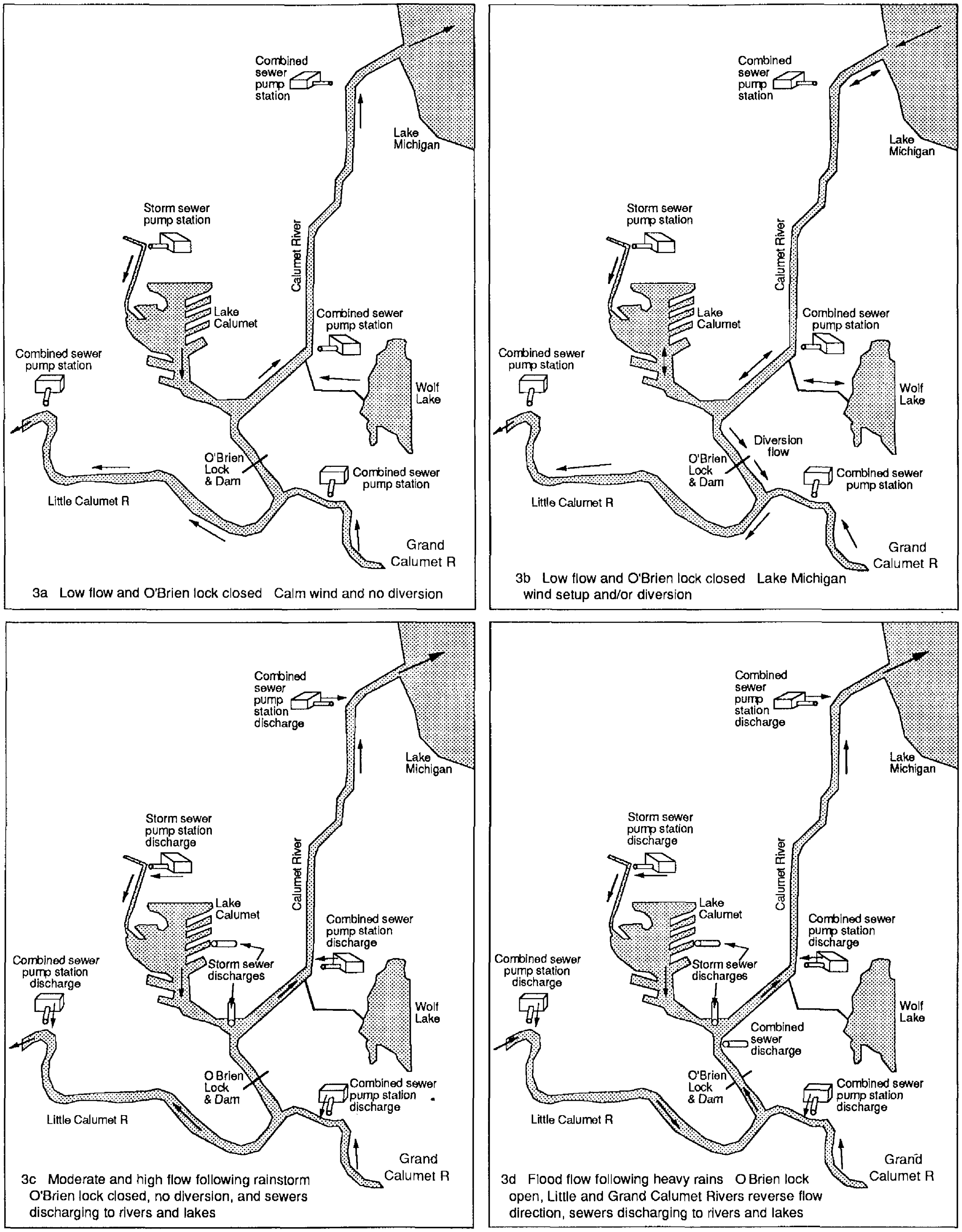
Water from the Calumet River is diverted south through the O'Brien Lock and Dam for navigational and discretionary purposes. Discretionary use generally applies to water diverted south to dilute flow in the Little Calumet and Calumet-Sag Channel for water quality improvement purposes. In Water Year 1988 an average of 245 cubic feet per second (approximately 160 million gallons per day) were diverted south through the lock and dam.

The topography of the area is relatively flat and the gradients of the streams and rivers are low. Channelization of the rivers and their tributaries and the presence of large impervious urban areas together with low-gradient channels have aggravated flood drainage problems. The low-gradient channels have aided the efforts to reverse the flow direction of the area's rivers away from Lake Michigan, yet during floods the control of flow direction can be difficult to maintain because of considerations related to preventing or reducing flood damages in upstream watersheds.

Typical flow conditions in the greater Lake Calumet area can be grouped into four general drainage patterns, shown in Figure 3. With low flow conditions in the region, calm winds, and no diversion of water south at the O'Brien Lock and Dam, the watersheds of Lake Calumet, Wolf Lake, and the Calumet River drain to the north and discharge to Lake Michigan (Figure 3a).

Under low flow conditions with diversion of water south through the O'Brien Lock and Dam, a flow gradient to the south through the Calumet River draws drainage from the watersheds of the river, Lake Calumet, and Wolf Lake away from Lake Michigan (Figure 3b). However, the relatively large cross-sectional area of the Calumet River (approximately 300 feet by 30 feet) and the average quantity of diversion result in very low average flow velocities generated by the diversion, on the order of 0.03 feet per second. Under these conditions, water in the Calumet River channel can flow in both the north and south directions in different portions of the river's cross section and/or at different times. Prevailing winds and setups on Lake Michigan can have greater effects on the flow and discharge directions than diversion at the lock and dam. Therefore, during the low flow conditions shown in Figures 3a and 3b, the rivers and inland lakes of the greater Lake Calumet area function much like a tidal basin of Lake Michigan where changes in Lake Michigan's water level and effects of wind direction can pump water in and out of the Calumet River and its tributary lakes and streams. The result of this pumping action is that polluted discharges in the watershed tributary to the Calumet River and sediments from the river's bed can be transported to Lake Michigan under relatively low flow conditions.

The effects of moderate and heavy rainstorms on the regional drainage pattern are shown in Figure 3c. Diversion of water south through the O'Brien Lock and Dam is usually reduced or stopped prior to and during rainfall and runoff events to increase the floodwater storage and conveyance capacity of the rivers and canals south of the lock and dam. Locally, the effect of reducing diversion is to increase the amount of runoff from the greater Lake Calumet area delivered to Lake Michigan. Therefore, when diversion is stopped, the entire runoff from the watersheds that are tributary to the Calumet River, including Lake Calumet, is discharged into Lake Michigan. A potentially more significant result of moderate and higher rainfall and runoff events is the discharge of untreated sewage into the Calumet River north of the lock and dam.



3a Low flow and O'Brien lock closed Calm wind and no diversion

3b Low flow and O'Brien lock closed Lake Michigan wind setup and/or diversion

3c Moderate and high flow following rainstorm O'Brien lock closed, no diversion, and sewers discharging to rivers and lakes

3d Flood flow following heavy rains O Brien lock open, Little and Grand Calumet Rivers reverse flow direction, sewers discharging to rivers and lakes

Figure 3 Typical Flow Patterns in the Greater Lake Calumet Region (after Bhowmik and Fitzpatrick, 1988)

The relatively inadequate combined sewer system of the area overloads frequently from storm water input. To prevent the backup of the sewer lines into homes and businesses of the area, the city of Chicago sewer pump stations divert untreated sewage from the trunk sewers into the Calumet, the Little Calumet, and Grand Calumet Rivers. Combined sanitary and storm sewers overflow to the waterways of the region 100 times per year (City of Chicago, 1976; MWRDGC, 1988). These sewer overflows account for 45% of the total pollutants delivered to the rivers of the area (City of Chicago, 1976). The Metropolitan Water Reclamation District of Greater Chicago (formerly the Metropolitan Sanitary District) initiated TARP (Tunnel and Reservoir Plan), an ambitious flood and pollution control program for the Calumet area which called for 37 miles of underground tunnels and reservoirs to contain sewage and storm runoff from the area. To date 9.2 miles of tunnels have been constructed in the Calumet area. These tunnels have reduced sewer overflows, but the system is presently insufficient to control larger rainfall and runoff events. Therefore sewage discharges to the rivers of the area and Lake Michigan continue.

In extreme floods, the lock gates of the O'Brien Lock and Dam have been opened to lower flood stages and reduce property damages to the south. Opening the lock gates during floods causes the Little Calumet River to reverse flow direction and discharge to the Calumet River and eventually into Lake Michigan (Figure 3d). These extreme floods have occurred on two recorded occasions in the past twenty years: June 13, 1981, and December 3, 1982. During the extreme floods which prompted the opening of the lock gates, the combined sanitary and storm sewers of the area were overloaded and discharging into waterways throughout the area, which resulted in the delivery of sewage from systems throughout the southern portion of Chicago, the south suburbs, and northwest Indiana to Lake Michigan at the Calumet Harbor.

Flow into Lake Michigan

Water and contaminants discharged into Lake Michigan at the Calumet Harbor (Figure 4) are transported into the lake by dispersion, transport by internal lake circulation currents, and currents generated by prevailing winds. Measurements of lake circulation and local winds published by USHEW (1965) have shown strong northerly current patterns from the Calumet area. These data indicate that discharges from the Calumet area can be transported north and west in Lake Michigan along the Illinois shoreline.

Mathematical simulation techniques were used by Katz and Schwab (1975) to assess the dispersion of pollutants discharged at the Calumet Harbor. A simulated slug of pollutants discharged to the harbor over a 24-hour period was shown to occupy the surface layers of the Illinois portion of Lake Michigan within six days (Figure 5). This simulation indicated that most of the southern basin of the lake would be impacted within 32 days. The work of Katz and Schwab and the data collected by USHEW indicate that public water supplies throughout the southern basin of Lake Michigan could be contaminated by pollutants discharged from the Calumet area.

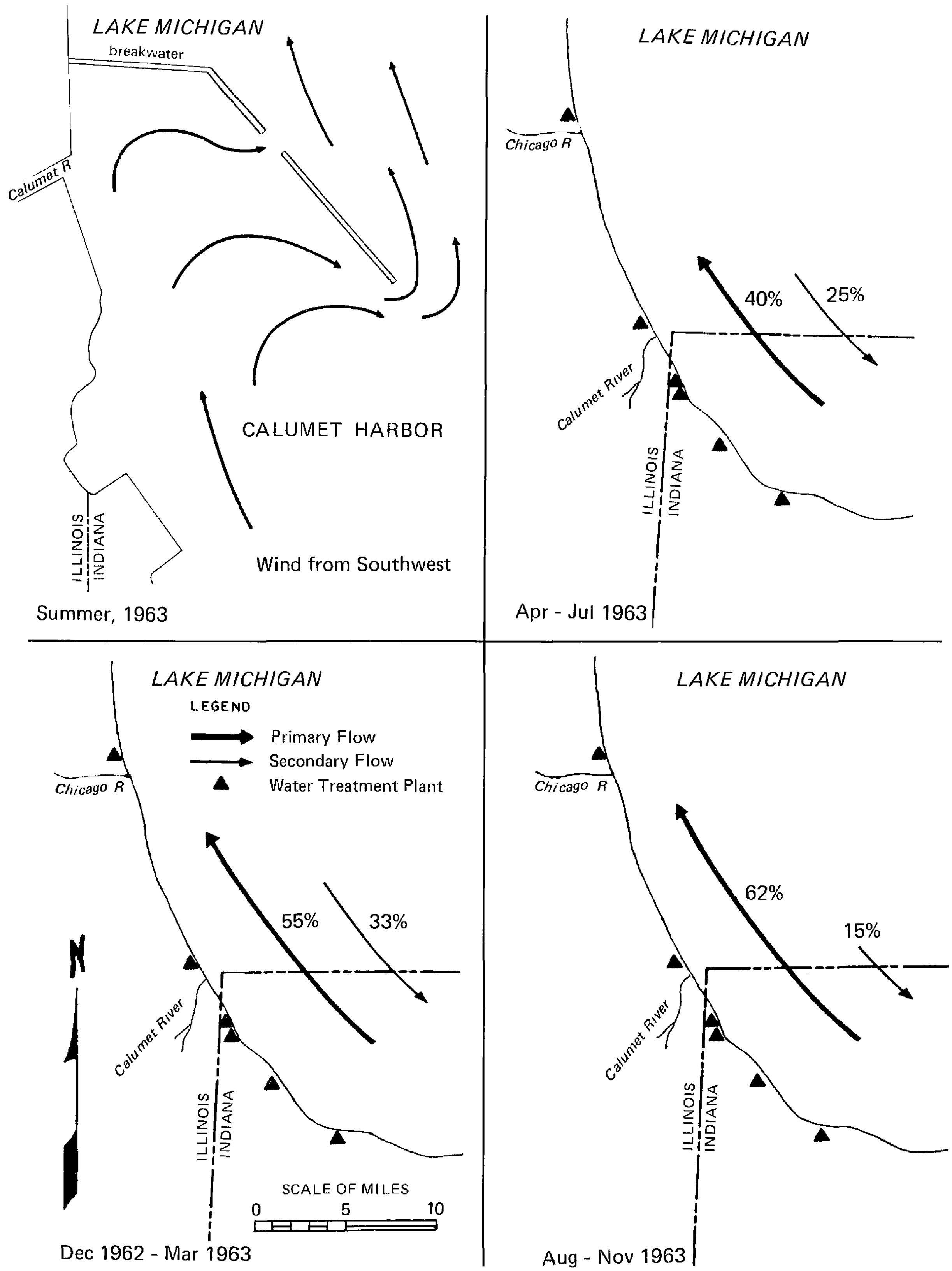


Figure 4 Current Patterns in Calumet Harbor and the Southern Basin of Lake Michigan (after USHEW, 1965)

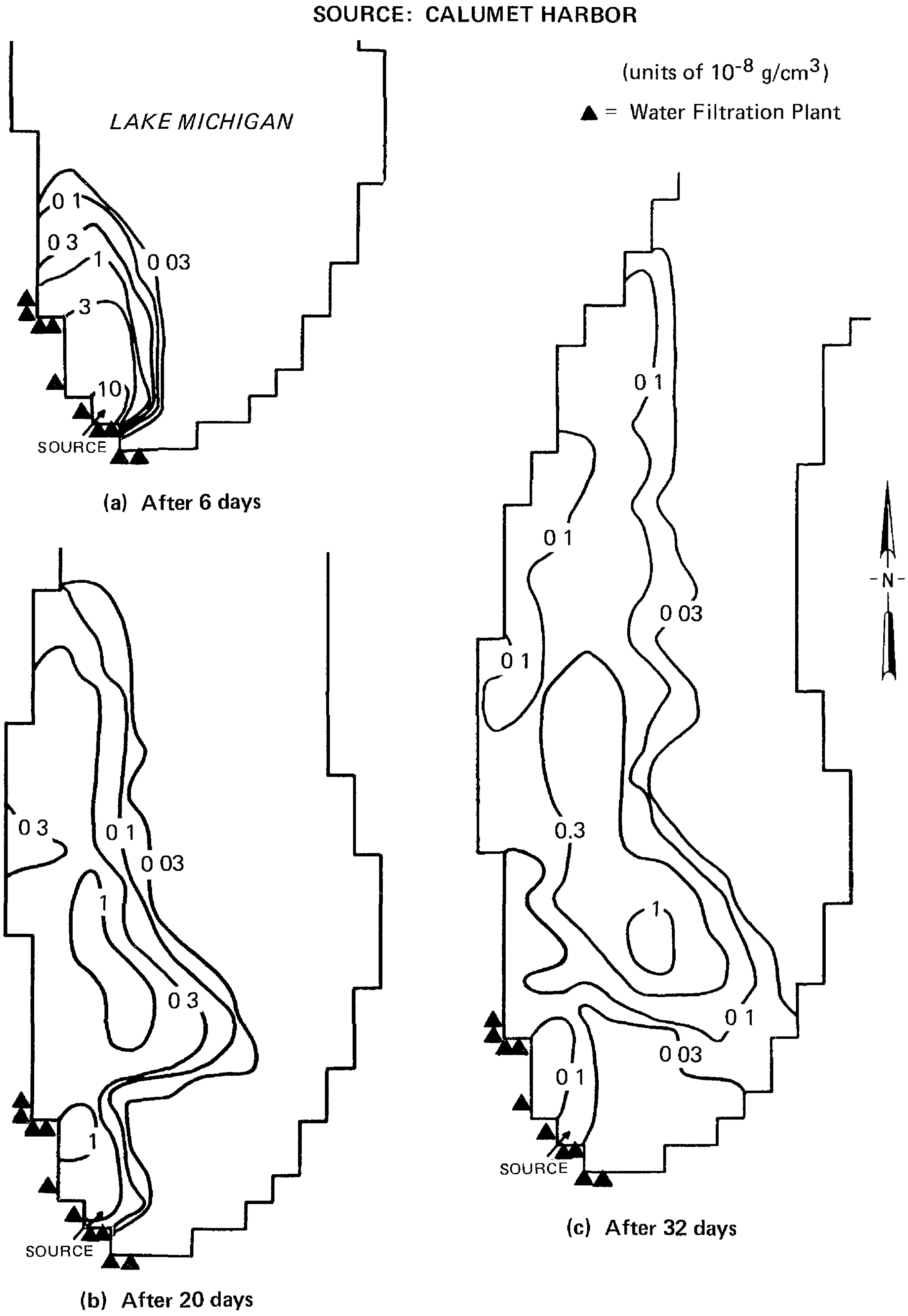


Figure 5. Simulation of a Pollution Slug Input in Calumet Harbor (after Katz and Schwab, 1975)

Conceptual Model of Drainage Patterns in the Greater Lake Calumet Area

Flow directions and discharges of the region are influenced by storm runoff, Lake Michigan's water level, diversion at the O'Brien Lock and Dam, combined sewer overflows, and flood control measures. Figure 6 is a conceptual model of drainage patterns in the greater Lake Calumet area. In this figure it can be seen that the interrelationship of the various lakes, rivers, and sewers is complex and changes according to low- or high-flow conditions. Locations of the various lakes, rivers, and sewer overflow points shown in this model can be seen in the maps of Figure 3. A key component of this model is the function of the O'Brien Lock and Dam, which isolates the drainage of the Little Calumet and Grand Calumet Rivers from Lake Michigan. The lock and dam is used in periods of low flow to divert the drainage of these rivers away from Lake Michigan and towards the Des Plaines River of the Illinois River Basin to keep the pollutant loads of these rivers out of the lake. During low flow, water is diverted from the Calumet River south through the lock and dam for navigational and water quality purposes. Diversion is usually stopped during storm events, which results in the entire runoff from the Calumet River and its tributaries discharging to Lake Michigan. Also shown in the model is the effect of flood flow reversal when the O'Brien locks are opened and the discharges of the Little Calumet and Grand Calumet Rivers change flow direction away from the Calumet-Sag Channel and flow to Lake Michigan.

Another key feature of the model in Figure 6 is the effects of the regional combined sewer system, which is capable of handling low-flow runoff and sanitary flow during dry periods but which overloads and spills into most of the rivers during high-flow periods. For example, in Figure 6 the low flow discharge from the sewer system is normally to the sewage treatment plant, and after treatment it is sent to the Little Calumet River and then to the Calumet-Sag Channel. However, during high flows, sewers are discharged to the Calumet River, which flows to Lake Michigan. During extreme floods when the flow of the Little Calumet is allowed to reverse and discharge into the Calumet River, the overflow from all the local sewers is carried through the O'Brien Lock and Dam and into Lake Michigan. This model illustrates the complex regional surface water drainage pattern. It shows the likely routes of pollutant transport by water in the area, as well as the water bodies which receive drainage from the area and the entrained pollutants carried by runoff and sewer overflows.

Local Drainage in the Vicinity of Lake Calumet

Locally the drainage of surface water is complex as a result of land use and land use changes in the area. Natural drainage channels in the vicinity of the lake originally were shallow and sluggish. Much of the study area still has relatively undeveloped drainage, as evidenced by the marsh areas to the east and northeast of Lake Calumet. Storm waters from the area north and east of the lake are discharged into the marsh areas east of the lake by roadside ditches and by the previously unnamed drainage ditch identified as Indian Treaty Creek in Figure 7. Drainage in

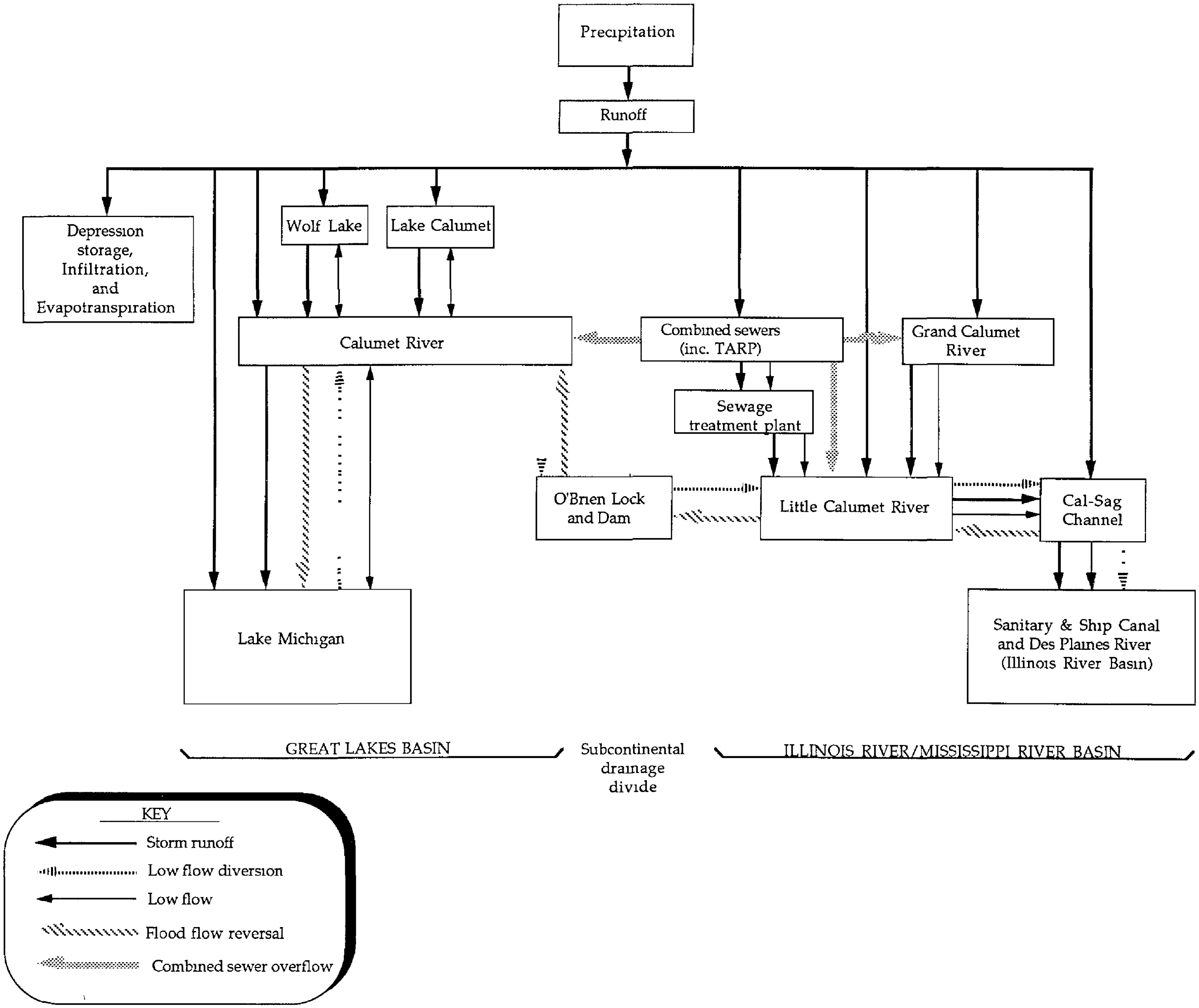


Figure 6. Conceptual Model of Drainage Patterns in the Greater Lake Calumet Area

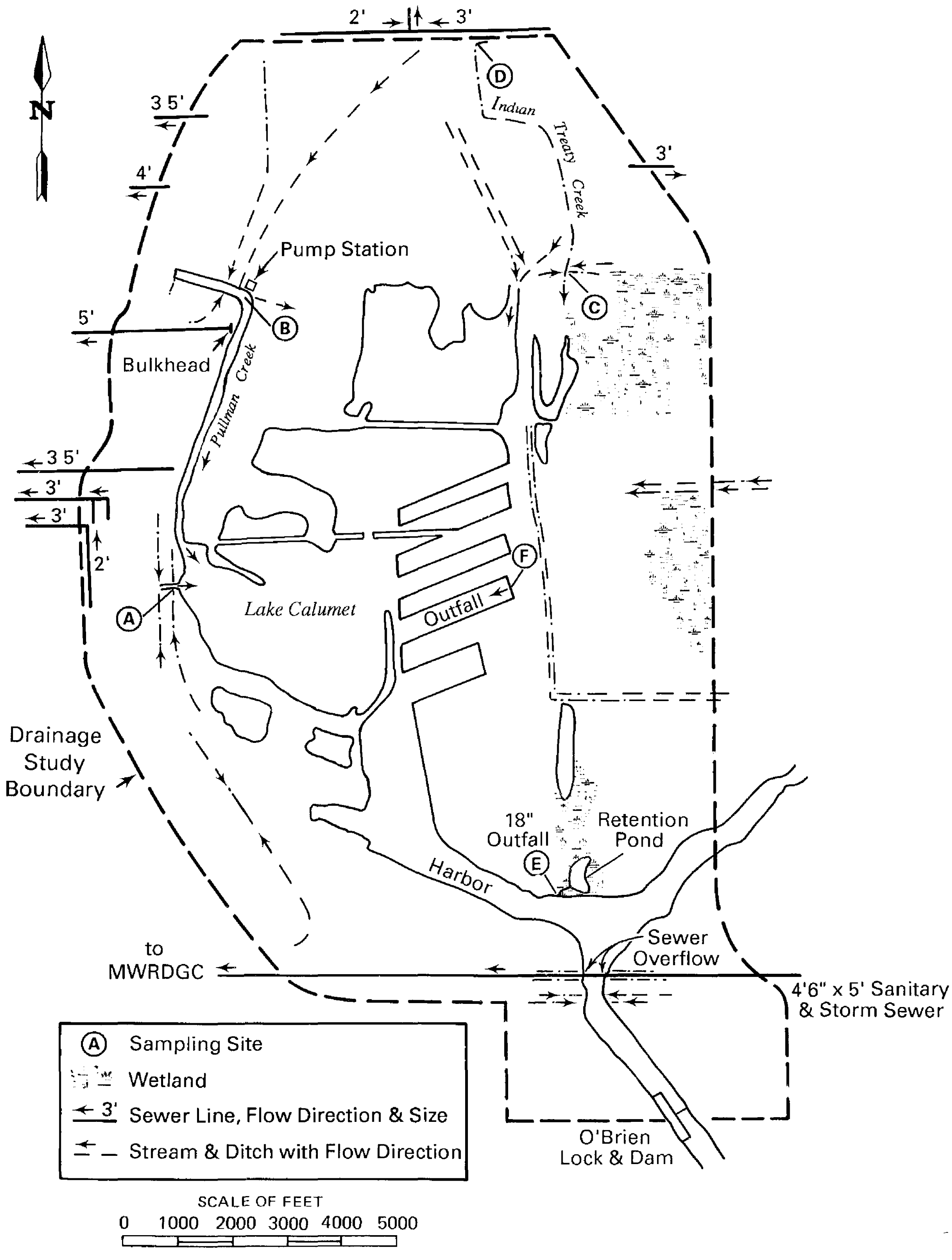


Figure 7. Local Drainage to Lake Calumet and Adjacent Wetlands

the areas south of the lake is accomplished by overland flow to the lake and the Calumet River and by combined sewers. The region west of the lake is drained by roadside ditches which flow by gravity into the lake at points shown on the drainage map of the lake (Figure 7).

The Illinois Department of Transportation maintains the drainage of Interstate 94. Roadside drainage ditches intercept runoff from the road and convey it to storm sewers beneath the interstate or to various discharge points along Lake Calumet. The storm sewers under the interstate are drained by a pump station located near the northwest shore of the lake. This pump station discharges into Pullman Creek, which flows south into Lake Calumet. Some areas adjacent to the interstate also drain into the Pullman Creek channel.

The city of Chicago has combined sewers servicing the residential areas west and south of the lake as shown in Figure 7. Trunk sewer lines connecting the city's sewer pumping stations cross through the study area along 130th Street. Industries on Chicago Port Authority properties are serviced by a sewer which discharges to the MWRDGC Calumet sewage treatment plant west of the lake.

CHAPTER 3

METHODS

Field Measurements and Sampling Techniques

Samples of water flowing into Lake Calumet and the wetlands were obtained for laboratory determination of total suspended sediment, total organic halides, total organic carbon, bioassay of toxicity, and concentrations of arsenic, chromium, cadmium, lead, and zinc. In addition to obtaining water samples, field measurements were performed for temperature, pH, and water discharge. Five sites were selected for routine sampling and measurements, and five additional sites were selected for comparative analysis and special-purpose sampling (Table 2 and Figure 8).

Table 2 Field Measurement Sites

Routine Sites	
CLA	Drainage from I-94, Doty Avenue, and fill areas west of the lake (±35 acres)
Pullman Creek (CLB)	I-94, IDOT pump sta and landfill areas west and north of the lake (±150 acres)
Indian Treaty Creek (CLC)	Drainage from wetlands north and east of the lake (±200 acres)
Sewer F (CLF)	Drainage from landfill areas east of the lake(±60 acres)
Sewer E (CLE)	Drainage from holding pond/sludge drying beds south of lake
Additional Sites	
Lake Michigan at Calumet Park boat launch	
Calumet River at 130th St	
Roadside ditch on 122nd Street near Stony Island Avenue receiving landfill area drainage	
Roadside ditch on Stony Island Avenue at 107th Street receiving MWRDGC sludge bed drainage	
Roadside ditch on Stony Island Avenue at 117th Street receiving landfill area drainage	
Indian Treaty Creek (CLD)	

Water Discharge Measurements

The flow of water at the sampling points was measured by using a Marsh-McBirney Model 201 current meter and the equal width increment technique of streamflow measurement developed by the United States Geological Survey (USGS) (Buchanan and Somers, 1969) and the American Society for Testing and Materials (standard practice for Open-Channel Flow Measurement of Water by Velocity-Area Method, Designation: D 3858-79, 1982). In flow conditions where the depth was greater than 1 foot, stream discharge was determined by subdividing the cross section of the channel into partial sections and measuring the velocity of the partial section at 0.2, 0.6, and 0.8 of the depth. The average velocity of the flow in each partial section was measured and multiplied by the flow area of the partial section. The sum of the individual partial section discharges determined the total stream discharge.

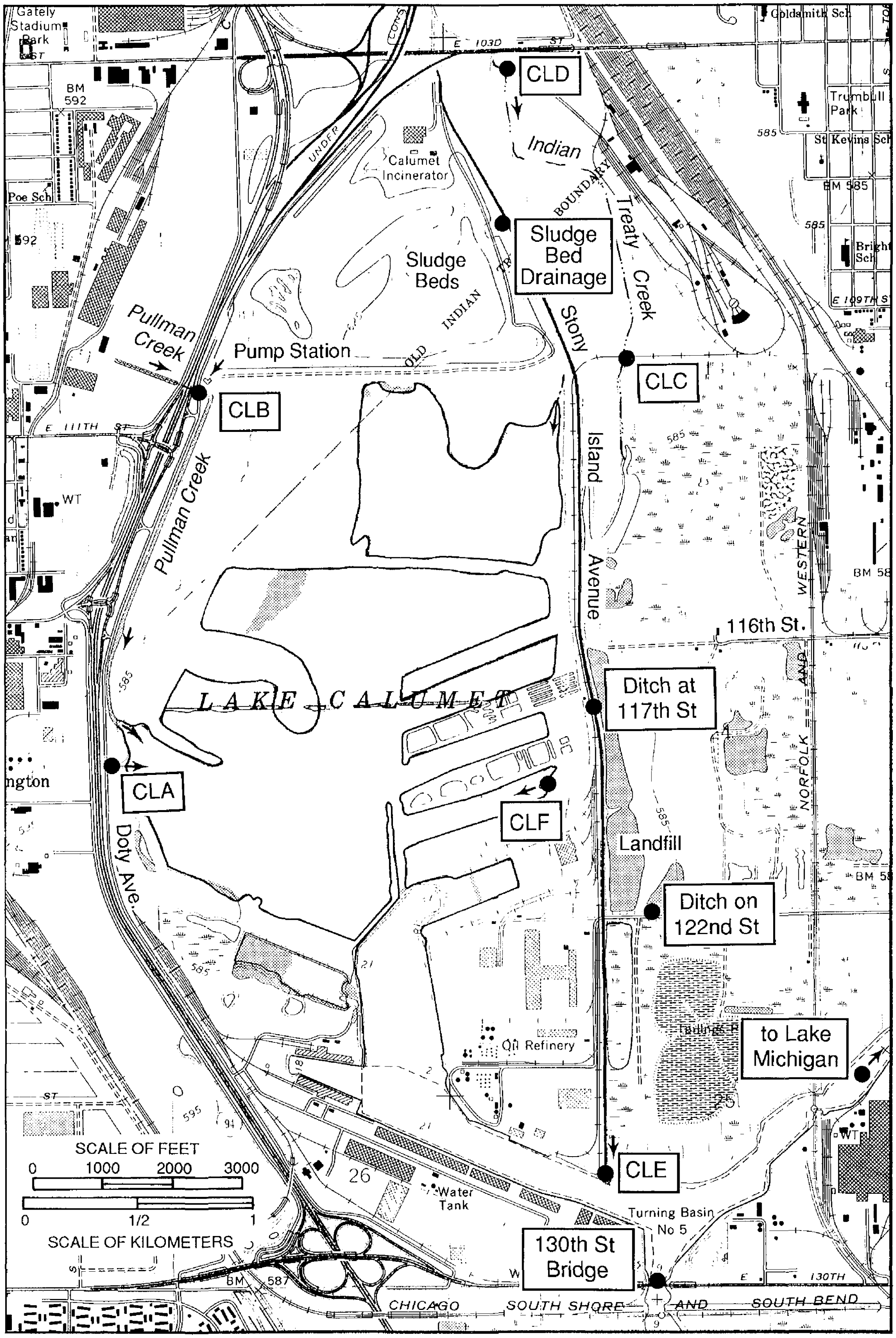


Figure 8 Project Monitoring Sites

At sites with less than 1 foot of depth, water discharge was determined by measuring the flow area and multiplying the areas by an estimated average velocity determined by visual observations and timing of the flow velocity through a measured distance.

Suspended Sediment Concentration Sampling

Two techniques were employed for sampling for suspended sediment concentration: isokinetic depth-integrating sampling and grab sampling. Isokinetic depth-integrating sampling was performed at sites with depths greater than 2 feet where the distribution of particulates through the cross section of flow was assumed to be non-uniform. The techniques for this type of sampling were described by Guy and Norman (1970) and the American Society for Testing and Materials (ASTM, proposed practices of Committee D-19, Water, and Subcommittee D-19.07, Sediment, 1982) This technique involved the use of a DH-59 isokinetic depth-integrating sampler which allows water to flow into the sampler at ambient stream velocity. By lowering the sampler through the water column at a constant transit rate, the sampler will integrate the sample of water and sediment to obtain an average sediment concentration in proportion to stream velocity at the measured vertical.

A second means of water sampling employed the grab sample technique (ASTM, Standard Practice for Sampling Water, Designation: D 3370-76, 1982), which was used in flow conditions where the depth was too shallow or the flow velocity too low for the depth-integrating method, or where the distribution of particles in the water was assumed to be fairly uniform (e.g., Lake Michigan).

Sampling for Metal and Organic Chemistry Parameters and Toxicological Bioassay

The sampling technique employed for these parameters was grab sampling directly with the sampling bottle, in accordance with instructions from the analytical laboratories. Sampling instruments such as the DH-59 were not used because of concerns about possible sample contamination from the metal samplers.

pH

Measurements of pH were performed in the field on suspended sediment samples by using an Ori Research model 211 portable digital pH meter calibrated with pH standards of 7.00, 8.80, and 10.00 prepared by the ISWS Analytical Chemistry Laboratory.

Field Observations

General observations, activities, and conditions during field data collection are summarized in the appendix.

Laboratory Procedures

Suspended Sediment

Samples were obtained by using standard pint (500 ml) glass bottles washed and rinsed in deionized water by the Inter-Survey Geotechnical Laboratory. Samples were identified, logged, and inspected in the field prior to storage in wire baskets for shipment to the analytical laboratory. Sample analyses were performed at the Inter-Survey Geotechnical Laboratory. The laboratory analytical procedure was to filter the sample through a Whatman 934AH borosilicate glass filter, dry the sample at 105°C overnight, weigh the dried sample retained on the filter, and then divide the filtered weight by the net sample weight (water and sediment mixture weight excluding the sample container weight). Sample results from the laboratory are reported in mg/l (milligrams per liter, approximately equivalent to parts per million, ppm).

Total Organic Halide (TOX)

Samples were obtained by using 500 ml amber glass bottles with Teflon-lined caps prepared by the Illinois State Water Survey (ISWS) Aquatic Chemistry Laboratory. The bottles were prepared by detergent cleaning, rinsing with organic-free deionized water, and then heating in an oven to 400°C. Sealed sample bottles were stored at ambient room temperature in the laboratory prior to pickup for field sampling. The bottles were transported to and from the sampling site in a cooler partially filled with ice. After sampling, the sample bottles were kept in the ice chest until returned to the lab, where they were transferred to a refrigerator and stored at 4°C until analysis. Maximum storage prior to analysis was two weeks. Analysis was performed on subsamples of the water and sediment mixture by using the Xertex/Dohrmann DX-20 Total Organic Halide Analyzer System. Field blanks were samples of organic-free water spiked at 10 micrograms per liter (μg/l) with trichlorophenol. Four blanks were prepared, of which two were kept in the lab and two were carried in the field. There were no significant differences between blanks kept in the lab or carried in the field, indicating that contamination or losses were negligible during all phases of sample collection, storage, and analysis. Daily cell check samples were prepared standards which were analyzed to ensure that the TOX system was functioning properly before the beginning of the analytical procedures. All recoveries were within the range of 90% ±10%, indicating that the system was functioning properly. Daily nitrate wash blank samples were used to monitor possible contamination of the TOX activated carbon absorbent. Values were less than 1.0 μg/l, indicating that the system was clean and not contaminating the samples. Storage blanks were samples of organic-free laboratory water prepared to monitor contamination in the field or in storage. All storage blank samples were within acceptable limits.

TOX results were reported in μg/l (micrograms per liter, approximately equivalent to parts per billion, ppb) chlorine equivalents and include both the purgeable and non-purgeable fractions. The method detection limit (MDL) for the TOX procedure was 1.8 μg Cl^-/l, with a 95% confidence interval of 1.3 to 3.0 μg/l (USEPA, 1982). The limit of quantification (LOQ) was defined as the level above which quantitative results may be obtained with a specific degree of confidence. The LOQ for the TOX procedure was 3.0 μg Cl^-/l. At levels equal to or above 3.0 μg Cl^-/l there was a minimum 95% certainty that the signal was statistically greater than zero. At levels between 1.3 and 3.0 μg Cl^-/l the results were reported as detectable but below the LOQ. At levels below 1.3 μg Cl^-/l the results were reported as not detected.

Total Organic Carbon (TOC)

Samples were obtained using 100 ml amber glass bottles with Teflon-lined caps prepared by the ISWS Aquatic Chemistry Laboratory. The bottles were prepared by detergent cleaning, rinsing with organic-free deionized water, and then heating in an oven to 400°C. Sealed sample bottles were stored at ambient room temperature in the laboratory prior to pickup for field sampling. The bottles were transported to and from the sampling site in a cooler partially filled with ice. Sample bottles were kept in the ice chest until returned to the lab, where they were transferred to a refrigerator and stored at 4°C until analysis. Maximum storage prior to analysis was two weeks. Analyses were performed on subsamples of the water and suspended sediment mixture by using an OI model 700 Total Organic Carbon Analyzer with a 5 ml sample loop. Potassium hydrogen phthalate (KHP) was the model organic compound. KHP was also the compound used for the field and calibration standards. The TOC analytical procedure assumed that all organic compounds were completely oxidized to carbon dioxide and water, as referenced by KHP analyses. The analytical MDL and LOQ are based on this assumption, which may not hold for samples with significant matrix effects (e.g., NaCl concentrations > 250 mg/l). The analytical MDL is 0.11 mg C/l and the 95% confidence interval is 0.08 to 0.18 mg C/l. The LOQ is 0.18 mg C/l. At levels equal to or above 0.18 mg C/l there was a minimum 95% certainty that the signal was statistically greater than zero. At levels between 0.08 and 0.18 mg C/l the results were reported as detectable but below the LOQ. At levels below 0.08 μg C/l the results were reported as not detected.

Metal Analyses

Metal samples were obtained in 500 ml and 250 ml high-density polyethylene bottles that were acid leached and prepared by the ISWS Analytical Chemistry Laboratory. Nitric acid (HNO_3 16M) was used as a preservative. Prior to analysis, the water and suspended sediment samples were digested for total metal analysis according to method METAL-4.1.3 (USEPA, 1983). Cadmium, lead, and zinc were determined by air-acetylene flame atomic absorption (AA) spectrophotometry utilizing deuterium continuum (D_2) background correction. A nitrous oxide - acetylene flame was used for chromium measurements. Arsenic was determined by graphite furnace atomic absorption spectrophotometry (GFAA) with D_2 background correction. The following USEPA methods were used: As - Furnace GFAA method 206.2; Cd - Flame AA method 213.1; Cr - Flame AA method 218.1; Pb - Flame AA method 239.1; and Zn - Flame AA method 289.1 (USEPA, 1983). Laboratory results were reported in mg/l. The standard deviation of the flame AA analyses for cadmium, chromium, zinc, and lead were expressed as plus or minus values which represent the 95% confidence interval calculated from the standard deviations of seven replicate analyses. The standard deviations of the GFAA analyses for arsenic were expressed as plus or minus values which represent the 95% confidence interval calculated from the standard deviations of seven replicate analyses of a 0.025 mg/l standard solution. Reagent blanks were analyzed to assess possible contamination of the samples as a result of the preservative acid or digestion procedures. Analyses of reagent blanks were below detection limits for all metals. Reference samples were prepared from USEPA Quality Control Samples (QCS) to verify instrument calibration and to document bias. All measurements were within the specified 95% confidence limits, indicating no significant biases. Detection limits and standard deviations of the results of these analyses are presented in Chapter 4.

Five water samples were analyzed by the inductively coupled argon plasma (ICAP) technique to screen for 26 different metals. The precision of the results was calculated from the standard deviations of four sequential measurements and represent the 95% confidence interval. Blank samples were prepared by using deionized water and nitric acid. They were analyzed in the same manner as the other samples to assess contamination due to reagents, materials, or sample digestion. The laboratory reported the blank results within expected ranges, and contamination did not appear to be a problem. In addition to the blank samples, two USEPA Quality Control Samples (QCS) (one each for metals and minerals) were analyzed to assess the accuracy of the measurements. Sample results were within the USEPA 95% confidence limit reported for the QCS with the exception of sulfur, which was reported as 4% higher than the USEPA 95% confidence limit.

Toxicological Bioassay

Fourteen water samples were analyzed for toxicity to biological organisms. Water samples were collected in 250 ml nalgene bottles prepared by the Illinois Natural History Survey (INHS) Aquatic Biology Laboratory. Water samples were filtered through high purity #1 Whatman filter paper (nominal porosity 11 μm) and through low absorption glass fiber filters (nominal porosity 1.2 μm). Dilutions of the filtered samples were prepared for Microtox^{TM} and *Panagrellus redivivus* (Nematode worm) development toxicity tests.

Microtox^{TM} toxicity tests (Bulich et al., 1981) were performed by using aliquots (10 μl) of commercially available reconstituted *P. phosphoreum* bacteria exposed, in duplicate, to 1.5 ml sample dilutions of 45.0, 22.5, 11.25, and 5.62%. Dilutions were prepared from commercially available Microtox™ diluent. Duplicate blank samples contained Microtox™ diluent and an aliquot of bacteria. Luminescence readings were taken prior to the addition of the elutriate and at 5 and 15 minutes after exposure to the sample. The decrease in luminescence in test samples was measured relative to the natural luminescent decay over time in the blank samples. A dose-response curve was constructed, and percent response values were determined. Results were presented as percent luminescent inhibition, where increasing values indicate increasing toxicity.

Panagrellus redivivus development toxicity tests (Samoiloff et al., 1980) were performed by analyzing the growth, from one stage to the next, of the post-embryonic stages of the nematode worm. Growth is inhibited when the normal physiological processes are blocked due to contamination (Ross et al., 1988a). The nematodes were exposed to 0.5 ml of 50% sample dilutions. Following 96 hours of exposure the proportions of nematodes at various stages were determined in the test and control animals. A composite parameter of fitness was calculated from the weighted averages of survival, growth, and maturity in each population. Results were reported in percent fitness reduction, where higher values indicate higher toxicity of the sample.

Calculation of Pollutant Loadings

The quantity of pollutants transported by flowing water over time can be calculated from the average concentration of a pollutant in the flow and the rate of flow (water discharge). The equation used for calculating the loading of pollutants was:

$$Qwq = Qw \times Cwq \times k \qquad (1)$$

where

Qwq is the load of the pollutant in pounds per hour
Qw is the water discharge in cubic feet per second (cfs)
Cwq is the pollutant concentration in mg/l
k is a conversion factor equal to 0.2246 (lbs liters)/(cfs mg hour)

Pollutant loading was calculated in pounds per hour to assess the quantity transported over time. An hour was selected as a convenient time unit for presenting these values. In-field sampling and water discharge measurements were performed essentially instantaneously; integrations of the changes in these parameters over time were not performed. Since changes in water discharge and concentrations can proportionately affect the calculated loads (equation 1), extrapolations of loads to time periods beyond one hour (e.g., daily, weekly) were not performed.

CHAPTER 4

RESULTS

Precipitation

Precipitation data for the Lake Calumet area were obtained from the National Weather Service records for the University of Chicago station (NOAA, 1987, 1988) located approximately 5 miles north of the study area. Precipitation over the monitoring period from November 1987 through October 1988 was below normal as shown in Table 3. The total amount of precipitation for the period was 29.96 inches, which represents only 85% of the normal annual amount of 35.28 inches. Normal annual and monthly amounts shown in Table 3 are the 30-year averages calculated from the records for 1951 through 1980.

The highest daily amount of precipitation over the study period was 1.73 inches recorded on December 15, 1987. The highest two-day precipitation amount was 2.07 inches recorded on July 17 and 18, 1988. The tributaries of Lake Calumet and the local wetlands were sampled 12 times over the study period (Table 3). The sampling dates represented a variety of conditions from very dry with little runoff, such as the July 12, 1988, sampling date (which followed 13 days of no recorded precipitation) to very wet conditions which occurred prior to the August 10, 1988, sampling date. The largest one-day storm event sampled was 0.32 inches on August 10, 1988. The largest two-day storm event preceding sampling was 1.69 inches on August 9 and 10, 1988.

Of the sampling dates, three occurred on days of measurable precipitation and four on days with precipitation in the previous 24 hours (Table 3).

In general, periods of below-normal precipitation coincide with below-normal runoff, erosion, and pollutant transport. The precipitation record therefore suggests that the study period was a time of relatively reduced runoff and pollutant loading to Lake Calumet and the local wetland areas.

Discharge Measurements

Water flow in the various streams and ditches of the Lake Calumet area is dependent on runoff from surrounding land surfaces caused by rainfall and other forms of precipitation. Discharge measurements were performed at the sampling points to assess the quantity of the measured pollutants transported in the sampled ditches and creeks. Discharges measured in the course of this study are shown in Table 4. The highest recorded discharge was 38 cubic feet per second (cfs) (1.02 million gallons per hour) in Pullman Creek on August 10, 1988. This flow was the result of the runoff in Pullman Creek of 18 cfs and the discharge of 20 cfs from the IDOT I-94 pump station located on the banks of Pullman Creek. Total flow measured on August 10, 1988, in the monitored inflowing tributaries of the lake was 43.8 cfs (1.18

Table 3 National Weather Service Precipitation Data, University of Chicago Station (NOAA, 1987, 1988)
(Values in inches, sampling dates shown in outline boxes)

Day	November	1987 December	1988 January	February	March	April	May	June	July	August	September	October
1	15	31		05	☐							05
2	26	T		14								74
3		11				25						.02
4		06		27		05					11	☐
5												T
6						1 05						
7		.33										
8	03	.26			01							
9	02	23		11	10		16			1.37		
10	02			14						.32		03
11	01	01		37						21		
12				08	02		07		☐		04	
13					06						13	
14				T	03					37		
15		1 73	01	37	03		04					
16	06						47	T			01	1 15
17	21		08	03					93			68
18	.03		51		07				1 14			
19	☐	11	T						02	25	20	
20		74	60	11	T						58	☐
21			T			06		10	42		01	15
22			T						05		06	T
23	04		02			30	05			.06	12	41
24		T	17		61		1 10			☐		01
25	65	09	06		09				16			
26			01		01				47			
27	07					.18	☐			02		
28	27	83	☐		37	.11				52		04
29	26	15			67			67				
30	10				.67				39			
31			.47		☐				.58			
Total	2 18	4 96	1 93	1 67	2 74	2 00	1 89	77	4 16	3 12	1 26	3 28
Normal*	2 23	2 37	1 86	1 51	2 81	4 01	3 35	3 91	3 84	3 77	3 05	2 57

T= trace amount of precipitation
* 1951-1980 average

University of Chicago Station
Illinois Division 02-Index number 1572
41°47' latitude, 87°36' W longitude

Table 4. Water Discharge at Monitoring Sites
(In cubic feet per second)

	Tributary to Lake Calumet						Tributary to Wetlands				
Date	CLA	Pullman Creek	IDOT I-94 pump sta.	Sewer E	Sewer F	NE trib. to Lake Calumet #	Indian Treaty Cr.	Indian T Cr @ 103rd Street *	122nd St. ditch	Stony Island Ave. ditch **	MWRDGC sludge bed drainage
4/7/87			0.0		3.0	2.0				0.0	
11/19/87	0.5	2.5	0.0	0.1	0.1		0.1	0 0			
12/8/87	0.4	0 1	0.0	1.5	3.0		0.4	0 0			
1/28/88	0.5	0 1	0.0	4.5	0.3		0.0	0.0			
3/1/88	0.5	0.1	0 0	3.0	0.2	0.0	0.0	0 1			
3/31/88	1.5	0.1	0.0	3.0	1.5		0.0	0 0		0 0	
4/28/88	0.1	11.5	0.0	0.1	0.1		0.0	0 0			
5/27/88	0.5	1.3	0 0	0.1	0.1		0.0	0 0			
7/12/88	0.3	0.4	0.0	0.0	0.2		0.1	0 0			
8/10/88	0.8	18.0	20.0	0.0	5.0		0.0	0.0		3.0	8.0
8/24/88	0.0	3.0	0.0	0.0	0.0		0.0	0.0			
10/4/88	0.2	6.0	0.0	0.0	0.1		0.5	0 0			
10/5/88		0.5	0.0								
10/20/88	1.5	1.0	0.0	0.0	0.2		0.0	0.0	0.0		
Number	12	13	14	12	13	2	12	12	1	3	1
Maximum	1.5	18.0	20.0	4.5	5.0	2.0	0.5	0 1	0.0	3.0	8.0
Minimum	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0 0	0.0	8.0
Average	0.6	3.4	1 4	1.0	1 1	1.0	0.1	0 0	0.0	1 0	8.0

Key:
Tributary of Lake Calumet flowing into the lake in the northeast corner of the north basin
* Indian Treaty Creek near 103rd Street, one mile upstream of routine sampling site
** Stony Island Ave. east roadside ditch samples: 4/7/87 and 3/31/88 @ 119th St., 8/10/88 @ 116th St.

million gallons per hour). The highest measured flow to the wetland areas east of the lake was 11 cfs, which also occurred on August 10, 1988. This flow was measured from two drainage ditches discharging to the wetlands: a flow of 3 cfs was observed from the east roadside ditch of Stony Island Avenue, which drained runoff from the landfills located between 116th and 122nd Streets; and a flow of 8 cfs was observed in the west roadside ditch along Stony Island Avenue at 107th Street, which was conveying runoff from the MWRDGC sludge drying beds. Water quality samples were obtained from these flows and the results are presented in the next section of the report.

Pullman Creek had the widest range of flow observed over the study period, ranging from a high of 38 cfs (including the pump station) on August 10, 1988, to a low of 0.1 cfs observed on four dates in the period December 1987 through March 1988. Indian Treaty Creek had the narrowest range of flows, ranging from zero, observed on eight dates, to 0.5 cfs on October 4, 1988. Indian Treaty Creek drains the wetland areas northeast of the lake, and its flow velocities tend to be very low. Water levels in the creek have been observed to fluctuate through a range of 1 foot; however, the water tends to collect in the wetland ponds and channels.

Laboratory Results

Suspended Sediment

Sample results exhibit a range of suspended sediment concentrations from 5.0 to over 33,000 mg/l (parts per million, ppm). The lowest concentration of 5.0 mg/l (0.0005% solids) was obtained from Lake Michigan at Calumet Park, and the highest was 33,254 mg/l (3.3% solids) from a sample of runoff from the MWRDGC sludge drying beds at 107th Street and Stony Island Avenue (Table 5).

Currently there is no standard for suspended sediment concentrations in waters of the state. The Illinois EPA, however, does limit suspended sediment (suspended solids) discharges in issuing NPDES (National Pollutant Discharge Elimination System) Permits to facilities discharging to waters of the state. A review of the NPDES permits for the Lake Calumet area (IEPA, 1986) indicated that the range of permissible suspended solids in discharge waters was 5/13 mg/l (average/maximum) for the Car Carrier Inc. permit to 45/75 mg/l for the Cargill Inc. Elevator permit. All of the monitored tributaries of Lake Calumet and the wetlands have exceeded the upper limit of the highest of the NPDES limits of 75 mg/l maximum suspended solids concentration. Although the NPDES limits apply to point source discharges and not non-point sources, the limits do provide a baseline for comparative analysis.

The monitoring site Sewer E located at the junction of Stony Island Avenue and the Calumet River had the lowest range of suspended sediment concentrations, ranging from 11.4 to 86.1 mg/l. Only one sample from this site was measured above 75 mg/l. The average of seven samples was 26.2 mg/l. The exact source of the water discharged by this site has not been determined; however, on the basis of field

Table 5. Suspended Sediment Sample Results
(In milligrams per liter)

	Tributary to Lake Calumet						Tributary to Wetlands						
Date	CLA	Pullman Creek	IDOT I-94 pump sta.	Sewer E	Sewer F	NE trib. to Lake Calumet #	Indian Treaty Cr	Indian T Cr. @ 103rd Street *	122nd St. ditch	Stony Island Ave. ditch **	MWRDGC sludge bed drainage	Lake Michigan##	Calumet River
4/7/87		34.7			857.9	419.6				418.0			
11/19/87	5.1	131.7		86.1	145.6		24.8						
12/8/87	129.3	40.0		23.3	237.5		27 1	8.2					
1/28/88	53.3	12.8		12.0	227.8		14 1						10 1
3/1/88	28.8	53.4		17 4	17.6		28.5					8.0	
3/31/88	377 1	57.6		11 4	120.3		11.2			322.0		5.0	
4/28/88	54.5	32.9		20.6	102.8		18.9						
5/27/88	81.3	25.2		12.6	315.3		27.0						
7/12/88	88.3	24.6			451.5		40.1						
8/10/88	15.3	455.5	187.0		19,840		120.6			28,476	33,254		
8/24/88		24.5			353.5		23.8						16.8
10/4/88	21.2	59.0			173.4		20.3						
10/5/88		34.0											
10/20/88	17.2	45.9			162.7		28.2		416.8				
Number	11	14	1	7	13	1	12	1	1	3	1	2	2
Maximum	377 1	455.5	187.0	86.1	19840.2	419.6	120.6	8.2	416.8	28,476	33,254	8.0	16.8
Minimum	5.1	12.8	187.0	11 4	17.6	419.6	11.2	8.2	416.8	322.0	33,254	5.0	10.1
Average	79.2	73.7	187.0	26.2	1769.7	419.6	32.0	8.2	416.8	9738.7	33,254	6.5	13.4

Key:
Tributary of Lake Calumet flowing into the lake in the northeast corner of the north basin
* Indian Treaty Creek near 103rd Street, one mile upstream of routine sampling site
** Stony Island Ave. east roadside ditch samples: 4/7/87 and 3/31/88 @ 119th St., 8/10/88 @ 116th St.
Lake Michigan sample obtained at Calumet Park boat launch

observations, the source is speculated to be a large holding pond 50 feet north of the site. This holding pond would tend to reduce suspended sediment concentrations by acting as a sedimentation basin.

Indian Treaty Creek also had relatively low concentrations of suspended sediment, which ranged from 11.2 to 120.6 mg/l. These low concentrations are due to the filtering and settling effects of the wetlands, which allow entrained solids carried by streamflow to deposit there. With the exception of one sample, all measured values were below 75 mg/l. The average of 12 samples was 32.0 mg/l.

Pullman Creek showed a fairly wide range of suspended sediment concentrations, which varied from 12.8 to 455.5 mg/l. Two samples (131.7 and 455.5 mg/l) out of the total of 14 were above 75 mg/l. The average concentration of 14 samples was 73.7 mg/l. Pullman Creek receives drainage from Interstate 94 and surrounding areas.

Roadside drainage from Interstate 94 and Doty Avenue discharges to Lake Calumet at monitoring site CLA on the west side of the lake. Concentrations in samples from this site ranged from 5.1 to 377.1 mg/l, with 4 out of 11 samples above 75 mg/l. The average for all samples was 79.2 mg/l, which was similar to Pullman Creek.

Only one sample was obtained from the IDOT pump station on Pullman Creek over the monitoring period. This sample had a concentration of 187.0 mg/l and was from water pumped from the storm sewers beneath the interstate during the rainfall of August 10, 1988. A sample obtained from the gravity drainage in Pullman Creek on the same date (455.5 mg/l) had a concentration nearly 2.5 times higher than the pump station sample.

Sewer F, discharging to Lake Calumet on its eastern shore, had the highest concentrations of all monitored tributaries (average = 1769.7 mg/l). Out of 13 samples, only one had a concentration less than 75 mg/l. The range of values was from a low of 17.6 to a high of 19,840 mg/l, which was nearly 44 times higher than the largest concentration measured at the other tributaries of the lake. This site was the single largest monitored source of suspended sediment to Lake Calumet.

A small tributary of Lake Calumet discharging into the north basin of the lake was sampled on April 7, 1987. The suspended sediment concentration was 419.6 mg/l. This tributary was receiving runoff from the landfill areas north of the lake.

Samples from ditches along Stony Island Avenue had very high concentrations ranging from 322.0 to 28,476 mg/l. These ditches receive drainage from the landfills east of the road. Drainage in these ditches is a major source of suspended sediment delivered to the wetlands east of the lake.

The sample with the highest sediment concentration obtained during this study (33,254 mg/l) was from drainage of the MWRDGC sludge beds at 107th Street and

Stony Island Avenue. This sample was obtained from flow spilling across Stony Island Avenue from the west and flowing into the wetlands northeast of the lake. Drainage from the sludge beds is a major source of suspended sediment delivered to the wetlands.

Samples from Lake Michigan were low in suspended sediment, with an average value of 6.5 mg/l. Concentration values from Lake Michigan were expected to be low owing to the relatively low water velocities of the lake, where suspended solids tend to settle out of the water column. In addition, local tributaries of the lake were in low flow on the sampling dates, and therefore the input of suspended sediment was relatively low as compared to times of high flow. Samples from the Calumet River were also low in suspended sediment, with an average value of 13.4 mg/l. During low flow, the Calumet River behaves like a bay of Lake Michigan. Suspended solids delivered by inflowing tributaries will tend to settle out or be dispersed in the large volume and low velocities of the river.

Organics

Total organic carbon concentration samples were obtained from eleven sites in the Lake Calumet area (Table 6). Sample results ranged from 2.6 to 126.1 mg C/l (milligrams carbon per liter). Indian Treaty and Pullman Creeks had the highest concentrations, and Lake Michigan and the Calumet River had the lowest. Organic carbon analyses measured carbon from natural and anthropogenic (man-made) sources. Research has shown significant correlations between organic carbon and trace metals in aquatic sediments (Cahill, 1981; Cahill and Steele, 1986; Ross et al., 1988a).

Total organic halide (TOX) samples were obtained from eleven sites in the Lake Calumet area (Table 7). Sample results ranged from 0.0 to 174.4 μg Cl/l (micrograms chlorine per liter). Sewer sites E and F had the highest concentrations, and Lake Michigan and the Calumet River the lowest. Elevated levels of TOX, above 5.0 μg Cl/l, may indicate contamination by synthetic organic compounds (ASTM, 1982). Out of a total of 57 samples, 46 showed concentrations greater than 5.0 μg Cl/l.

Metals

This section presents the results of water sample analyses for metals and compares the results to the state's water quality standards as described by the IEPA (1985). Water samples were analyzed for five metal concentrations on a routine basis: arsenic (As), cadmium (Cd), chromium (Cr), lead (Pb), and zinc (Zn). These five metals are typically associated with anthropogenic sources (Cahill and Steele, 1986).

Arsenic is a toxic element classified as a known carcinogen (Group A) by the National Cancer Institute's National Toxicology Program (IEPA, 1985). Arsenic is typically used in herbicides and insecticides. Over half of the total of 30 arsenic analyses were below the analytical detection limit (Table 8). All results were below the

Table 6. Total Organic Carbon (TOC) Sample Results
(In milligrams per liter)

	Tributary to Lake Calumet					Tributary to Wetlands					
Date	CLA	Pullman Creek	IDOT I-94 pump sta.	Sewer E	Sewer F	Indian Treaty Cr.	122nd St. ditch	Stony Island Ave. ditch *	MWRDGC sludge bed drainage	Lake Michigan#	Calumet River
3/31/88	10 1	55.9			37 7	40 4		39.1		2.6	
4/28/88	9.8	41 4		39.0	49 0	119.2					
5/27/88	12.0	45.0		40.4	49 6	126.1					
7/12/88	21.0	57 7			39 0	64.0					
8/10/88	16.6	36.0	13.5		14 4	36.2		8.9	9.2		
8/24/88		53.0			23.0	39.9					5.4
10/4/88	16.1	48.4			17 6	47 4					
10/5/88		42.4									
10/20/88	13.5	52.9			22.7	60.3	15.4				
Number	7	9	1	2	8	8	1	2	1	1	1
Maximum	21.0	57 7	13.5	40.4	49 6	126.1	15.4	39.1	9.2	2.6	5.4
Minimum	9.8	36.0	13.5	39 0	14 4	36.2	15.4	8.9	9.2	2.6	5 4
Average	14.2	48.1	13.5	39 7	31.6	66.7	15.4	24.0	9.2	2.6	5.4

Key:
* Stony Island Ave. east roadside ditch samples: 3/31/88 @ 119th St., 8/10/88 @ 116th St.
# Lake Michigan sample obtained at Calumet Park boat launch

Table 7 Total Organic Halide (TOX) Sample Results
(In micrograms per liter)

	Tributary to Lake Calumet					Tributary to Wetlands					
Date	CLA	Pullman Creek	IDOT I-94 pump sta.	Sewer E	Sewer F	Indian Treaty Cr.	122nd St. ditch	Stony Island Ave. ditch *	MWRDGC sludge bed drainage	Lake Michigan#	Calumet River
12/8/87	103.4	50.9			156.6	59.7					
1/28/88	101 6	140 7		174 4	142.5	102.2					5.4
3/1/88	11 1	28.6		82.0	81 0	110.0				4.9	
3/31/88	19 7	17.9			81.3	26.5		12.7		1 7	
4/28/88	36.3	54 6		45.8	76.8	72.2					
5/27/88	71.3	80.9		49 7	32.4	61 6					
7/12/88	45.2	61.6			137 6	85.2					
8/10/88	1.8	2.0	2.5		2.1	5.1		2.8	9.0		
8/24/88		4.3			1 4	4.6					0.0
10/4/88	81.9	70.1			51.5	32.4					
10/5/88		64.5									
10/20/88	79.0	81 6			62.2	72.1	67.6				
Number	10	12	1	4	11	11	1	2	1	2	2
Maximum	103.4	140.7	2.5	174 4	156.6	110.0	67 6	12.7	9.0	4.9	5.4
Minimum	1.8	2.0	2.5	45.8	1 4	4.6	67 6	2.8	9.0	1 7	0
Average	55.1	54.8	2.5	88.0	75.0	57 4	67.6	7.8	9.0	3.3	2.7

Key·
* Stony Island Ave. east roadside ditch samples: 3/31/88 @ 119th St., 8/10/88 @ 116th St.
# Lake Michigan sample obtained at Calumet Park boat launch

Table 8. Arsenic Sample Results
(In milligrams per liter; results in bold type exceed water quality standards)

	Tributary to Lake Calumet				Tributary to Wetlands		
Date	CLA	Pullman Cr	Sewer E	Sewer F	Indian Treaty Cr	Stony Island Ave. ditch*	Lake Michigan #
12/8/87	BDL	.015±50%		.014±50%	.010±70%		
1/28/88	BDL	BDL	BDL	BDL	BDL		
3/1/88	BDL	BDL	BDL	BDL	BDL		BDL
3/31/88	BDL	BDL		BDL	BDL	BDL	
4/28/88	.011±60%	.009±80%	.008±90%	.017±40%	.007±100%		
5/27/88	.008±90%	.009±80%	.011±60%	.011±60%	BDL		
Number	6	6	4	6	6	1	1
Maximum	.011±60%	.015±50%	.011±60%	.017±40%	.010±70%		
Minimum	BDL	BDL	BDL	BDL	BDL		

Arsenic water quality standards in mg/l:

1.000	General use waters
1.000	Secondary contact
0.050	Public water supply

Key:
* Stony Island Ave. east roadside ditch sample @ 120th St.
\# Lake Michigan sample obtained at Calumet Park boat launch
BDL= below detection limit of .007 mg/l

water quality standards for arsenic of 0.050 mg/l for public water supply. The highest measured concentration was 0.017 mg/l from the monitoring site Sewer F. The samples from Lake Michigan and the Stony Island Avenue ditch were below the analytical detection limit.

Cadmium has been classified as a suspected carcinogen (Group B) by the National Cancer Institute (IEPA, 1985). Cadmium is a naturally occurring metal typically present in earth materials in concentrations below 1 ppm. In surface and ground waters the typical range is 1 to 10 parts per billion (ppb) (USEPA, 1987). Cadmium is produced as a by-product of the production of zinc and is used in metal plating, electronics, paints and pigments (USEPA, 1987). Fifty-four analyses were performed for cadmium concentration (Table 9). Only two of the samples had concentrations above the analytical detection limit. A sample from the drainage from the MWRDGC sludge drying beds had 4.4 mg/l, which was well above the established water quality standards of .010, .050, and .150 mg/l for public water supply, general use, and secondary contact, respectively. The other sample above the analytical detection limit was 0.010 mg/l from the monitoring site Sewer F.

Chromium analyses were performed on 54 water samples (Table 10). The National Cancer Institute has classified chromium as a known carcinogen (Group A) (IEPA, 1985). Chromium is used extensively in metal pickling and plating, leather tanning, paints, dyes, explosives, ceramics, glass, and photography (ASTM, 1982). Seven of the water samples (13% of the total) were above both the analytical detection limit and the water quality standard of .050 mg/l (public water supply). The highest measured concentration of 65 mg/l was from a sample of runoff from the MWRDGC sludge drying beds. This sample was over 1000 times the water quality standard. The two laboratory analytical detection limits (0.08 and 0.10 mg/l) were both above the water quality standard; therefore other samples could have been above the water quality standard but below measurable values.

Lead is not classified as a carcinogen; however, it is toxic to humans (IEPA, 1985). The public water supply standard for lead is 0.05 mg/l. Lead is used in metal smelting and in chemical and paint production. Lead analyses were performed on 54 water samples (Table 11). Six of these samples (11% of the total) had concentrations above the analytical detection limit. All six samples with positive results were above the water quality standards for lead of .05 and .1 mg/l for public water supply and general use/secondary contact, respectively. The highest concentration was 12.5 mg/l from the MWRDGC sludge drying beds, which was 125 times the general use/secondary contact standard. A sample from Lake Michigan had a lead concentration of 0.14 mg/l, which was above both the public water supply and the general use/secondary contact standards.

Zinc analyses indicate that 45 out of a total of 54 samples had concentrations above detection limits (Table 12). Only two of these sample concentrations exceeded the water quality standards. The highest measured concentration was 98.0 mg/l from a sample of runoff from the MWRDGC sludge drying beds. This value is nearly 100

Table 9. Cadmium Sample Results
(In milligrams per liter; results in bold type exceed water quality standards)

	Tributary to Lake Calumet					Tributary to Wetlands					
Date	CLA	Pullman Creek	IDOT I-94 pump sta.	Sewer E	Sewer F	Indian Treaty Cr	122nd St. ditch	Stony Island Ave. ditch*	MWRDGC sludge bed drainage	Lake Michigan#	Calumet R.
12/8/87	BDL1	BDL1			BDL1	BDL1					
1/28/88	BDL1	BDL1		BDL1	BDL1	BDL1					
3/1/88	BDL1	BDL1		BDL1	BDL1	BDL1				BDL1	
3/31/88	BDL1	BDL1			BDL1	BDL1		BDL1			
4/28/88	BDL2	BDL2		BDL2	BDL2	BDL2					
5/27/88	BDL2	BDL2		BDL2	BDL2	BDL2					
7/12/88	BDL2	BDL2			BDL2						
8/10/88	BDL2	BDL2	BDL2		0.010±65%	BDL2		BDL2	**4.4±10%**		
8/24/88		BDL2			BDL2	BDL2					BDL2
10/4/88	BDL2	BDL2			BDL2	BDL2					
10/5/88		BDL2									
10/20/88	BDL2	BDL2			BDL2	BDL2	BDL2				
Number	10	12	1	4	11	10	1	2	1	1	1
Maximum	-	-	-	-	.010	-	-	-	4 4	-	-
Minimum	-	-	-	-	.010	-	-	-	4.4	-	-

Cadmium water quality standards in mg/l:

.050	General use waters
150	Secondary contact
.010	Public water supply

Key:
* Stony Island Ave. east roadside ditch samples: 3/31/88 @ 120th St., 8/10/88 @ 116th St.
# Lake Michigan sample obtained at Calumet Park boat launch
BDL1= below detection limit of .006 mg/l
BDL2= below detection limit of .008 mg/l

Table 10. Chromium Sample Results
(In milligrams per liter; results in bold type exceed water quality standards)

	Tributary to Lake Calumet					Tributary to Wetlands					
Date	CLA	Pullman Creek	IDOT I-94 pump sta.	Sewer E	Sewer F	Indian Treaty Cr	122nd St. ditch	Stony Island Ave. ditch*	MWRDGC sludge bed drainage	Lake Michigan#	Calumet River
12/8/87	BDL1	BDL1			BDL1	BDL1					
1/28/88	BDL1	BDL1		BDL1	BDL1	BDL1					
3/1/88	BDL1	BDL1		BDL1	BDL1	BDL1				BDL1	
3/31/88	BDL1	BDL1			BDL1	BDL1		BDL1			
4/28/88	BDL2	BDL2		BDL2	BDL2	BDL2					
5/27/88	BDL2	BDL2		BDL2	BDL2	BDL2					
7/12/88	BDL2	BDL2			**.25±25%**						
8/10/88	BDL2	**.10±80%**	**.11±80%**		**.47±10%**	BDL2			**65.±10%**		
8/24/88		BDL2			BDL2	**.12±80%**		BDL2			BDL2
10/4/88	BDL2	BDL2			BDL2	**.13±80%**					
10/5/88		**.12±80%**									
10/20/88	BDL2	BDL2			BDL2	BDL2	BDL2				
Number	10	12	1	4	11	10	1	2	1	1	1
Maximum	-	12	11	-	47	13	-	-	65	-	-
Minimum	-	10	11	-	.25	12	-	-	65	-	-

Chromium water quality standards in mg/l:

-	General use waters
-	Secondary contact
.050	Public water supply

Key:
* Stony Island Ave. east roadside ditch samples: 3/31/88 @ 120th St., 8/10/88 @ 116th St.
# Lake Michigan sample obtained at Calumet Park boat launch
BDL1= below detection limit of 1 mg/l
BDL2= below detection limit of .08 mg/l

Table 11 Lead Sample Results

(In milligrams per liter; results in bold type exceed water quality standards)

	Tributary to Lake Calumet					Tributary to Wetlands					
Date	CLA	Pullman Creek	IDOT I-94 pump sta.	Sewer E	Sewer F	Indian Treaty Cr	122nd St. ditch	Stony Island Ave. ditch*	MWRDGC sludge bed drainage	Lake Michigan#	Calumet River
12/8/87	BDL1	BDL1			BDL1	BDL1					
1/28/88	BDL1	BDL1		BDL1	BDL1	BDL1					
3/1/88	BDL1	BDL1		BDL1	BDL1	BDL1					
3/31/88	BDL1	BDL1			BDL1	BDL1		BDL1		**.14±36%**	
4/28/88	BDL2	BDL2		BDL2	BDL2	BDL2					
5/27/88	BDL2	BDL2		BDL2	BDL2	BDL2					
7/12/88	**.15±50%**	BDL2			BDL2						
8/10/88	BDL2	**.23±35%**	BDL2		**.58±20%**	BDL2		**.12±50%**	**12.5±20%**		
8/24/88		BDL2			BDL2	BDL2					BDL2
10/4/88	BDL2	BDL2			BDL2	BDL2					
10/5/88		BSL2									
10/20/88	BDL2	BDL2			BDL2	BDL2	BDL2				
Number	10	12	1	4	11	10	1	2	1	1	1
Maximum	15	.23	-	-	.58	-	-	12	12.50	14	-
Minimum	15	.23	-	-	.58	-	-	12	12.50	14	-

Lead water quality standards in mg/l:

100	General use waters
100	Secondary contact
.050	Public water supply

Key:
* Stony Island Ave. east roadside ditch samples: 3/31/88 @ 120th St., 8/10/88 @ 116th St.
# Lake Michigan sample obtained at Calumet Park boat launch
BDL1= below detection limit of .06 mg/l
BDL2= below detection limit of .08 mg/l

Table 12. Zinc Sample Results
(In milligrams per liter; results in bold type exceed water quality standards)

	Tributary to Lake Calumet					Tributary to Wetlands					
Date	CLA	Pullman Creek	IDOT I-94 pump sta.	Sewer E	Sewer F	Indian Treaty Cr	122nd St. ditch	Stony Island Ave. ditch*	MWRDGC sludge bed drainage	Lake Michigan#	Calumet River
12/8/87	BDL1	114±10%			126±10%	.022±60%					
1/28/88	BDL1	.070±21%		.024±62%	BDL1	057±26%					
3/1/88	.019±79%	112±13%		.035±42%	.045±33%	.084±18%				BDL1	
3/31/88	.084±18%	.237±6%			.052±29%	044±34%		0.13±12%			
4/28/88	165±5%	.059±15%		.023±30%	.018±50%	.019±50%					
5/27/88	.048±30%	.024±30%		BDL2	.088±10%	.021±50%					
7/12/88	.330±4%	.020±30%			.264±4%						
8/10/88	.038±20%	.282±4%	.249±4%		**5.6±10%**	.040±20%		.216±4%	**98.±10%**		
8/24/88		.014±50%			BDL2	.018±50%					BDL2
10/4/88	.033±20%	.086±10%			BDL2	.018±50%					
10/5/88		.027±30%									
10/20/88	.026±50%	.046±20%			BDL2	033±20%	.031±20%				
Number	10	12	1	4	11	10	1	2	1	1	1
Maximum	0.33	0.282	0.249	0.035	5.6	0.084	0.031	0.216	98	-	-
Minimum	BDL1	0.014	0.249	BDL2	BDL2	0.018	0.031	130	98	-	-

Zinc water quality standards in mg/l:

1.000	General use waters
1.000	Secondary contact
5.000	Public water supply

Key:
* Stony Island Ave. east roadside ditch samples: 3/31/88 @ 120th St., 8/10/88 @ 116th St.
# Lake Michigan sample obtained at Calumet Park boat launch
BDL1= below detection limit of .015 mg/l
BDL2= below detection limit of .008 mg/l

times the lower standard for general use/secondary contact of 1.00 mg/l. The only other sample with a concentration above the water quality standards (5.6 mg/l) was from the monitoring site Sewer F.

Results of inductively coupled argon plasma (ICAP) analyses performed on five samples for 26 metals are shown in Table 13. For metals with established standards, most values were well below the limit. However, manganese results were above the standard in three out of five samples. The iron standard was exceeded in two of the five samples, and copper and chromium were exceeded in one each.

Toxicological Bioassay

Microtox™. Results of the bioassay of fourteen water samples tested for toxicity with the Microtox™ method are shown in Table 14. The relative average toxicity classifications indicate that the samples ranged from no response to extremely toxic. Sewer F consistently ranks extremely toxic in all samples. Laboratory reports indicated that the results from Sewer F samples were the highest observed for the Microtox™ technique. Pullman Creek samples exhibited a fairly wide range of results from moderately to extremely toxic, with three of four samples in the moderately toxic range. The average of all samples from Pullman Creek was moderately toxic. Indian Treaty Creek also exhibited fairly high toxicity based on this technique. The average of three samples ranked extremely toxic, although considerably lower than the samples from Sewer F. The average results for site CLA ranked extremely toxic, higher than the results for Indian Treaty Creek but less than those for Pullman Creek. Single samples from the Calumet River and the 122nd Street ditch caused no toxic responses in these tests.

***Panagrellus redivivus* Nematode.** Results from this assay ranged from moderately to extremely toxic (Table 15). Pullman Creek and Indian Treaty Creek samples ranged from highly to extremely toxic, and both sites had average values of extremely toxic. Sewer F and site CLA samples also ranged from highly to extremely toxic. The averages for both sites were rated as highly toxic.

Composite Toxicity Index. The average of the two assay classes for the Microtox™ and *P. redivivus* methods is used as the composite index of toxicity (Table 16).

Table 13 Metals Results from Inductively Coupled Argon Plasma Analyses
(In milligrams per liter)

	CLA 12/8/87	Pullman Creek 12/8/87	Indian Treaty Creek 12/8/87	Sewer F 3/1/88	Sewer E 3/1/88	Average*	Standard	
Aluminum	0 18	1 32	0 20	0 22	0 50	0 48		
Barium	0 123	0 094	0 070	0 102	0 066	0 09	1 000	a
Beryllium	<0 002	<0 002	<0 002	<0 002	<0 002	<0 002		
Calcium	206 1	135 5	121 8	155 6	68 2	137 42		
Cadmium	<0 008	<0 008	<0 008	<0 008	<0 008	<0 008	0 15	b
Cobalt	<0 006	<0 006	<0 006	<0 006	<0 006	<0 006		
Chromium	0 045	0 049	0 067	0 029	0 018	0 04	0 050	a
Copper	0 022	0 049	0 019	0 020	0 013	0 02	0 020	c
Iron	<0 04	1 08	0 16	0 11	1 17	0 51	1 00	c
Potassium	24 3	27 1	37 5	123 3	65 8	55 57		
Lanthanum	<0 003	<0 003	<0 003	<0 003	<0 003	<0 003		
Magnesium	1 76	59 30	40 00	65 46	65 24	46 35		
Manganese	0 009	0 140	0 223	0 369	0 239	0 20	0 150	c
Molybdenum	0 049	0 026	<0 016	0 180	<0 016	0 08		
Sodium	183 2	247 0	128 9	480 1	294 0	266 61		
Nickel	0 028	0 037	0 047	0 046	0 036	0 04	1 000	c
Phosphorus	<0 30	0 44	<0 30	0 35	<0 30	0 39		
Lead	<0 032	<0 032	<0 032	<0 032	<0 032	<0 032	0 100	c
Sulfur	47 7	153 9	95 0	127 1	89 9	102 70		
Selenium	<0 04	<0 04	<0 04	<0 04	<0 04	<0 04	1 00	c
Silicon	2 43	8 65	7 05	6 82	3 41	5 67		
Strontium	1 029	0 774	0 479	0 994	0 387	0 73		
Titanium	<0 005	0 056	0 009	0 010	0 016	0 02		
Vanadium	0 006	0 010	0 005	0 017	0 005	0 01		
Zinc	<0 006	0 069	<0 006	<0 006	0 010	0 02	5 000	a
Zirconium	<0 006	<0 006	<0 006	<0 006	<0 006	<0 006		

* Values below the detection limit were assigned a value of 1/2 the detection limit for the purpose of calculating the averages
a = public water supply
b = secondary contact
c = general use

Table 14 Microtox™ Bioassay Results

Date	Location	Microtox™ % Luminescence Inhibition	Toxicological Class	Relative Toxicity Classification
8/24/88	Pullman Cr	16 83	2	Moderately toxic
	Indian T Cr	88 53	4	Extremely toxic
	Sewer F	279 5	4	Extremely toxic
	Calumet R	0 89	0	No response
10/4/88	CLA	48 69	3	Highly toxic
	Pullman Cr	37 77	2	Moderately toxic
	Indian T Cr	76 42	4	Extremely toxic
	Sewer F	276 76	4	Extremely toxic
10/5/88	Pullman Cr	15 2	2	Moderately toxic
10/20/88	CLA	279 5	4	Extremely toxic
	Pullman Cr	69 33	4	Extremely toxic
	Indian T Cr	54 05	3	Highly toxic
	Sewer F	249 58	4	Extremely toxic
	122nd St	0 0	0	No response

Table 15 *P redivivus* Bioassay Results

Date	Location	*P redivivus* % Fitness Reduction	Toxicological Class	Relative Toxicity Classification
8/24/88	Pullman Cr	54 60	3	Highly toxic
	Indian T Cr	65 43	4	Extremely toxic
	Sewer F	92 86	4	Extremely toxic
	Calumet R	75 56	4	Extremely toxic
10/4/88	CLA	15 33	2	Moderately toxic
	Pullman Cr	69 91	4	Extremely toxic
	Indian T Cr	48 09	3	Highly toxic
	Sewer F	18 98	2	Moderately toxic
10/5/88	Pullman Cr	52 93	3	Highly toxic
10/20/88	CLA	70 93	4	Extremely toxic
	Pullman Cr	74 42	4	Extremely toxic
	Indian T Cr	81 08	4	Extremely toxic
	Sewer F	68 54	4	Extremely toxic
	122nd St	14 68	2	Moderately toxic

Table 16 Average Toxicity of Water Samples by Sample Location Based on the Composite Index

Location	Number of Samples	Microtox™ Toxicological Class	*P redivivus* Toxicological Class	Composite Toxicity Index	Relative Toxicity Class
Pullman Cr	4	2	4	3 0	Highly toxic
Indian T Cr	3	4	4	4 0	Extremely toxic
Sewer F	3	4	3	3 5	Highly toxic
CLA	2	4	3	3 5	Highly toxic
Calumet R	1	0	4	2 0	Moderately toxic
122nd St	1	0	2	1 0	Slightly toxic

Correlation of Water Quality Parameters

Previous studies have shown a significant degree of correlation between organic carbon and trace metals in aquatic sediments (Cahill, 1981; Cahill and Steele, 1986; Ross et al., 1988a). Cahill and Steele observed that clay-sized sediment and organic carbon often control the distribution of trace metals. Risatti and Sheridan (Ross et al., 1988a) also observed a significant degree of correlation between organic carbon and some trace metals. These researchers suggested that the distribution and concentrations of trace metals attributed to anthropogenic sources and associated with fine-grained materials may be due to coatings of organic carbon on fine-grained sediments. An analysis of the degree of correlation of the various measured water quality parameters suggests that chromium and zinc are fairly well correlated with suspended sediment (Table 17). The rest of the values show little correlation.

Table 17 Correlation Coefficient (R) between Water Quality Concentrations*

	Total Organic Carbon	Organic Halide	Suspended Sediment
Arsenic	242	259	362
Chromium	561	192	844
Lead	435	068	630
Zinc	212	175	707
Organic carbon	--	286	317
Organic halides	286	--	286
Suspended sediment	317	286	--

* Cadmium was excluded from this analysis due to the low number of positive results (n=2)

Water and Pollutant Discharges

Water Discharge

Water is discharged to the lake and wetland areas primarily in response to precipitation. The monitoring period was relatively dry, with only 85% of normal precipitation, and therefore runoff to the lake and wetlands was less than normal. Over the course of the study period, water inflow at the four monitored tributaries of Lake Calumet (CLA, Pullman Creek and the IDOT pump station, Sewer E, and Sewer F) varied from 0.9 to 43.8 cfs (Figure 9). The highest measured discharge occurred on August 10, 1988, during a 0.32 inch rainfall. The lowest discharge to the lake was recorded on July 12, 1988, during a very dry period following 17 days without measurable rainfall. The average inflow from 12 observations was 7.8 cfs.

Water inflow to the wetlands east of the lake followed the same pattern as the inflow to Lake Calumet (Figure 9). The highest inflow at the monitored tributaries (Indian Treaty Creek, and the Stony Island Avenue ditches including the sludge bed drainage) was 11 cfs on August 10, 1988. The lowest inflow was 0.0 cfs measured on six days over the course of the study. The average inflow from twelve observations was 1.1 cfs.

Sediment Discharge

The range of sediment discharge to Lake Calumet varied from 16.5 to nearly 25,000 pounds per hour (Figure 10). Sediment inflow to the wetlands from the three monitored sources ranged from a low of 0 to a high of nearly 79,000 pounds per hour (Figure 11). The highest measured inflow of sediment to the lake and wetlands occurred on August 10, 1988, coincident with the highest water discharges. The average sediment inflow rates to the lake and wetland, based on 12 observations, were approximately 2,100 and 6,600 pounds per hour, respectively. The storm of August 10, 1988, generated the bulk of the observed sediment transport. This storm produced 99% and 97% of the observed sediment inflow to the wetland and lake, respectively.

Organics

Total organic halide (TOX) inflow to the lake ranged from 0.003 to 0.2 pounds per hour (Figure 12). The average inflow to the lake from twelve observations was 0.07 pounds per hour. The highest inflow rate was observed on January 28, 1988, which was a relatively dry period in contrast with the storm of August 10, 1988, which produced an inflow of only 0.02 pounds per hour. TOX inflow to the wetlands was less than that observed to the lake. The peak inflow measured to the wetlands was 0.016 pounds per hour, and the average rate was 0.002 pounds per hour.

Organic carbon concentrations were measured on eight dates. Inflow to the lake ranged from 8 to 225 pounds per hour (Figure 13). Inflow to the wetlands varied from

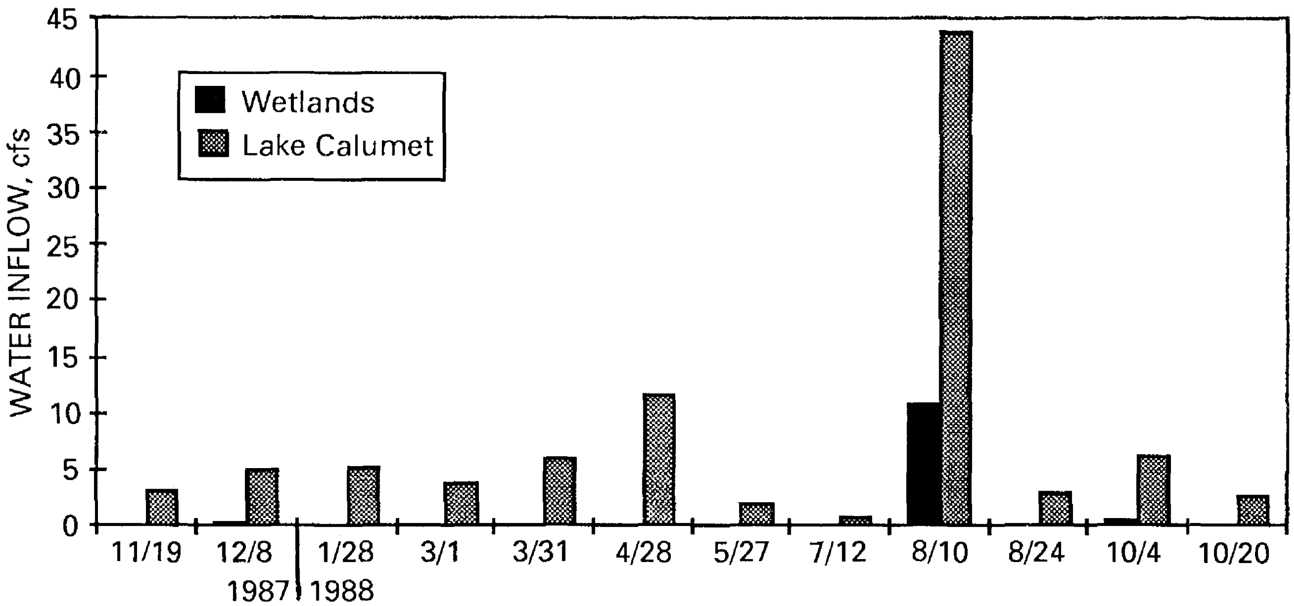


Figure 9. Water Inflow to Lake Calumet and Wetlands in cfs

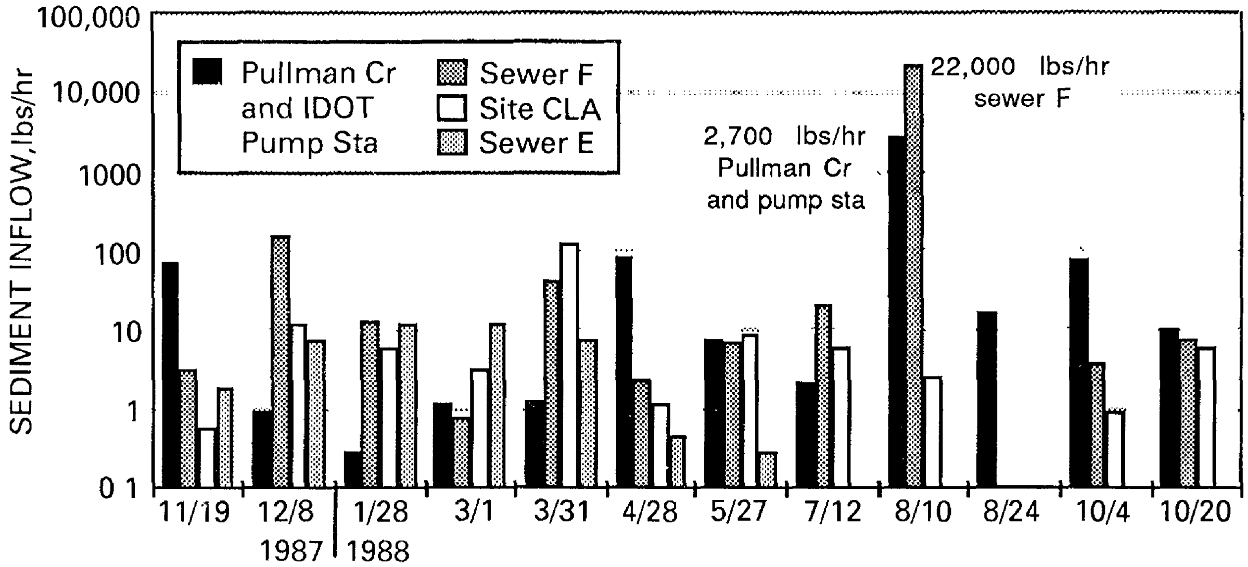


Figure 10 Observed Sediment Inflow to Lake Calumet from Four Tributaries in lbs/hr

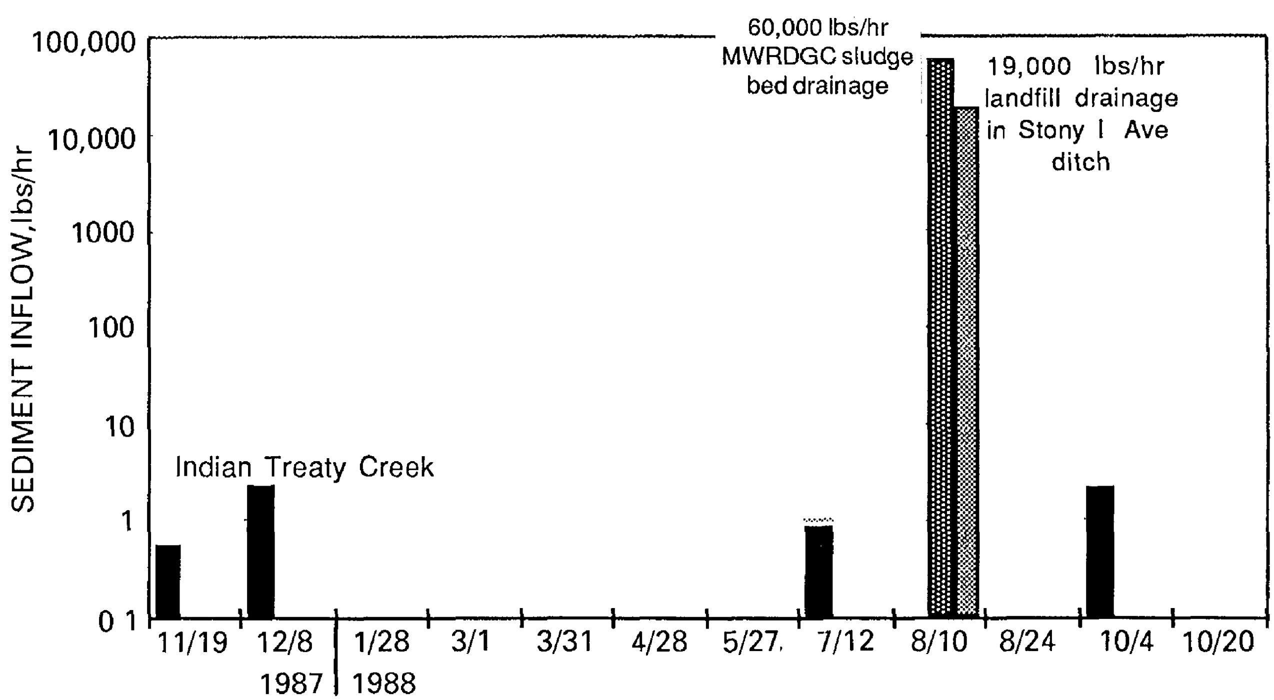


Figure 11. Observed Sediment Inflow to Wetlands East of Lake Calumet from Three Sources in lbs/hr

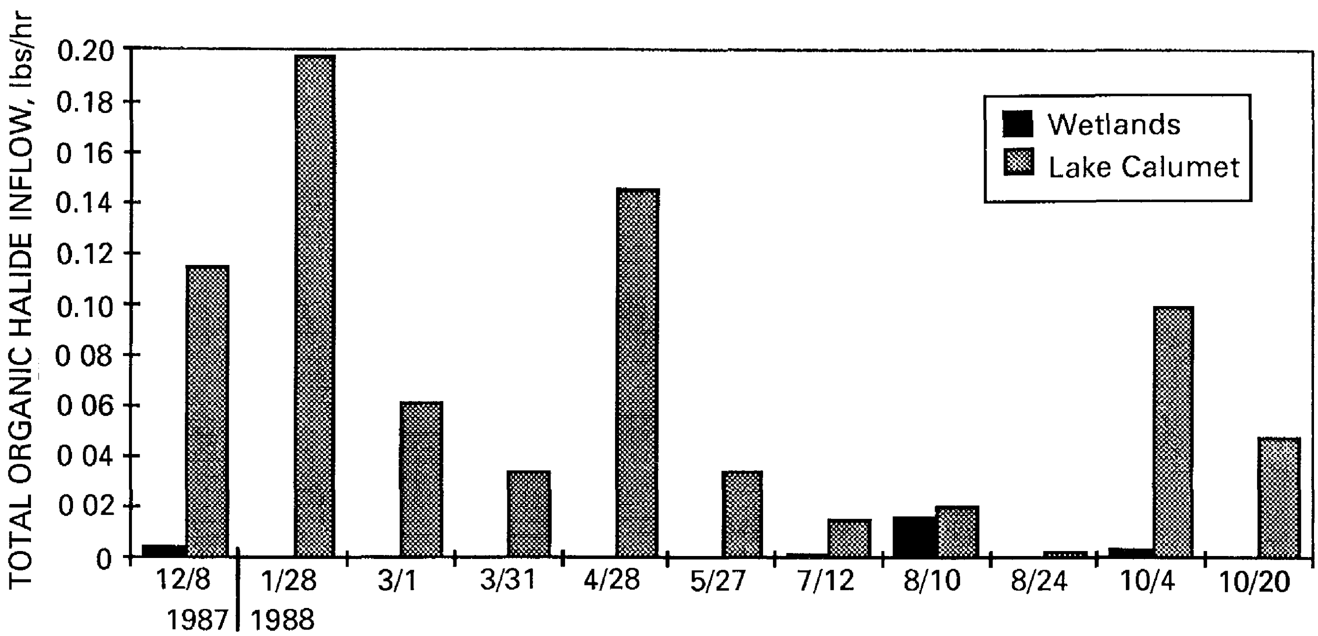


Figure 12 Total Organic Halide Inflow to Lake Calumet and Wetlands in lbs/hr

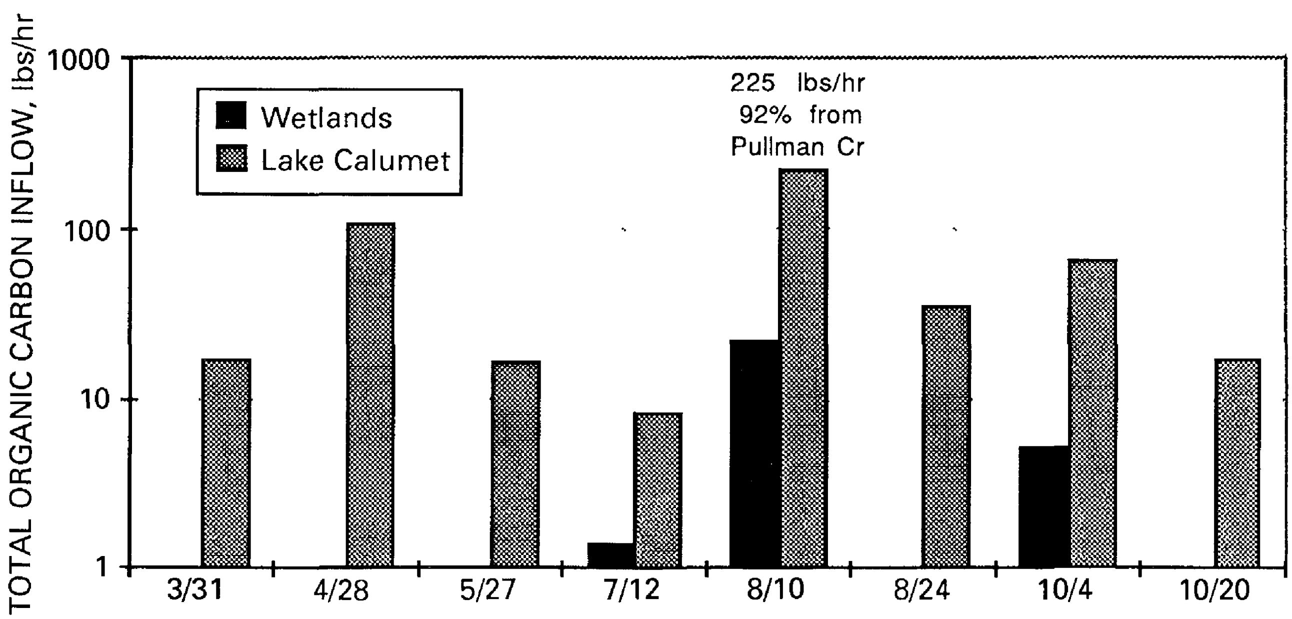


Figure 13 Total Organic Carbon Inflow to Lake Calumet and Wetlands in lbs/hr

0 to 23 pounds per hour. The highest inflow rates occurred on August 10, 1988. The average inflow rates based on eight observations were 3.7 and 61.9 pounds per hour to the wetlands and lake, respectively.

Metals

Arsenic inflow was monitored on six dates. The peak inflow rates were 0.001 and 0.023 pounds per hour to the wetlands and lake, respectively (Figure 14). Three dates had measurable inflow of arsenic to the lake, and only one day had measurable inflow to the wetlands.

Cadmium inflow was monitored on eleven dates. Only August 10, 1988, had measurable inflow to the lake and wetlands (Figure 15). Nearly 8 pounds per hour of cadmium was measured flowing from the sludge beds to the wetlands east of the lake on this date. In contrast, the measured rate for inflow to Lake Calumet on this date was 0.01 pounds per hour.

Chromium inflow was also monitored on eleven dates. Only three days had measurable inflow to the lake and wetlands (Figure 16). The highest measured rate to the wetlands was 117 pounds per hour from the sludge bed drainage. In contrast, the highest measured inflow rate to the lake was a combined total of 1.4 pounds per hour from Pullman Creek, Sewer F, and the pump station. The average inflow rates to the lake and wetlands were 0.13 and 10.6 pounds per hour, respectively.

Of the eleven monitoring dates, only two days had measurable inflows of lead to the lake and wetlands (Figure 17). Over 22 pounds per hour of lead was measured flowing into the wetlands on August 10, 1988. In contrast, only 1.6 pounds per hour was measured flowing to Lake Calumet on August 24, 1988. The average inflow rates to the lake and wetland were 0.1 and 2.0 pounds per hour, respectively.

Zinc inflow was monitored on eleven dates (Figure 18). The highest inflow rates for the lake and wetlands were 8.5 and 176 pounds per hour respectively on August 10, 1988. The rates on this date were responsible for 94% and 99% of the total observed inflow to the lake and wetlands, respectively. The average rates of inflow were 0.8 pounds per hour to the lake and 16.0 pounds per hour to the wetlands.

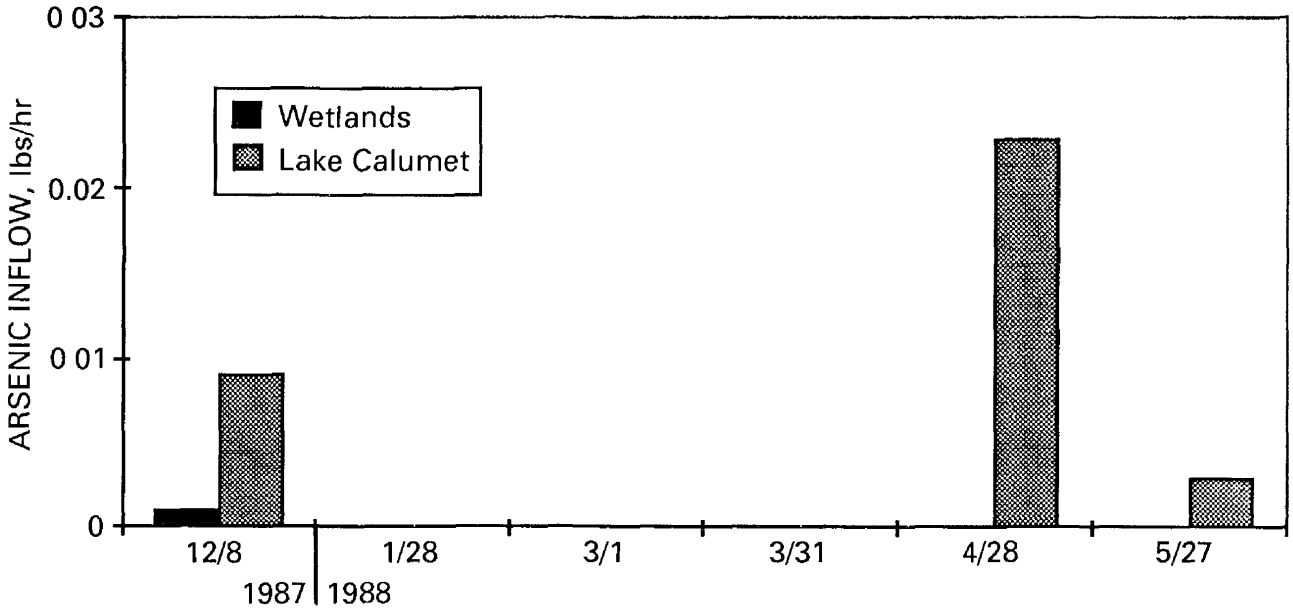


Figure 14 Arsenic Inflow to Lake Calumet and Wetlands in lbs/hr

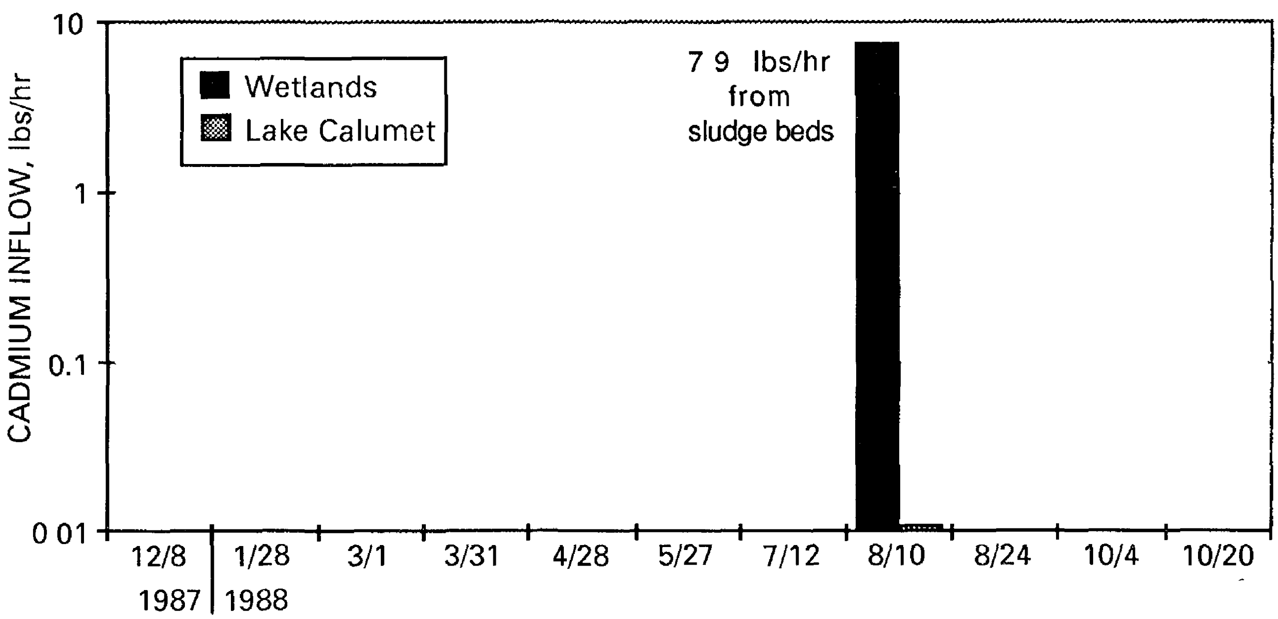


Figure 15 Cadmium Inflow to Lake Calumet and Wetlands in lbs/hr

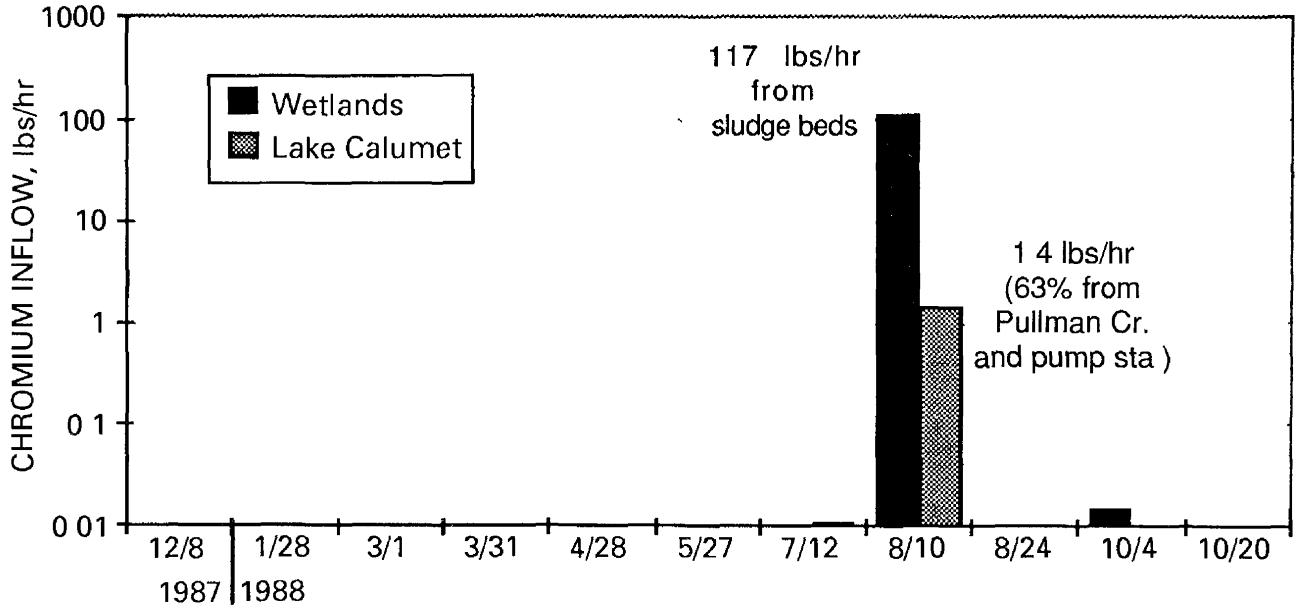


Figure 16 Chromium Inflow to Lake Calumet and Wetlands in lbs/hr

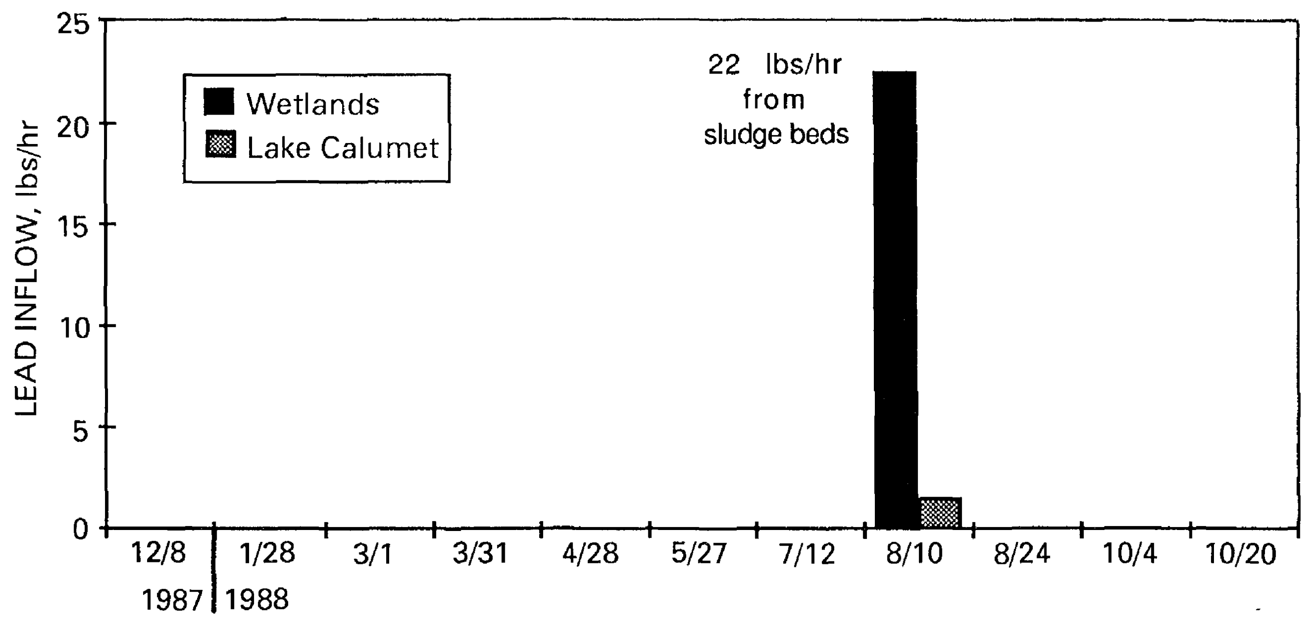


Figure 17 Lead Inflow to Lake Calumet and Wetlands in lbs/hr

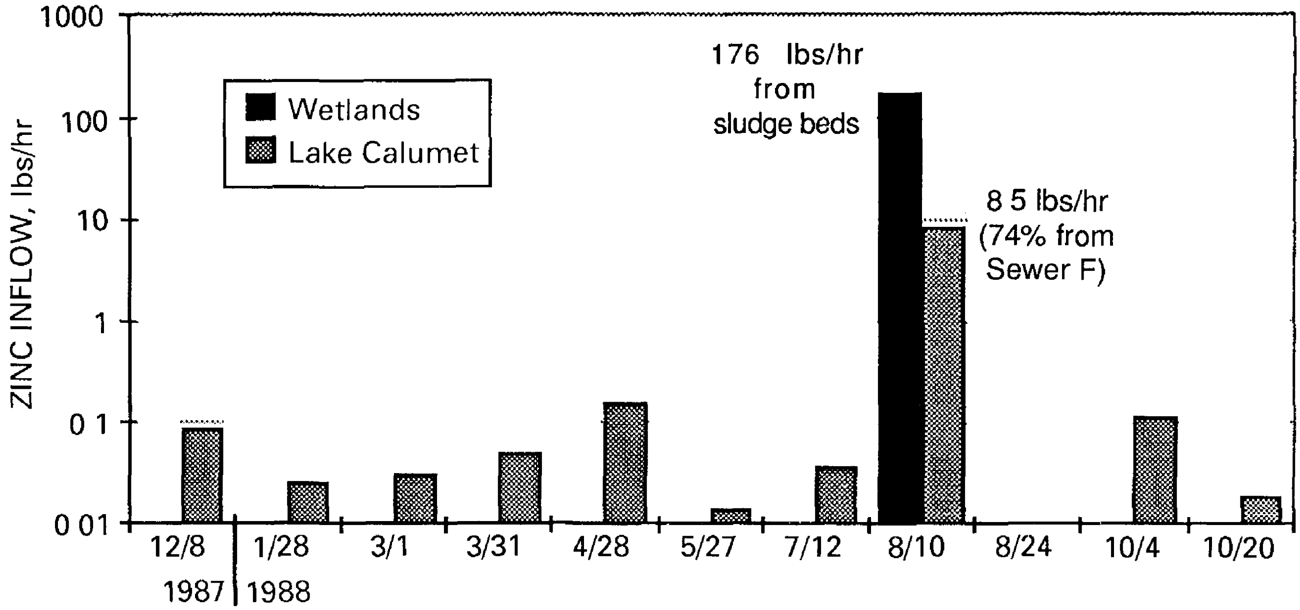


Figure 18 Zinc Inflow to Lake Calumet and Wetlands in lbs/hr

CHAPTER 5

DISCUSSION

Water Quality

The results of this study have shown that Lake Calumet and the wetlands east of the lake are receiving significant quantities of pollutants from streams and sewers. The concentrations of metals are generally higher in the tributaries of Lake Calumet and the wetlands east of the lake than in other rivers and lakes of the area (Table 18).

Table 18 Selected Average Trace Metal Concentrations (in mg/l) in Water from Streams, Rivers, and Lakes in the Lake Calumet Area (Maximum sample results in parentheses)

Location	As	Cd	Cr	Pb	Zn
Cal-Sag Channel (a)	0 002	0	0	0	0
Grand Cal R (b)	--	0	--	0	--
Grand Cal R (e)	0 001(005)	0 003(02)	0(03)	0 05(07)	0 05(2)
Calumet R (d)	0	0	0	0 03 (6)	0 2(2 0)
Calumet R (f)	0	0	0	0 05(13)	0 1(6)
Calumet R (c)	0	0	0	0 02 (4)	0 1(1 0)
Calumet R (i)	0	0	0	0 02(05)	0 03(2)
Wolf Lake (g)	--	--	--	0 04(21)	--
Lake Michigan (h)	0 002(011)	0(003)	0 011(032)	0	0
Pullman Cr	0 003(015)	0	0 018(12)	0 019(23)	0 091(28)
CLA	0 003(011)	0	0	0 015(15)	0 074(33)
Sewer E	0 004(011)	0	0	0	0 020(04)
Sewer F	0 007(017)	0 001(01)	0 065(47)	0 053(58)	0 563(5 6)
Indian Treaty Cr	0 003(010)	0	0 025(13)	0	0 036(08)
Sludge bed drainage	--	4 4(4 4)	65 (65)	12 5(12 5)	98 (98)

a = Sag Bridge, Oct 1979-Sept 1980 (USGS,1981)
b = Forsythe Avenue, Mar 1969-Jan 1971 (IEPA, 1986)
c = Ewing Br , Mar 1967-July 1974 (IEPA, 1986)
d = 130th Street Br , Mar 1969-Jan 1971 (IEPA, 1986)
e = Burham, Dec 1974-Oct 1975 (IEPA, 1986)
f = 130th St , Dec 1974-Mar 1975 (IEPA, 1986)
g = June 1975-Mar 1977 (IEPA, 1986)
h = Southern Lake Michigan, May 1984 and Oct 1984 (City of Chicago, 1985)
i = Ewing Br , Dec 1974-Mar 1975 (IEPA, 1986)

Sediment Quality

Unpolluted sediments tend to have low concentrations of anthropogenic elements. A source of concern related to sediment chemistry is that the material reacts with overlying waters, absorbing or releasing contaminants, and therefore the sediments may pose a threat to water quality. Previous studies have documented significant levels of pollution in the sediments of the lake and wetlands of the Lake Calumet area. Table 19 shows the average levels of metals in sediments from Lake Calumet and other water bodies of the area as compiled from various studies by Risatti and Sheridan (Ross et al., 1988a).

Table 19 Average Concentrations (in ppm) of Selected Elements in Sediments of Lake Calumet and in Sediments of Surrounding Water Systems

Elements	Lake Calumet[a]	Calumet Harbor[b]	Little Cal River[c]	Lake Michigan[d]	Cal-Sag Channel[c]	Wolf Lake[e]
Antimony	2 4	--	--	1 1	--	--
Arsenic	29 8	6 2	5 5	10 5	15	21
Bromine	4 2	--	--	33 0	--	--
Cadmium	1 8	3 2	2 5	0 9	8 5	2 0
Chromium	76 7	46 0	66	46 0	105 0	18 0
Copper	57 5	44	88	22 0	125 0	27 0
Iron (%)	2 7	--	2 9	2 2	3 4	1 5
Lead	187 0	144	190 0	40	370 0	110 0
Nickel	23 6	--	--	24	--	--
Phosphorus	20 0	20 6	130 0	70 0	300 0	36 0
Selenium	0 7	--	--	1 2	--	--
Silver (ppb)	561 0	--	--	460 0	--	--
Sodium	470 0	--	--	458 0	--	--
Thallium	6 2	--	--	--	--	--
Zinc	341 0	268 0	375 0	97 0	1100 0	255 0

a = Ross et al (1988a)
b = USACE (1985)
c = IEPA (1984)
d = Cahill and Shimp (1984)
e = Kelly and Hite (1981)

Sediments from lakes and rivers in the Lake Calumet region tend to have trace metal concentrations two to ten times the levels in Lake Michigan. The Calumet-Sag Channel and the Little Calumet River generally have the highest concentrations, and Lake Michigan and Wolf Lake the lowest.

Demissie et al. (Ross et al., 1988a) documented the deposition of 2,500 cubic feet of sediment, estimated to weigh 44 tons, on the beds of Lake Calumet and Pullman Creek over a nine-day period, indicating that the drainage delivered to the lake from Pullman Creek is a significant source of pollutants. Risatti and Sheridan (Ross et al., 1988a) described elevated concentrations of trace metals in sediments at the mouth of Pullman Creek and the area near the outfall of Sewer F in Lake Calumet. Composite toxicological investigations of the sediment of Lake Calumet performed by Ross et al. (1988a) showed "highly toxic" results for samples obtained from the mouth of Pullman

Creek and the outfall of Sewer F. These results indicate that these sources have in the past contributed large quantities of pollutants to the lake. In addition, once polluted sediments are deposited in the lake they are available for resuspension and transport within the lake and can be continuing sources of pollution. This investigation has shown that over time the large deltas at the mouths of Pullman Creek and site CLA which were deposited during the high lake levels of 1986 and 1987 were exposed by the subsequent drop in the lake level and washed into the lake.

Toxicity of Water Samples

Two studies of the toxicity of the elutriate waters from bed sediments of areas known to be contaminated provide a basis for comparison with the results obtained in this study. The purpose of bioassay testing is to provide a means for determining the combined effects of various contaminants in water and sediments. Individual measurements of the concentrations of constituent pollutants in water and sediment may not provide sufficient information regarding the cumulative or reduced effects of various contaminants on toxicity.

Results indicate that the inflow waters of Lake Calumet and the wetlands are more toxic to the Microtox™ bacterium than the elutriates of Lake Calumet and Waukegan Harbor's bed materials (Table 20). Toxicity tests based on the *P. redivivus* nematode bioassay indicate that the inflowing waters of Lake Calumet and the wetlands are more toxic than the elutriate samples from Lake Calumet but less toxic than the elutriates from Waukegan Harbor (Table 21). Both of these assay techniques therefore suggest that the inflowing waters of Lake Calumet and the wetland areas are continuing sources of contamination.

Table 20 Comparison of Microtox™ Results from Three Studies
(% luminescence inhibition)

	Lake Calumet Tributaries and Wetland Samples	Lake Calumet Elutriates*	Waukegan Harbor Elutriates**
Average	106 65	42 01	39 28
Maximum	279 50	162 63	113 00
Minimum	0 0	1 40	8 26
Standard deviation	111 50	37 08	
Number of samples	14	32	21
Average toxicological classification	Extremely toxic	Highly toxic	Highly toxic

* Ross et al , 1988a
** Ross et al , 1988b

Table 21 Comparison of *P. redivivus* Bioassay Results from Three Studies
(% fitness reduction)

	Lake Calumet Tributaries and Wetland Samples	Lake Calumet Elutriates*	Waukegan Harbor Elutriates**
Average	57 38	36 07	61 67
Maximum	92 86	78 41	97 00
Minimum	14 68	0 00	22 00
Standard deviation	25 04	22 66	21 58
Number of samples	14	21	24
Average toxicological classification	Highly toxic	Moderately toxic	Extremely toxic

* Ross et al , 1988a
** Ross et al , 1988b

Sources of Pollution

The principal sources of pollutants to the lake and wetlands are inflowing tributaries (streams, sewers, and overland flow), atmospheric deposition, and resuspension and redistribution of accumulated polluted sediments. This investigation examined the role of inflowing tributaries in transporting pollutants to the lake and determined from periodic sampling the largest measured sources of pollutants to the lake and wetlands (Table 22). The sludge drying bed drainage was the single largest monitored source of pollutants to the wetland area east of the lake. The second largest monitored source to the wetlands was the drainage from the landfill areas east of Stony Island Avenue. The principal measured sources of pollutants to Lake Calumet were from the drainage of Pullman Creek and Sewer F.

Table 22 Largest Measured Sources of Pollutants
(In pounds per hour)

	Lake Calumet		Wetlands	
Pollutant	Source	Rate	Source	Rate
Sediment	Sewer F	22,000 a	Sludge beds	59,600 a
Zinc	Sewer F	6 3 a	Sludge beds	176 a
Chromium	Pullman Cr *	0 90 a	Sludge beds	117 a
Lead	Pullman Cr *	0 93 a	Sludge beds	22 a
Cadmium	Sewer F	0 01 a	Sludge beds	7 9 a
Arsenic	Pullman Cr *	0 02 c	Indian T Cr	0 001 d
TOX	Sewer E	0 176 b	Sludge beds	0 02 a
TOC	Pullman Cr *	206 a	Sludge beds	16 5 a

* Pullman Creek including pump station
Dates of samples a = 8/10/88, b = 1/28/88, c = 4/28/88, d = 12/8/87

MWRDGC Sludge Drying Beds

Drainage from the sludge beds was the single largest measured source of contamination of the lake and wetlands. Drainage from these beds was measured on August 10, 1988, at 107th Street and Stony Island Avenue. Other drainage points from these beds are assumed to exist; however, only one point was monitored. No toxicological bioassay samples were obtained from this source.

On March 31, 1988, following three days of rain (Table 3), evidence of sludge drainage was observed at two locations on Stony Island Avenue. Sludge had filled the roadside drainage ditches and covered the street to a depth of 4 inches for a distance of 100 feet along the street. The estimated total volume of sludge on the street was 2,600 cubic feet or 117 tons.

On August 10, 1988, during heavy rain the flow off of the sludge bed at this location was 8 cfs. Flow was coming off of the beds to the west roadside ditch, overflowing the ditch, and flowing east across Stony Island Avenue to the wetlands. The flow was measured to have a sediment concentration of 33,000 mg/l, indicating that 59,600 pounds per hour of solids were flowing to the wetlands. The metal content of the flow was measured to be 176, 117, 22, and 7.9 pounds per hour of zinc, chromium, lead, and cadmium, respectively. The total measured metal discharge to the wetlands was over 322 pounds per hour.

Site Sewer F

The discharge from the outfall of Sewer F was observed to be the most significant measured source of contamination to Lake Calumet. Bioassay samples were obtained from this site on three dates. Five of the six bioassay test results were rated as extremely toxic.

On March 1, 1988, the sewer was discharging a flow of 0.2 cfs to the lake during a very dry period of nine days without rainfall. Dozens of dead fish were scattered around the outfall. Metals concentrations were all below detection limits on this sample date.

On July 12, 1988, the sewer was also observed to be discharging 0.2 cfs to the lake during a dry period of 13 days without rain. Flow was very turbid and suspended sediment concentration was 451 mg/l. Chromium concentration was 0.25 mg/l, five times the water quality standard. Forty-six sea gull and two fish carcasses were scattered around the sewer outfall.

On August 10, 1988, during heavy rain, the combined drainage from a channel conveying the sewer and overland flow was discharging at 5 cfs. Suspended sediment concentration was 19,800 mg/l. The load of sediment from this source was 22,000 pounds per hour. Zinc, lead, and chromium concentrations were in excess of water quality standards. Metal discharge to the lake was over 7 pounds per hour. Additional bird and fish carcasses were observed at this site.

CHAPTER 6

CONCLUSIONS

Pollution of Lake Calumet and adjacent wetlands, as documented by previous studies of the toxicity and trace metal concentrations of the sediments, is continuing. This investigation showed concentrations of metals in runoff waters to the lake and wetlands that were well in excess of levels that are toxic to humans. Polluted waters and sediment in the Lake Calumet area are a potential threat to fish and wildlife as well as to humans who use the area. In addition, the outlet for drainage from the Lake Calumet area is the Calumet River, which is hydraulically connected to the Calumet-Sag Channel of the Illinois River Basin and to Lake Michigan. Therefore, the continual degradation of the Lake Calumet area could affect the fishery, recreational uses and water supply of Lake Michigan as well as the Illinois River Basin.

Initially, marshes and wetlands were a prominent feature of the Lake Calumet area. Most of the wetlands have been filled for industrial and commercial siting and waste disposal. The remaining areas however, still provide the important functions of providing habitats for aquatic wildlife, flood control, water quality improvements, and resting areas for migrating species. The loss of the few remaining wetlands as a result of contamination and filling would be a great loss to the wildlife that depend on these areas and to the people of the region.

We recommend that tighter control of runoff from the existing landfills, sludge beds, and sewer outfalls be implemented immediately to reduce the delivery of contaminants to the wetlands, rivers, and lakes of the area. In addition, the remaining wetlands and open waters of the area should be managed for the benefits of flood control and water quality, as well as for migratory and native wildlife uses and endangered species habitat. The continual use of this area for legal and illegal waste disposal will further stress the quality of the environment and increase the eventual cost of controlling and reversing damages due to contamination.

Illegal dumping in the area poses a threat to the health of humans and water resources and must be stopped. The piles of dumped materials on roads in the area, especially Stony Island Avenue, tend to promote further dumping. There is a real threat of attracting "midnight dumpers" of hazardous and toxic substances. In addition, these piles of dumped materials pose a threat to road and rail traffic.

Past disposal practices continue to pose a threat to human health and the environment. The effects of drainage from the many past and present hazardous waste landfills must be quantified. Liquid wastes from hazardous landfills such as the U.S. Scrap Corp., a USEPA Superfund site three-quarters of a mile from the lake, have been observed leaching from an embankment and flowing through drainage channels to protected wetland areas used by native and migratory waterfowl. Chemical, bacteriological, and radiological wastes are known to have been illegally buried in drums and unlined pits at many locations in the area. However, the contamination at the most dangerous of these areas has not yet been fully characterized.

This study represents only a first step: an overview of current levels of pollutants delivered to the lakes and wetlands of the area by a few drainage pathways. This was not a comprehensive study; only a few of the many sources of contaminants were examined. Some sources were not examined, such as drainage from various hazardous waste disposal sites and Superfund sites. Although this study documented previous and continuing contamination of the environment, a detailed evaluation of the sources and fate of pollutants in the region and the effects of these pollutants on local and regional water resources is greatly needed.

In regard to the paramount concern of the Illinois legislative Joint Committee on Hazardous Waste in the Lake Calumet Area that "the state needs full assurance that the Lake Calumet area is not harming the quality of the valuable waters of Lake Michigan," indications are that this assurance cannot be given on the basis of the current levels of contamination measured by this investigation. The interrelationship of the hydrology of the Greater Lake Calumet Area and Lake Michigan is reviewed in this report. The current situation of water resource management in the region includes extremely frequent combined sanitary and storm sewer overflows to water bodies of the area, especially Lake Michigan; uncontrolled drainage from toxic waste disposal sites, Superfund sites, sludge drying beds, and landfills; and the presence of contaminated sediments in the rivers, lakes, and wetlands of the region as well as in Lake Michigan. All of these factors indicate that contamination of water resources is continuing and may pose a threat to water resources and humans.

The Illinois State Water Survey, in cooperation with the Hazardous Waste Research and Information Center, has prepared a proposal to address the concerns of the Illinois legislative Joint Committee on Hazardous Waste in the Lake Calumet Area and various citizens' groups and environmental organizations. The proposed investigation, "A Monitoring and Evaluation Plan for Surface Water Contaminants and Sediments within the Greater Lake Calumet Area and Southwestern Shores of Lake Michigan," would assess and quantify the degree of contamination of the water resources of the area and the effects on the regional water supply, Lake Michigan. Specific programs have been outlined for quantifying the sources, fate, and effects of present and past pollution. The results of the proposed project would be invaluable for identifying, controlling, and mitigating pollution in the region.

REFERENCES

American Society for Testing and Materials (ASTM). 1982. Annual Book of ASTM Standards, Part 31, Water.

Bhowmik, N.G., and W.P. Fitzpatrick. 1988. A Monitoring and Evaluation Plan for Surface Water Contaminants and Sediments within the Greater Lake Calumet Area and Southwestern Shores of Lake Michigan. Hazardous Waste Research and Information Center, HWRIC TN88-009, Savoy, IL.

Buchanan, T.J., and W.P. Somers. 1969. Discharge Measurements at Gaging Stations. Book 3, Chapter A8 in Techniques of Water Resources Investigations of the United States Geological Survey, U.S. Government Printing Office, Washington, D.C.

Bulich, A.A., M.W. Greene, and D.L. Isenberg. 1981. Reliability of the Bacterial Luminescence Assay for Determination of the Toxicity of Pure Compounds and Complex Effluents. ASTM STP 737. American Society for Testing and Materials, pp. 338-347.

Cahill, R. A. 1981. Geochemistry of Recent Lake Michigan Sediments. Illinois State Geological Survey Circular 517.

Cahill R.A., and J.D. Steele. 1986. Inorganic Composition and Sedimentation Rates of Backwater Lakes Associated with the Illinois River. Illinois State Geological Survey Environmental Geology Notes 115.

City of Chicago. 1976. Study of Sewer Improvements in the Calumet Area, June.

City of Chicago. 1985. Lake Michigan Water Quality Report 1984. Chicago Department of Water and Illinois Environmental Protection Agency, November.

Colten, C.E. 1985. Industrial Wastes in the Calumet Area, 1869-1970. Hazardous Waste Research and Information Center, HWRIC RR001, Champaign, IL, 124p.

Ecology and Environment, Inc. 1986. Scope of Work for Site Inspection Follow-Up, U.S. Scrap. TDD R05-8512-02(02A) Chicago, IL, June 6.

Guy, H.P., and V.W. Norman. 1970. Field Methods for Measurement of Fluvial Sediments. Book 3, Chapter C2, in Techniques of Water Resources Investigations of the United States Geological Survey, U.S. Government Printing Office, Washington, D.C.

Hydro Qual Inc. 1985. Grand Calumet River Wasteload Allocation Study. Indiana State Board of Health, Indianapolis, Indiana.

IEPA. 1984. Illinois Water Quality Report 1982-1983. IEPA/WPC/84-024.

IEPA. 1985. Summary of Toxicity Information, Water Quality Criteria and Standards for the Priority Pollutants. Office of Chemical Safety, November.

IEPA. 1986. The Southeast Chicago Study: An Assessment of Environmental Pollution and Public Health Impacts, Springfield, March.

Joint Committee on Hazardous Waste in the Lake Calumet Area (JCHWLCA). 1987. Report Submitted to the General Assembly and the Public. Senator Emil Jones, Chairman, and Representative Sam Panayotovich, Vice-Chairman, Dec. 2.

Katz, P.L., and G.M. Schwab. 1975. Modeling Episodes in Pollutant Dispersion in Lake Michigan. University of Illinois Water Resources Center Research Report 97.

Kelly, M.H., and R.L. Hite. 1981. Chemical Analysis of Surficial Sediments from 63 Illinois Lakes, Summer 1979, IEPA, Springfield, IL.

Metropolitan Water Reclamation District of Greater Chicago. 1988. Facilities Planning Study, Update Supplement and Summary, Chicago, IL, December.

National Oceanic and Atmospheric Administration. 1987 and 1988. Climatological Data, Illinois. National Climatic Data Center, Asheville, North Carolina, Volume 92, No. 4 through Volume 93, No. 6.

Northeastern Illinois Planning Commission (NIPC). 1977. Areawide Water Quality Management Plan.

Romano, R.R., A.W. McIntosh, W.V. Kessler, V. Anderson, and J.M. Bell. 1977. Trace Metal Discharges of the Grand Calumet River. Journal of Great Lakes Research 3(1-2), International Association of Great Lakes Research, pp. 144-147.

Ross, P.E., M.S. Henebry, J.B. Risatti, T.J. Murphy, and M. Demissie. 1988a. A Preliminary Environmental Assessment of the Contamination Associated with Lake Calumet, Cook County, Illinois. Hazardous Waste Research and Information Center, HWRIC RR-019, Champaign, IL.

Ross, P.E., M.S. Henebry, W. Wang, and L.C. Burnett. 1988b. Assessment of Ecotoxicological Hazard of Waukegan Harbor Sediments. Hazardous Waste Research and Information Center, HWRIC RR-018, Savoy, IL.

Samoiloff, M.R., S. Schulz, Y. Jordan, K. Denich, and E. Arnott. 1980. A Rapid Simple Long-Term Toxicity Assay for Aquatic Contaminants Using the Nematode *Panagrellus redivivus*. Canadian Journal of Fisheries and Aquatic Sciences 37:1167-1174.

Shimp, N.F., J.A. Schleicher, R.R. Ruch, D.B. Heck, and H.V. Leland. 1971. Trace Element and Organic Carbon Accumulation in the Most Recent Sediments of Southern Lake Michigan. Illinois State Geological Survey, Environmental Geology Notes, No. 41, 35 p.

USACE. 1982. Chicago District, Final Environmental Impact Statement, May 1982, Chicago Area Confined Disposal Facility and Maintenance Dredging in Cook County, Illinois.

USACE. 1983. Phase II Letter Report: Little Calumet River, Illinois. U.S. Army Corps of Engineers Chicago District, 22 p.

USACE. 1985. Draft Environmental Impact Statement: Section 10 and Section 404 Permit for a Sanitary Landfill in a Wetland Adjacent to Lake Calumet, Chicago, Cook County, IL, Chicago, IL.

USACE. 1988. Lake Calumet Special Area Management Plan, Public Notice. U.S. Army Corps of Engineers Chicago District, 16 p.

U.S. Department of Health, Education, and Welfare (USHEW). 1965. Report on Pollution of the Waters of the Grand Calumet River, Little Calumet River, Calumet River, Lake Michigan, Wolf Lake, and Their Tributaries, Illinois-Indiana. Division of Water Supply and Pollution Control, Region V, Chicago, IL, February, 46+ p.

USEPA. 1982. Methods for Chemical Analysis of Municipal and Industrial Wastewater. EPA-600/4-82-057.

USEPA. 1983. Methods for Chemical Analysis of Water and Waste. Environmental Monitoring and Support Laboratory, Revised March 1983.

USEPA. 1987. Cadmium Health Advisory Draft. Office of Drinking Water, U.S. Environmental Protection Agency, March.

USGS. 1981. Water Resources Data for Illinois, Volume 2. Illinois River Basin Water Year 1980.

APPENDIX

SUMMARY OF FIELD OBSERVATIONS

APPENDIX

Summary of field observations

October 28-29, 1987

General:	Tour of area to examine surface drainage and potential sampling sites. Identified major drainage ditches, culverts, and sewer outlets. Detailed examination of the surface drainage to Indian Treaty Cr., Pullman Creek, the Doty Avenue roadside ditches, I-94 ditches, and Stony Island Avenue ditches. Preliminary selection of future sampling sites. Met USEPA and Ecology and Environment, Inc. personnel and toured the U.S. Scrap Superfund site located 3/4 mile west of the lake. No sampling was performed these dates. 112th and Stony Island Avenue: street almost completely blocked by illegal garbage and trash dump piles. Dump truck hauling concrete rubble attempting to drive around the piles slid off the street and was resting at a 45° angle on the N&W RR tracks.

November 19, 1987

General:	Sampling for suspended sediment began this trip. Weather: hazy, 15-20 mph winds, 44°F.
CLA:	water clear, extensive mudflats eroding into lake, trash in channel
Pullman Cr:	turbid water yellow brown color, oil slicks on surface, pump station not operating
CLC:	water turbid dark brown, tannin and organic odor, very low flow
Sewer F:	water turbid whitish color, heavy rancid smell
Sewer E:	water clear, no odor, very low flow

December 8, 1987

General:	Performed discharge measurements and sampling for suspended sediment, metals, and TOX. Weather cloudy hazy, light rain, S 12 mph wind, 52°F. Rain over the last few days; ground is saturated, drainage ditches along Doty Avenue 1/2 full but little flow.
CLA:	water clear but channel bed covered with greenish-white slime, light rain
Pullman Cr:	water turbid yellow brown color, very low flow-pulsating, light rain
CLC:	oil film on surface, flow pulsing in response to wind, light rain, rising stage
CLD:	ponded water both sides of road, water very clear, very low flow through culvert
Sewer F:	strong garbage smell to water, turbid, roadside ditches flowing into storm drains

Sewer E: water has light green color, moderate flow, retention pond discharging to sewers

January 28, 1988

General: Weather: 22°F, SSE 6 mph wind, 1/2 in. snow cover on ground, lake & ditches ice covered.
CLA: ice cover 1.5 inches, low flow, water clear under ice
Pullman Cr: brownish gold color water, oil slicks, very low flow, ice cover 50%, no pumping
CLC: water light gold brown color, ice cover 90%, very low flow
Sewer F: turbid, bed covered with same light grey clay as roadside ditches, burning car near site
Sewer E: high flow, water has yellow tint, no discharge from retention pond
Calumet R.: river 10% ice covered, recent barge and tow passages evident in broken ice, flow to north

March 1, 1988

General: Weather: 32°F, ESE 12 mph wind, clear with light haze. Lake Calumet still ice covered but open at tributary inflow points.
CLA: recent dumping in channel, bed has oily stained appearance, eroding mud flats
Pullman Cr: very low flow, oil slick on surface, pump station not operating
CLC: low flow, oil slick on surface, water has tannish yellow color, 6 dead minnows floating
Sewer F: low flow, 12 dead fish (11-14) within 20 ft. of outfall; dozens more along shore
Sewer E: moderate flow, water has tannish yellow appearance.
L. Michigan: sampled at boat launch at Calumet Pk. Water cold and clear. Waves three feet, from SE.

March 31, 1988

General: Began TOC sampling. Weather: 42°F, NE 10 mph wind, cloudy and hazy.
CLA: recent dumping of garbage in channel, plume from this tributary visible in L. Calumet, water light grey
Pullman Cr: no pumping, eroding mudflats, 6 dead fish (6-10) on downstream mudflats, water yellowish tint
CLC: water clear, no flow
107 & Stony Island: sewage sludge on street at 2 locations, source was likely from MWRDGC sludge beds. Sludge covers the street to a depth of 4 in.
Sewer F: water cloudy, dead fish and clam on shore near outfall

Sewer E:	fairly high flow, water clear but foam plume from outfall in Calumet River
Stony Island ditch:	sample of ditch water near L&L landfill across from Steelmet driveway, green tint color
L. Michigan:	sampled at boat launch at Calumet Pk. Water cold and clear. waves 1 ft., from N.

<u>April 28, 1988</u>

General:	Began pH measurements. Weather: sunny with scattered clouds, 49°F, N 10 mph winds.
CLA:	very low flow, sample at box culvert under Doty Avenue
Pullman Cr:	no pumping, high flow, water dark yellow, ponded water on Doty Avenue
CLC:	very low flow
Sewer F:	very low flow, dead fish from last visit gone, lake level slightly higher
Sewer E:	very low flow
107 & Stony Island Ave:	roadside ditches cleaned out and rubble and garbage piled on ditch bank on the edge of the street.

<u>May 27, 1988</u>

CLA:	Water clear with floating scum on surface
Pullman Cr:	no pumping, water clear with yellow tint. Several anglers at mouth of creek.
CLC:	very low flow; water dark green-brown. Shotgun shells scattered throughout site.
Sewer F:	very low flow, water slightly cloudy
Sewer E:	very low flow, water slightly cloudy. Retention pond almost empty; two ducks feeding in puddles at the bottom.
U.S. Scrap:	Observed six seeps on west side of RR embankment. Fluid is orange-brown color staining the surrounding ground and vegetation. Vegetation appears to be killed off in vicinity of the seeps and drainage paths. Seeps drain into MWRDGC wetland ponds west of site. Half dozen ducks swimming in ponds near the seeps.

<u>July 12, 1988</u>

General:	Warm 76°F at 3:20 p.m.
CLA:	low flow, greenish grey tint, sewage odor, oil film on surface. Anglers on shore.
Pullman Cr:	low flow pulsing with wind gusts, no pumping at DOT pump sta.
CLC:	low flow water has yellow brown tannic swamp color, 8 inch turtle in upstream pool.

Sewer F:	water dark yellow brown color. 46 dead sea gulls scattered around outfall, also dead fish 2 feet in length.
Sewer E:	no flow no samples, holding pond dry

July 13, 1988

Reported bird kill at site Sewer F to IEPA Maywood office.

August 10, 1988

General:	Moderate to heavy rain, wind E. 10 mph
CLA:	low flow, water clear with yellow tint. More garbage dumped in channel. Light rain.
Pullman Cr:	light rain. Moderate flow, water dark grey color, pump station operating.
DOT pump station:	sampled pump station outfall to Pullman Creek.
CLC:	Heavy rain but no discharge through culvert
Stony Island Avenue:	Overland flow of runoff from sewage sludge beds west of street to wetlands, turbid black color. Street almost completely blocked in places due to illegal dump piles.
Sewer F:	heavy rain, runoff same color and odor as landfill ditches east of Stony Island. Dead birds & fish on shore. Sampled combined drainage from sewer outfall and surface channel from industrial lot north of site.
Sewer E:	very heavy rain but no discharge
L&L landfill ditch:	heavy rain, drainage from landfill, flow to north to wetlands, very turbid chocolate brown color

August 24, 1988

CLA:	Very low flow- no samples taken
Pullman Cr:	low flow
CLC:	no flow
Sewer F:	very low flow, water clear with suspended white clay, no fresh bird kills
Sewer E:	no flow at outfall, retention pond dry.
Calumet R.:	dip sampled river from shore at Sewer E.

October 4, 1988

CLA:	low flow, very clear
Pullman Cr:	moderate flow, no pumping at DOT pumps
CLC:	low flow
Sewer F:	low flow, milky white color, no new dead birds
Sewer E:	no flow, no samples
Stony Island Avenue:	More garbage and trash on street; most observed to date. Burning BMW on roadside.

122nd St.:	Three new 8 inch iron culverts placed under street connecting storm drains on north side to wetlands on south side.

<u>October 5, 1988</u>

Pullman Cr: very low flow, no pumping at DOT pumps

<u>October 20, 1988</u>

CLA:	low flow, water has grey tint, more garbage in channel
Pullman Cr:	low flow, no pumping at DOT pumps, oil slick on surface
CLC:	low flow, water has yellow brown color
Sewer F:	low flow, water has white tint. No new dead birds this site.
Sewer E:	no flow, no samples
122nd Street outfall:	sampled outfall from new culverts placed under 122nd Street draining to wetlands from L&L Landfill. No discharge at outfalls; sampled water in ditch.
Stony Island Avenue:	Just south of incinerator, backhoe cleaning out drainage ditches on west side of street removing trash, garbage, and accumulated sludge. South on Stony Island more trash and garbage than last visit.