

***Protecting Our Water Environment***



***Metropolitan Water Reclamation District of Greater Chicago***

**RESEARCH AND DEVELOPMENT  
DEPARTMENT**

***REPORT NO. 99-8***

***BIOLOGICAL WATER QUALITY WITHIN THE  
CALUMET WATERWAY SYSTEM***

***DURING 1989***

***S.G. Dennison  
W.G. Schmeelk  
I. Polls  
P. O'Brien  
S.J. Sedita  
P. Tata  
C. Lue-Hing***

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By

Samuel G. Dennison  
Biologist II

William G. Schmeelk  
Microbiologist III  
(Retired)

Irwin Polls  
Biologist III

Parnell O'Brien  
Research Scientist II  
(Retired)

Salvador J. Sedita  
Microbiologist IV

Prakasam Tata  
Research and Technical Services Manager

Cecil Lue-Hing  
Director of Research and Development

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## DISCLAIMER

Mention of proprietary equipment and chemicals in this report does not constitute endorsement by the Metropolitan Water Reclamation District of Greater Chicago.

## EXECUTIVE SUMMARY

The deep draft portion of the Calumet River System, which includes the Calumet River, the Little Calumet River, and the Cal-Sag Channel, was studied during 1989. The study was designed to determine the water quality within the system by examining populations of the indigenous biota, including selected bacterial indicators, benthic invertebrates, fish, and periphyton. A summary of the major results of the biological samplings are shown in Figure 1.

### Calumet River Water Quality

#### BACTERIA

The sanitary water quality of the Calumet River was relatively good. Total coliform (TC) and fecal coliform (FC) bacteria counts were less than in the Little Calumet River or Cal-Sag Channel (Figure 1). Except for a sample at Ewing Avenue collected on May 1, 1989, with a FC density of 560 colony forming units (cfu) per 100 mL, the samples taken from Ewing Avenue and 130th Street for bacterial analysis during 1989 had a FC density less than the General Use Water Quality Standard of 400 cfu/100 mL.

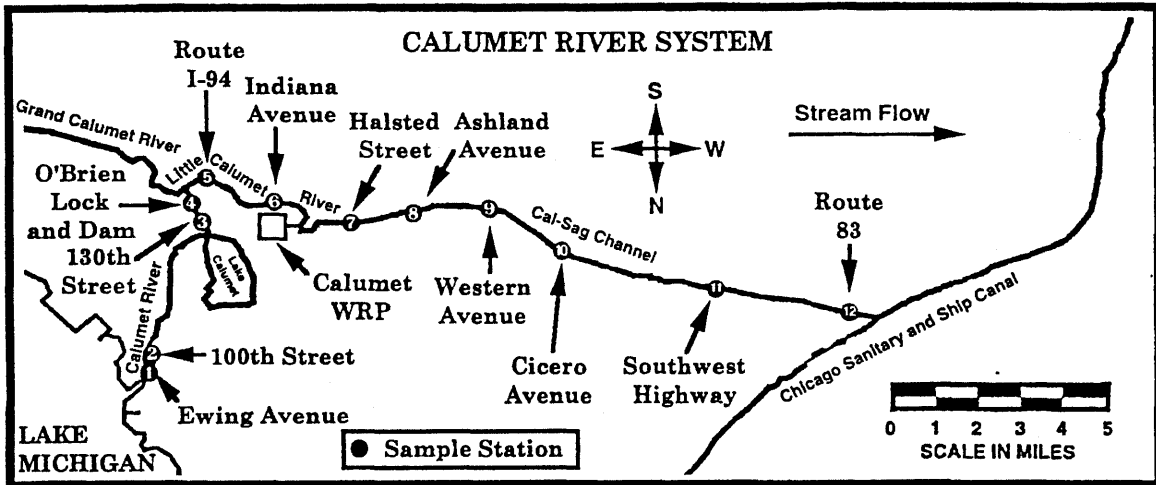
#### BENTHIC INVERTEBRATES

Fifty-six benthic taxa were identified from the 100th Street and 130th Street stations, with an overall estimated mean faunal density of 14,016 organisms per square centimeter.

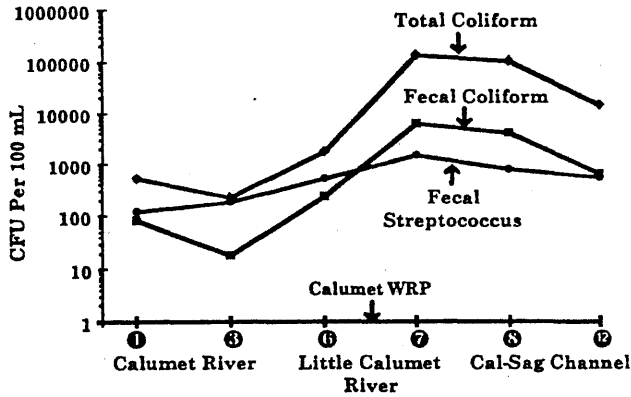
METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 1

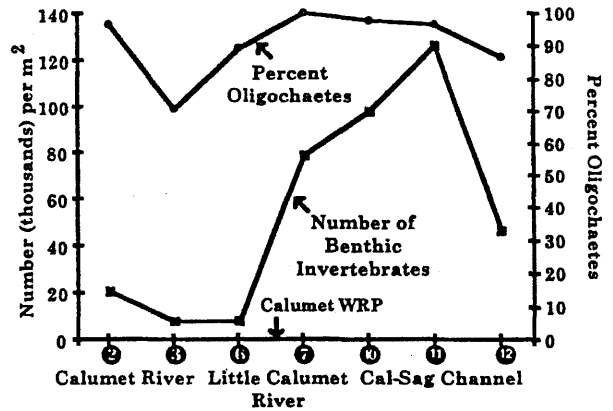
SUMMARY OF BIOLOGICAL SAMPLING RESULTS FROM THE ECOSYSTEMATIC STUDY OF THE CALUMET RIVER SYSTEM DURING 1989



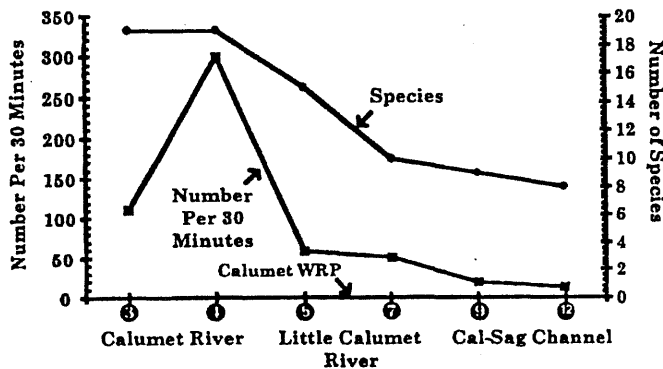
**Bacteria**



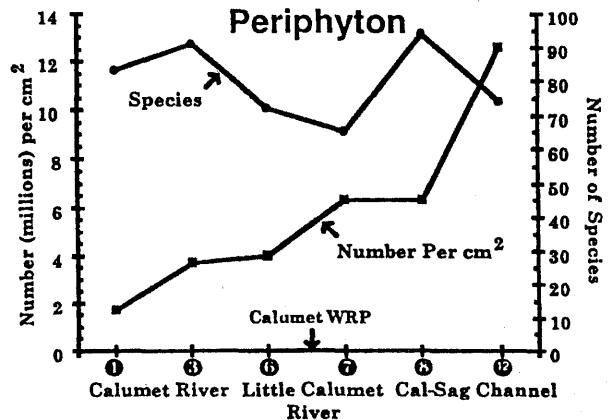
**Benthic Invertebrates**



**Fish**



**Periphyton**



Overall, the benthic community was dominated by the oligochaetes, including the tubificid and naidid worms (1).

The mean number of benthic invertebrates in the Calumet River was higher at 100th Street (20,271 organisms/m<sup>2</sup>) than at 130th Street (7,795 organisms/m<sup>2</sup>), as shown in Figure 1. There was evidently an area of organic enrichment of the sediment at the 100th Street station in which the percent oligochaete worms was greater than 90% of the total benthic invertebrate density. The sediment quality of the Calumet River at 130th Street was better, with 71% of the total benthic community made up of oligochaetes.

#### FISH

More fish and fish species were collected in the Calumet River than in the Little Calumet River or in the Cal-Sag Channel (Figure 1). Relative abundance of fish was 111 fish and 300 fish per 30 minutes, with 19 and 20 fish species, at the 130th Street and O'Brien Lock and Dam sample stations, respectively. The total catch in the Calumet River was 1,736 fish composed of 23 species. The total weight of the catch was 264 kilograms (581 pounds). The major species, by number, was the alewife and the major species, by weight, was the carp. Harvestable size fish included bluegill, carp, channel catfish, freshwater drum, largemouth bass, white bass, white sucker, and yellow bass. In 1989, the Calumet River was a

moderate aquatic resource with fair stream quality for fish (2).

#### PERIPHYTON

The periphyton results also indicated water of good quality and low in nutrient enrichment. The greatest numbers of periphyton species occurred in the Calumet River, as well as the smallest numbers of total periphyton (Figure 1).

#### Little Calumet River Water Quality

#### BACTERIA

The Little Calumet River, from its junction with the Grand Calumet River to the Cal-Sag Channel, is a designated secondary contact water and has no bacterial water quality standard.

Compared with the 130th Street station on the Calumet River, the geometric means of the TC and FC densities increased significantly at Indiana Avenue on the Little Calumet River (Figure 1). The TC density increased from 220 cfu/100 mL to 1,800 cfu/mL, an 8-fold increase. The FC density increased from 18 cfu/100 mL to 230 cfu/100 mL, a 13-fold increase. These increases in TC and FC densities upstream of the Calumet WRP at Indiana Avenue suggest a discharge of wastewater upstream of the Calumet WRP outfall. This wastewater could have come from a WRP in Indiana discharging to the Grand Calumet River, which joins the Little Calumet River

upstream of the Calumet WRP discharge, or from combined sewer overflows.

Compared with the Indiana Avenue station, the geometric means of the TC and FC densities increased significantly at Halsted Street. The TC density increased from 1,800 cfu/100 mL to 130,000 cfu/100 mL, a 72-fold increase. The FC density increased from 230 cfu/100 mL to 6,200 cfu/100 mL, a 27-fold increase. These increases in TC and FC densities below the discharge of the Calumet WRP at Halsted Street reflect the input of treated, unchlorinated, wastewater to the Little Calumet River by the Calumet WRP.

#### BENTHIC INVERTEBRATES

Twenty-seven species of benthic invertebrates were collected from the Indiana Avenue and Halsted Street stations in the Little Calumet River. The overall mean abundance was 43,270 organisms per square meter (1). The benthic invertebrate results indicated degraded water quality below the Calumet WRP outfall. The mean number of benthic invertebrates increased in the Little Calumet River, at the Indiana Avenue station (7,900 organisms/m<sup>2</sup>) and at the Halsted Street station (78,639 organisms/m<sup>2</sup>), as shown in Figure 1.

#### FISH

In comparison with the Calumet River, the number of fish and fish species decreased in the Little Calumet River, as

shown in Figure 1. Relative abundance was 60 and 51 fish per 30 minutes, with 15 and 10 fish species, at the Indiana Avenue and Halsted Street sample stations, respectively. The total catch in the Little Calumet River was 678 fish composed of 15 fish species. The total weight of the catch was 121 kilograms (266 pounds). The major species, by number, was the gizzard shad, and the major species, by weight, was the carp. Harvestable size fish included black bullhead, bluegill, carp and largemouth bass. In 1989, the Little Calumet River was a limited aquatic resource with poor stream quality for fish (2).

#### PERIPHYTON

The periphyton results also indicated degraded water quality both above and below the Calumet WRP discharge. The number of periphyton species decreased while the total number of periphyton increased (Figure 1), indicating nutrient enrichment.

#### Cal-Sag Channel Water Quality

#### BACTERIA

The TC and FC counts at the Route 83 station, 17 miles downstream of the Calumet WRP discharge, were of the same order of magnitude as the values for these bacterial groups upstream of the Calumet WRP. The values at Route 83 had decreased from the relatively high numbers at the Halsted Street and Ashland Avenue stations, indicating that a natural reduction in numbers of bacteria had occurred by the time the



water reached the Route 83 station in the Cal-Sag Channel. This corroborated the conclusion of Haas et al. (14) that receiving water bacterial concentrations immediately downstream of a WRP showed a transient increase after the cessation of wastewater effluent chlorination, but that beyond 15 miles from the WRP discharge no additional effect upon the microbial water quality could be observed.

#### BENTHIC INVERTEBRATES

A total of 28 benthic taxa was collected from the Western Avenue, Southwest Highway, and Route 83 stations. The estimated overall mean faunal density was 89,909 organisms/m<sup>2</sup> (1). The benthic invertebrate population was composed of almost 100% oligochaete worms at each Cal-Sag Channel station, indicating degraded sediment quality throughout the length of the Cal-Sag Channel. In the Cal-Sag Channel the mean number of benthic invertebrates at the Western Avenue station was 97,664 organisms/m<sup>2</sup>, 126,006 organisms/m<sup>2</sup> at the Southwest Highway station, and 45,993 organisms/m<sup>2</sup> at the Route 83 station (Figure 1).

#### FISH

The number of fish and fish species were lower in the Cal-Sag Channel than in the other waterways (Figure 1). Relative abundance was 19 and 13 fish per 30 minutes, with 9 and 8 fish species, at the 130th Street and O'Brien Lock and Dam

sample stations, respectively. Sixty-four percent of the fish collected were pollution tolerant carp, goldfish, and carp x goldfish hybrids. The Cal-Sag Channel total catch was 159 fish composed of 11 species. The total weight of the catch was 50 kilograms (110 pounds). The major species by number and weight was the carp. Harvestable size fish included carp and largemouth bass. In 1989, the Cal-Sag Channel was a limited aquatic resource, with poor stream quality for fish (2).

#### PERIPHYTON

The increase in total numbers of periphyton (Figure 1) also indicated nutrient enrichment, indicating degraded water quality, in the Cal-Sag Channel.

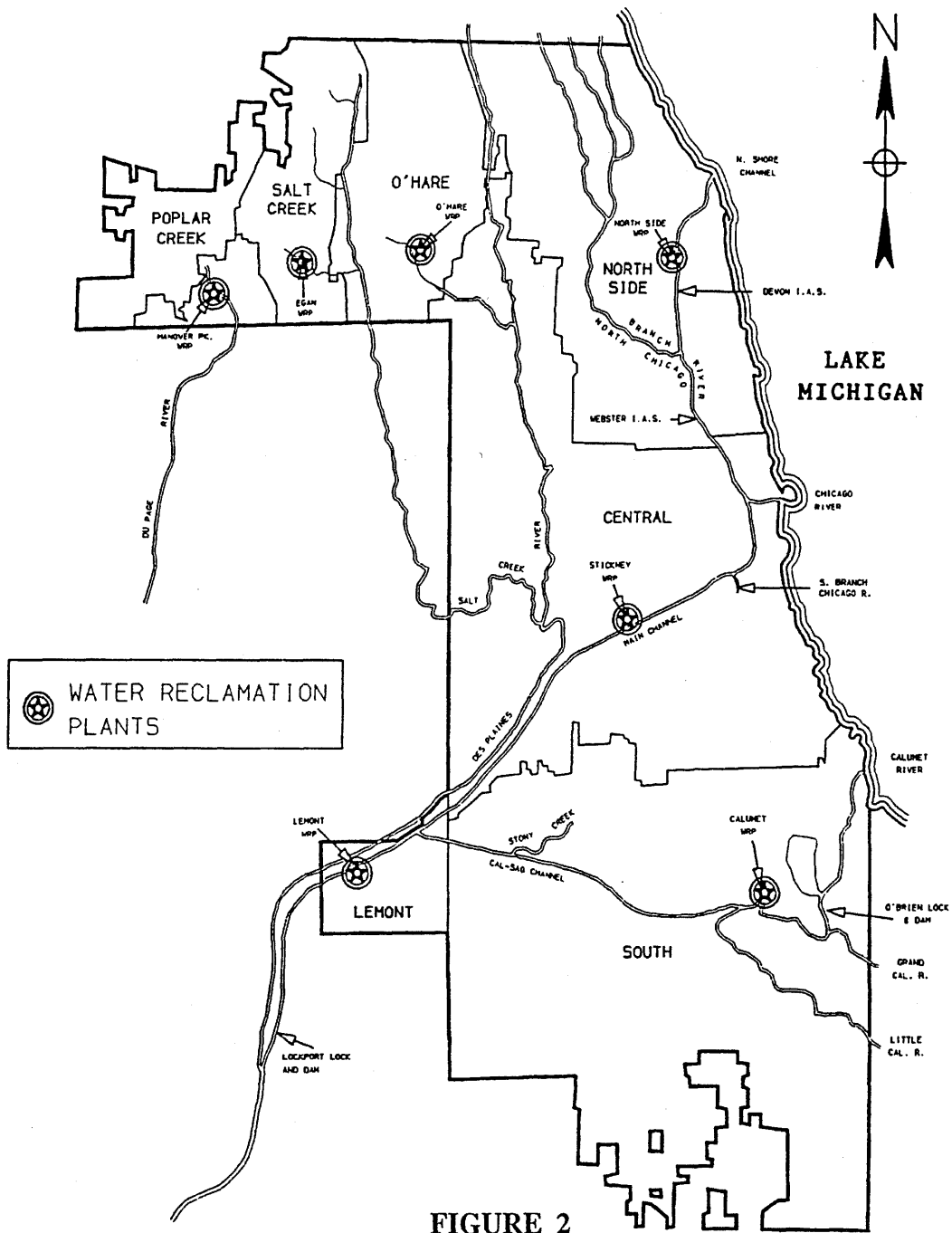
## INTRODUCTION

The Metropolitan Water Reclamation District of Greater Chicago (District) serves an area of 872 square miles. The area is highly urbanized and industrialized. The District treats a total domestic and nondomestic wastewater load that is equivalent to a population of 9.5 million people. Approximately 375 square miles of the District's area is served by combined sewers, with the remainder being either unsewered or served by storm sewers. The District presently owns and operates seven water reclamation plants (WRPs) all of which utilize the conventional activated sludge process, and which are connected by approximately 537 miles of intercepting sewers. The North Side, Stickney, Calumet, and Lemont WRPs together have 1,889 MGD of secondary capacity. The Hanover, Egan, and Kirie WRPs have a combined tertiary capacity of 114 MGD (3).

In order to protect the area's primary water supply, Lake Michigan, the flow of the Chicago River System was reversed in 1900, and the Calumet River System was reversed in 1922. Fifty-four miles of navigable canals were constructed and connected to existing river systems to form the 81 mile long Chicago Waterway System (Figure 2).

The District is responsible for the quality of the water in the streams and canals within its jurisdiction. The District established its Ecosystematic Study Program (4) in 1974 to monitor these waterways on a regular basis using biological

# METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO



MAP OF MAJOR FACILITIES AND SERVICE AREAS

parameters (Table 1). The Calumet River System was monitored during 1989 for this report. It was previously monitored during 1974, 1975, 1976 and 1988.

The objective of this study was to sample the bacteria, benthic invertebrates, periphyton, and fish of the Calumet River System, including the Calumet River, Little Calumet River, and Cal-Sag Channel, and to characterize the water quality of these waterways using metrics from these biological populations. Bacterial densities were measured in water samples because of the importance of bacteria as indicators of the sanitary quality of the water for human and animal health. Benthic invertebrates were sampled because they are good indicators of the water and sediment quality for the bottom dwelling organisms. Periphyton were sampled as "quick response" indicators of water quality for these microscopic plants. Fish were sampled because they are indicators of the quality of the river for fish. Measurements were made of the chemical quality of the water at the time of fish collections in order to determine the toxicity of the water to fish.

#### Study Area

The Calumet River System (Figure 1) is composed of three segments, as follows:

1. The Calumet River is 7.73 miles long and 8.5 to 11.5 feet deep (3). The River flows from Calumet Harbor to the junction with the Grand

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TABLE 1

WATERWAYS MONITORED DURING THE ECOSYSTEMATIC STUDY  
1975 THROUGH 1989

YEARS	WATERWAYS
1975, 1976 and 1977	North Shore Channel North Branch of the Chicago River Chicago River South Branch of the Chicago River Chicago Sanitary and Ship Canal Calumet River Little Calumet River Cal-Sag Channel
1978 and 1979	Des Plaines River in Cook County
1980 and 1981	North Branch of the Chicago River in- cluding the West Fork, Middle Fork, and Skokie River
1982 and 1983	Little Calumet River and Thorn Creek
1984 and 1985	Wilmette, Chicago and Calumet Harbors
1986 and 1987	North Shore Channel North Branch Chicago River
1988 and 1989	Calumet River Little Calumet River Cal-Sag Channel

Calumet River, just downstream of the O'Brien Lock and Dam.

2. The deep draft portion of the Little Calumet River is 6.55 miles long and 14 feet deep (3). The original Calumet WRP began operation on September 11, 1922. It was replaced by a conventional activated sludge plant in 1935 (5). The final effluent from the Calumet WRP flows into the Little Calumet River.
3. The Cal-Sag Channel is 15.98 miles long and 8.8 to 11.7 feet deep (3). The Channel extends from its junction with the Little Calumet River to its junction with the Chicago Sanitary and Ship Canal.

As the Calumet River flows in a southerly direction away from Lake Michigan and joins with the Little Calumet River that connects with the Cal-Sag Channel, the water and sediment quality is markedly influenced by a combination of the advanced secondary treated wastewater from the Calumet WRP, treated municipal and industrial wastewater from the state of Indiana, and periodic discharges from urban storm water and combined sewer overflows both in the states of Indiana and Illinois.

## Biological Samples

### BACTERIA

Total coliform (TC), fecal coliform (FC), and fecal streptococcus (FS), are used by the District to indicate the sanitary quality of water. Analyses for these indicator bacteria have been performed routinely on all District waterways, including the Calumet River System, for many years.

In 1983, the Appellate Court of Illinois allowed cessation of effluent chlorination for District WRPs discharging into secondary contact and indigenous aquatic life waters. In 1983, the District filed a petition before the Illinois Pollution Control Board (IPCB) requesting a variance from the water quality effluent standards for the Calumet WRP, which discharges its final effluent into the designated secondary contact waters of the Little Calumet River (Figure 2). This variance was granted for the period of August 1, 1983 through March 31, 1984. On March 21, 1984, the IPCB granted a variance beginning April 1, 1984, for the District's three major WRPs, Calumet, North Side, and Stickney (6). The North Side WRP discharges its final effluent into the designated secondary contact waters of the North Shore Channel (Figure 2). The Stickney WRP discharges final effluent into the designated secondary contact waters of the Chicago Sanitary and Ship Canal (Figure 2).

The enterococcus group (ME) is a subgroup of the fecal streptococci that is a bacterial indicator for determining the



extent of fecal contamination of recreational surface waters. Studies at bathing beaches have shown that swimming associated gastroenteritis is related directly to the quality of the bathing water, and that enterococci are efficient bacterial indicators of water quality.

Escherichia coli (EC) is an opportunistic intestinal pathogen and is a member of the fecal coliform group. EC is also a valuable indicator of bathing water quality.

Pseudomonas aeruginosa (PA) is a common inhabitant of soil and water and has worldwide distribution. It is responsible for a number of infections in humans, particularly in debilitated or immunocompromised hosts.

Salmonella spp. (SAL) are enteric pathogens, some species of which occur naturally in the environment.

The Standard Plate Count (SPC) is used to estimate the total number of viable heterotrophic bacteria in water.

#### BENTHIC INVERTEBRATES

The benthic invertebrate community frequently has been used to assess the environmental quality of aquatic ecosystems. These organisms are sensitive to both physical and chemical changes in the environment, and they continually adjust to the water and sediment quality. They also have sufficiently long life cycles and low motility and, therefore, reflect both past and present environmental conditions.

An unstressed bottom community consists of a large number of different benthic groups with relatively few individuals within each group. Conversely, when a community is under stress, the number of benthic groups decreases and the number of individuals in the remaining tolerant groups increases.

#### FISH

Fish collections and analyses give the most meaningful index of water quality to the public. Fish occupy the upper levels of the aquatic food chain as the ultimate aquatic consumer. Therefore, changes in water quality that significantly affect the other organisms within the aquatic community will also affect the species composition and abundance of the fish population.

A knowledge of the assemblage of fish species in a stream and the numerical relationships of these species provides an excellent biological picture of the watercourse and its well being. When such information is available over a long period of time, fish can be one of the most sensitive indicators of the quality of the aquatic environment (7).

#### PERIPHYTON

The periphyton assemblage (primarily algae) represent the primary producer trophic level, they exhibit a different range of sensitivities, and will often indicate effects only indirectly observed in the benthic and fish communities. Algae

generally have rapid reproduction rates and very short life cycles, making them valuable indicators of short-term impacts. As primary producers, algae are most directly affected by physical and chemical factors.

## METHODS AND MATERIALS

### Bacteria

Water samples for bacterial analyses were collected from bridges passing over the Calumet River, Little Calumet River, and Cal-Sag Channel as designated in Figure 1. These samples were placed in sterile four liter containers with sufficient sodium thiosulfate to neutralize 15 mg/L chlorine and transported on ice to the District's Research and Development Laboratory in Stickney, Illinois. Analyses were begun approximately six to twenty-four hours after sample collection began, and from two to twenty hours after the last sample was collected. The TC, FC, FS, and SPC analyses were performed according to Standard Methods for the Examination of Water and Wastewater (Standard Methods), 14th Edition (8). The SAL were estimated using a modification of the most probable number (MPN) technique described by Kenner and Clark (9). Presumptive *Salmonella* were identified biochemically utilizing the API 20<sup>®</sup> system for identification of enterobacteriaceae. Confirmation of these isolates was performed with polyvalent "O" antisera. The PA analyses were performed according to the tentative method in Standard Methods, 15th Edition (10). The EC were enumerated by the membrane filter procedure of Dufour et al. (11), and ME were enumerated using the membrane filter procedure of Dufour (12). Results were expressed as the geometric means of samples collected four times during the year.

Colony confirmations for TC, FC, FS, EC, ME, and PA are presented in Table 2. The confirmation rates for typical TC, FC, FS, EC, ME, and PA colonies were 87.5 percent, 83.1 percent, 75.6 percent, 75.8 percent, 71.8 percent, and 86.3 percent, respectively. These data demonstrate that the analyses were recovering acceptable percentages of the indicated populations.

#### Benthic Invertebrates

Materials and methods for the collection and analysis of benthic invertebrates are listed in Reference 1.

#### Fish

Materials and methods for the collection and analysis of fish are listed in Reference 2.

#### Periphyton

The periphyton were sampled by providing artificial substrates (microscope slides) for them to colonize at the six locations designated in Figure 1. They were collected at two week intervals, protected from autooxidation by wrapping them in aluminum foil, kept viable at 4°C, and transported to the laboratory. For diatoms, the allotted slides were covered with 30% hydrogen peroxide overnight, scraped with a rubber spatula, and then the sample was completely oxidized using potassium dichromate. The sample was allowed to stand to concentrate the diatom frustules, and then washed with sterile

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TABLE 2

TOTAL COLIFORM (TC), FECAL COLIFORM (FC), FECAL STREPTOCOCCUS (FS), ESCHERICHIA COLI (EC), ENTEROCOCCI (ME), AND PSEUDOMONAS AERUGINOSA (PA) COLONY CONFIRMATIONS FOR THE CALUMET RIVER SYSTEM DURING 1989

Bacterial Group	Number of Colonies Tested	Number Confirmed	Percent Confirmed
TC	84	84	100
FC	82	78	95.1
FS	86	77	89.5
EC	79	72	91.1
ME	76	61	80.3
PA	36	31	86.1

<sup>1</sup>Biochemical confirmation tests: Total coliforms: gas in lauryl tryptose broth; gas in brilliant green bile broth. Fecal coliforms: gas in EC medium at 44.5°C. Escherichia coli: oxidase test; gas in lauryl tryptose broth; citrate blackening of bile esculin agar; growth at 45°C; growth in 6.5% NaCl. Pseudomonas aeruginosa: Casein hydrolysis on milk agar and yellowish to greenish diffusible pigments.

distilled or deionized water. After removing all of the dichromate (yellow color), the sample volume was adjusted to concentrations that would provide readable slides (10 to 50 diatom frustules) when two mL were dried on a 22 x 50 mm cover slip. This residue was mounted in a high refractive index medium (Hyrax<sup>®</sup>), and 500 organisms or 300 fields were identified and counted. A minimum of 15 fields were counted.

The nondiatom portion of the algae sample was scraped from the slides, and preserved with 0.5 percent glutaraldehyde. The gelatinous matrix surrounding some organisms was dissolved with Triton N-101<sup>®</sup>, a wetting agent. The sample was allowed to settle in the refrigerator in the dark for a minimum of four hours to allow the preservative to penetrate and harden the organisms. Serial sedimentation was used to concentrate the organisms, and wet mounts of 0.1 mL of the concentrate were made on a 22 x 50 mm cover slip. Five hundred organisms or 300 fields were counted and identified with a minimum of 15 fields observed.

## RESULTS

### Bacteria

The geometric means of four quarterly samples for the bacterial population densities of TC, FC, FS, ME, SPC, EC, PA, and SAL are presented in Table 3 for each of the six stations on the Calumet River/Cal-Sag Channel System.

#### CALUMET RIVER

On the Calumet River, the geometric mean TC and FC densities were 520 TC cfu/100 mL and 82 FC cfu/100 mL at the Ewing Avenue station, and 220 TC cfu/100 mL and 18 FC cfu/100 mL at the 130th Street station. These were the lowest annual geometric means for any of the waterways in the Calumet River System. The stream reach from the O'Brien Lock and Dam to Lake Michigan was defined by the General Use Standard (Title 35: Subtitle C: Chapter I: Part 302 B: § 302.209 Fecal Coliform) which, for practical reasons, the District interprets to mean a limitation of 400 cfu/100 mL, at any time (13).

The geometric mean EC densities followed the trend shown by the FC, of which they are a subset. The EC densities in the Calumet River System were lowest at Ewing Avenue with 65 cfu/100 mL and at 130th Street with 11 cfu/100 mL.

The geometric mean FS densities in the Calumet River System during 1989 were lowest at the Ewing Avenue station at 120 cfu/100 mL, and at 130th Street on the Calumet River at



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 3

BACTERIAL INDICATOR DENSITIES<sup>1</sup> FOR THE CALUMET RIVER SYSTEM<sup>2</sup>  
DURING 1989

Bacterial Group <sup>3</sup>	Calumet River		Little Calumet River		Cal-Sag Channel	
	Ewing Avenue <sup>4</sup>	130th Street <sup>5</sup>	Indiana Avenue <sup>6</sup>	Halsted Street <sup>5</sup>	Ashland Avenue <sup>5</sup>	Route 83 <sup>5</sup>
TC	520	220	1,800	130,000	100,000	14,000
FC	82	18	230	6,200	4,100	640
FS	120	180	510	1,500	810	540
EC	65	11	170	4,100	3,400	600
ME	19	26	57	670	330	200
SPC	200	1,100	15,000	28,000	27,000	15,000
PA	1	1	10	35	54	16
SAL	0.15	0.16	0.15	0.24	0.20	0.21

<sup>1</sup>All densities are given in colony forming units (cfu)/100 mL except SPC which is in cfu/mL and SAL which is in most probable number (MPN)/per 100 mL.

<sup>2</sup>Figure 1.

<sup>3</sup>TC = Total Coliform; FC = Fecal Coliform; FS = Fecal Streptococcus; ENT = Enterococcus; SPC = Standard Plate Count; EC = Esherichia coli; PA = Pseudomonas aeruginosa; SAL = Salmonella.

<sup>4</sup>Values shown are the geometric means of analyses of two samples taken March 6 and May 1, 1989.

<sup>5</sup>Values shown are the geometric means of analyses of four samples taken March 6, May 1, August 7, and October 23, 1989.

<sup>6</sup>Values shown are the geometric means of analyses of three samples taken May 1, August 7, and October 2, 1989.

180 cfu/100 mL. The ME are a subset of the FS and are found mostly in the human intestinal tract. The ME densities were 19 cfu/100 mL at Ewing Avenue, and 26 cfu/100 mL at 130th Street.

The SPC is a measure of the total heterotrophic bacteria population, i.e., those microorganisms requiring organic compounds for energy and growth. The geometric mean SPC densities in the Calumet River System were lowest at Ewing Avenue at 200 cfu/mL and at 130th Street at 1,100 cfu/mL.

The mean PA densities in the Calumet River System were lowest at the Ewing Avenue and 130th Street stations at 1 cfu/100 mL.

The geometric mean densities of SAL in the Calumet River were 0.15 MPN/100 mL at Ewing Avenue and 0.16 MPN/100 mL at 130th Street.

#### LITTLE CALUMET RIVER

The geometric mean TC and FC densities upstream of the discharge of the Calumet WRP at Indiana Avenue were 1,800 cfu/100 mL and 230 cfu/100 mL, respectively. The highest geometric mean TC and FC densities in the Calumet River System were measured at the Halsted Street station, one mile below the discharge of the Calumet WRP, at 130,000 cfu/100 mL and 6,200 cfu/100 mL, respectively.

The geometric mean EC densities were 170 cfu/100 mL at Indiana Avenue, and 410 cfu/100 mL at Halsted Street.

The geometric mean FS and ME densities were 510 cfu/100 mL and 57 cfu/100 mL at Indiana Avenue, and 1500 cfu/100 mL and 670 cfu/100 mL at Halsted Street, respectively.

The geometric mean SPC heterotrophic bacteria density was 15,000 cfu/mL at Indiana Avenue. The SPC was highest in the Calumet River System at Halsted Street at 28,000 cfu/mL.

The PA density at Indiana Avenue was 10 cfu 100/mL, while at Halsted Street the PA density was 35 cfu/100 mL.

The mean density of SAL was 0.15 MPN/100 mL at Indiana Avenue and 0.24 MPN/100 mL at Halsted Street.

#### CAL-SAG CHANNEL

The mean density of TC at the Ashland Avenue station on the Cal-Sag Channel was 100,000 cfu/100 mL. The FC density at this station was 4,100 cfu/100 mL. These TC and FC values decreased to 14,000 cfu/100 mL and 640 cfu 100/mL, respectively, at Route 83.

The geometric mean EC densities in the Calumet River System followed the trend shown by the FC of which they are a subset. The EC densities were 3,400 cfu/100 mL at Ashland Avenue and 600 cfu/100 mL at Route 83. The EC are associated primarily with the intestinal tract of humans, and as such they are more specific indicators of sewage contamination. The agreement in numbers between the FC and EC indicates that there are few, if any, FC present which are not of human origin.

### Benthic Invertebrates

Detailed sample statistics for each waterway and sample station in the Calumet River System are listed in Reference 1. Summaries of these results are listed in Figure 1 and Appendix Table AII-1 (Calumet River), Table AII-2 (Little Calumet River), and Table AII-3 (Cal-Sag Channel).

### Fish

Detailed sample statistics for each waterway and sample station in the Calumet River System are listed in Reference 2. Summaries of these results are listed in Figure 1 and Appendix Table AIII-1 (Calumet River), Table AIII-2 (Little Calumet River), and Table AIII-3 (Cal-Sag Channel).

### Periphyton

#### CALUMET RIVER

The average number of diatoms/sample in the Calumet River during 1989 (Table 4) ranged from 141,000 organisms/cm<sup>2</sup> at Ewing Avenue to 332,000 organisms/cm<sup>2</sup> at the O'Brien Lock and Dam. The average number of diatom species was 21 species/sample at Ewing Avenue and 17 species/sample at the O'Brien Lock and Dam. The total number of diatom species was 62 species at Ewing Avenue and 66 species at the O'Brien Lock and Dam.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 4

DIATOMS AT EACH STATION IN THE CALUMET RIVER SYSTEM  
DURING 1989

Location	Number of Samples	Average Number (Thousands /cm <sup>2</sup> )	Number of Species <sup>1</sup>	
			Average	Total
<u>Calumet River</u>				
Ewing Avenue	13	141	21	62
O'Brien Lock and Dam	14	332	17	66
<u>Little Calumet River</u>				
Indiana Avenue	15	412	14	48
Halsted Street	13	530	15	45
<u>Cal-Sag Channel</u>				
Ashland Avenue	14	381	19	72
Route 83	12	1,599	14	46

<sup>1</sup>See Appendix Table AIV-1 for a detailed list of species at each location.

The average number of total periphyton/sample in the Calumet River during 1989 (Table 5) ranged from 1.7 million organisms/cm<sup>2</sup> at Ewing Avenue to 3.7 million organisms/cm<sup>2</sup> at the O'Brien Lock and Dam. The average number of periphyton species was 25 species per sample at Ewing Avenue and 22 species per sample at the O'Brien Lock and Dam. The total number of periphyton species was 83 species at Ewing Avenue and 91 species at the O'Brien Lock and Dam.

#### LITTLE CALUMET RIVER

The average number of diatoms/sample in the Little Calumet River during 1989 (Table 4) ranged from 412,000 organisms/cm<sup>2</sup> at Indiana Avenue to 530,000 organisms/cm<sup>2</sup> at the Halsted Street. The average number of diatom species was 14 species/sample at Indiana Avenue and 15 species/sample at Halsted Street. The total number of diatom species was 48 species at Indiana Avenue and 45 species at Halsted Street.

The average number of total periphyton/sample in the Little Calumet River during 1989 (Table 5) ranged from 4.0 million organisms/cm<sup>2</sup> at Indiana Avenue to 6.3 million organisms/cm<sup>2</sup> at Halsted Street. The average number of periphyton species was 20 species per sample at both Indiana Avenue and Halsted Street. The total number of periphyton species was 72 species at Indiana Avenue and 65 species at Halsted Street.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 5

PERIPHYTON AT EACH STATION IN THE CALUMET RIVER SYSTEM  
DURING 1989

Waterway and Sample Location	Number of Samples	Average Number (Millions /cm <sup>2</sup> )	Number of Species <sup>1</sup>	
			Average	Total
<u>Calumet River</u>				
Ewing Avenue	13	1.7	25	83
O'Brien Lock and Dam	14	3.7	22	91
<u>Little Calumet River</u>				
Indiana Avenue	15	4.0	20	72
Halsted Street	13	6.3	20	65
<u>Cal-Sag Channel</u>				
Ashland Avenue	13	6.3	24	94
Route 83	10	12.6	20	74

<sup>1</sup>See Appendix Table AIV-1 for a detailed list of species at each location.

## CAL-SAG CHANNEL

The average number of diatoms in the Cal-Sag Channel during 1989 (Table 4) ranged from 381,000 organisms/cm<sup>2</sup> at Ashland Avenue to 1,599,000 organisms/cm<sup>2</sup> at Route 83. The average number of diatom species was 19 species/sample at Ashland Avenue and 14 species/sample at Route 83. The total number of diatom species was 72 species at Ashland Avenue and 46 species at Route 83.

The average number of total periphyton in the Cal-Sag Channel during 1989 (Table 5) ranged from 6.3 million organisms/cm<sup>2</sup> at Ashland Avenue to 12.6 million organisms/cm<sup>2</sup> at Route 83. The average number of periphyton species was 24 species per sample at Ashland Avenue and 20 species per sample at Route 83. The total number of periphyton species was 94 species at Ashland Avenue and 74 species at Route 83.



## DISCUSSION

### Bacteria

#### CALUMET RIVER

Sanitary water quality, as reflected by the densities of the indicator groups, was best at Ewing Avenue and at 130th Street in the Calumet River than at any other locations in the Calumet River System.

#### LITTLE CALUMET RIVER

The increases in TC and SPC upstream of the Calumet WRP at Indiana Avenue suggest discharge of wastewater upstream of the Calumet WRP's outfall. This wastewater could have come from a WRP in Indiana discharging to the Grand Calumet River, which joins the Little Calumet River upstream of the discharge of the Calumet WRP, or from combined sewer overflows. The abrupt increase of TC and FC below the discharge of the Calumet WRP at Halsted Street reflected the input of treated wastewater to the Little Calumet River.

#### CAL-SAG CHANNEL

The TC and FC counts at Route 83, 17 miles downstream of the Calumet WRP discharge, were similar to the values upstream of the Calumet WRP, indicating that a natural bacterial reduction had occurred at this point in the Calumet River System.

## Benthic Invertebrates

### CALUMET RIVER

Stations at 100th Street and 130th Street in the Calumet River are approximately 1.6 and 6.5 miles, respectively, below Lake Michigan and 10.3 and 5.3 miles, respectively, above the final effluent outfall from the Calumet WRP. The area above these two sampling stations receives some dilution water from Lake Michigan, a small amount of urban and industrial storm water, and discharges from six combined sewers. The 100th Street and 130th Street stations were established as controls with which to compare downstream stations. As seen in Figure 1 and Table AII-1, these two sampling stations yielded 20,000 organisms/m<sup>2</sup> (97% oligochaetes) and 7,800 organisms/m<sup>2</sup> (71% oligochaetes), respectively. The lower mean abundance of invertebrates, as well as the lower proportion of oligochaete worms, indicates a higher water and sediment quality at the 130th Street station in the Calumet River compared with the 100th Street location.

### LITTLE CALUMET RIVER

In Indiana, overflows from separate and combined sewers, and treated municipal and industrial effluents discharge into the Grand Calumet River. The western portion of the Grand Calumet River flows into Illinois, eventually merging with the Calumet and Little Calumet Rivers. The Indiana Avenue station

in the Little Calumet River is approximately 3.5 miles below the junction with the Grand Calumet River. Compared to upstream in the Calumet River (Figure 1 and Table AII-2), the abundance of benthic invertebrates at the Indiana Avenue station (mean of 7,900 organisms/m<sup>2</sup>) was similar to the 130th Street station in the Calumet River. However, the percent of the oligochaete worms increased to 89% at Indiana Avenue. The increased mean abundance of oligochaetes indicated a poorer water and sediment quality at the Indiana Avenue station than at the 130th Street station upstream in the Calumet River.

Flow in the Little Calumet River is augmented 1.7 miles above its junction with the Cal-Sag Channel by the secondary effluent from the Calumet WRP. Also entering the system below the Calumet WRP outfall are periodic discharges from numerous combined and separate storm sewers. The treated effluent from the Calumet WRP and these periodic overflows affected the benthic community downstream at Halsted Street station in the Little Calumet River. The mean number of benthic organisms collected at the Halsted Street station increased greatly (78,000 organisms/cm<sup>2</sup>) and the benthic community at the Halsted Street station was composed almost entirely of oligochaete worms. The increased number of pollution tolerant worms indicated a poorer water and sediment quality below the Calumet WRP in the Little Calumet River.

## CAL-SAG CHANNEL

The number of benthic organisms collected at Western Avenue (98,000 organisms/cm<sup>2</sup>, 98% oligochaetes), Southwest Highway (126,000 organisms/cm<sup>2</sup>, 97% oligochaetes), and Route 83 (46,000 organisms/cm<sup>2</sup>, 87% oligochaetes) remained very high, exceeding the number collected above the Calumet WRP by more than three-fold (Figure 1 and Table AII-3). This increase in abundance was again due primarily to the great numbers of pollution tolerant aquatic oligochaete worms that made up more than 95% of the benthic invertebrates. This indicated poor water and sediment quality in the Cal-Sag Channel.

## Fish

### CALUMET RIVER

The most fish (1,736 fish), fish species (23 species) and greatest percent game fish (26% game fish, as shown in Table AIII-1) occurred in the Calumet River than in the two waterways downstream. Based on the Index of Biotic Integrity (IBI), the Calumet River was a moderate aquatic resource with fair stream quality for fish.

### LITTLE CALUMET RIVER

In comparison with the Calumet River, the number of fish (678 fish), fish species (16 species) and percent game fish (12% for the combined total, 19% at Route I-94 and 3% at Halsted Street) decreased in the Little Calumet River, while the

percent of pollution tolerant rough fish increased from 8% in the Calumet River to 41% in the Little Calumet River (Table AIII-2). Based on the IBI, the Little Calumet River was a limited aquatic resource with poor stream quality for fish.

#### CAL-SAG CHANNEL

The number of fish (159 fish) and fish species (11 species) were lower in the Cal-Sag Channel than in the other waterways. The percent game fish was about the same as in the Little Calumet River, (16% for the combined total, 5% at Cicero Avenue and 21% at Route 83) but the percent rough fish increased to 64% in the Cal-Sag Channel (Table AIII-3). Based on the IBI, the Cal-Sag Channel was a limited aquatic resource, with poor stream quality for fish.

### Periphyton

#### CALUMET RIVER

Total numbers of periphyton species (158 and 171 species) were greatest and total numbers of periphyton ( $1.4 \times 10^6/\text{cm}^2$  to  $2.0 \times 10^6/\text{cm}^2$ ) were least in the Calumet River as compared to the Little Calumet River and Cal-Sag Channel downstream, as seen in Tables 4 and 5. This indicated relatively good water quality and low nutrient enrichment in the Calumet River as compared to the downstream waterways.

#### LITTLE CALUMET RIVER

Total numbers of periphyton species (144 and 130 species) decreased, and total numbers of periphyton ( $4.9 \times 10^6/\text{cm}^2$  to  $5.5 \times 10^6/\text{cm}^2$ ) increased in comparison to the Calumet River, as seen in Tables 4 and 5. This indicated a degradation of water quality with nutrient enrichment in the Little Calumet River.

#### CAL-SAG CHANNEL

Total numbers of periphyton species (127 and 98 species) decreased, and total numbers of periphyton ( $6.4 \times 10^6/\text{cm}^2$  to  $5.6 \times 10^6/\text{cm}^2$ ) increased in comparison to the Little Calumet River, as seen in Tables 4 and 5. This indicated a degradation of water quality with nutrient enrichment in the Cal-Sag Channel.

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APPENDIX AI

BACTERIAL DENSITIES IN THE  
CALUMET RIVER SYSTEM  
DURING 1989

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1

BACTERIAL DENSITIES IN THE CALUMET RIVER SYSTEM DURING 1989

Station	Date	TC	FC	FS	EC	ME	SPC	PA	SAL
<u>Calumet River</u>									
Ewing Ave.	3/6/89	50	12	37	70	14	110	<1	<0.15
	5/1/89	5500	560	390	60	26	360	2	<0.15
	8/8/89	No Sample - Bridge Out							
	10/2/89	No Sample - Bridge Out							
130th St.	3/6/89	56	8	82	4	7	520	<1	<0.15
	5/1/89	490	4	40	2	<2	150	<2	<0.15
	8/8/89	490	170	680	180	240	8,500	<2	0.2
	10/2/89	190	18	490	10	130	2,600	<1	<0.15
<u>Little Calumet River</u>									
Indiana Ave.	3/6/89	No Sample - Bridge Out							
	5/1/89	170	91	3100	130	100	2600	<10	<0.15
	8/8/89	18,000	1,400	91	800	20	23,000	10	<0.15
	10/2/89	1,900	100	480	50	91	52,000	<10	<0.15
Halsted St.	3/6/89	290,000	10,000	5,400	7,000	4,000	40,000	60	0.45
	5/1/89	72,000	2,200	3,200	3,900	360	13,000	30	<0.15
	8/8/89	90,000	4,800	400	1,700	290	29,000	20	<0.15
	10/2/89	170,000	14,000	740	6,300	490	41,000	40	0.35

AI-1

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1 (Continued)

BACTERIAL DENSITIES IN THE CALUMET RIVER SYSTEM DURING 1989

Station	Date	TC	FC	FS	EC	ME	SPC	PA	SAL
<u>Cal-Sag Channel</u>									
Ashland Ave.	3/6/89	250,000	14,000	8,100	12,000	4,800	44,000	70	<0.15
	5/1/89	53,000	1,600	230	1,600	140	9,500	40	0.45
	8/8/89	62,000	2,800	640	2,100	80	27,000	60	<0.15
	10/2/89	130,000	4,600	360	3,200	210	47,000	50	<0.15
Route 83	3/6/89	800,000	17,000	7,800	21,000	2,900	47,000	70	0.55
	5/1/89	560	160	660	160	91	2,600	<10	<0.15
	8/8/89	16,000	600	830	390	320	14,000	<10	<0.15
	10/2/89	6,000	100	20	100	20	30,000	<10	<0.15

TC = Total Coliform, FC = Fecal Coliform, FS = Fecal Streptococcus, EC = *Escherichia coli*, ME = Entrococcus, SPC = Standard Plate Count, PA = *Pseudomonas aeruginosa*, SAL = *Salmonella* spp.; units in cfu/100 mL except SPC which is in cfu/mL and SAL which is in MPN/100 mL.

AI-2

APPENDIX AII

AVERAGE NUMBER AND PERCENTAGE COMPOSITION OF BENTHIC  
INVERTEBRATE GROUPS FROM THE CALUMET RIVER SYSTEM DURING 1989

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AII-1

AVERAGE NUMBER (N) PER SQUARE METER AND PERCENTAGE COMPOSITION (%) OF BENTHIC INVERTEBRATES FROM THE CALUMET RIVER DURING 1989<sup>1</sup>

Benthic Invertebrate Group	Sample Station			
	100th Street		130th Street	
	N	%	N	%
Coelenterata (Hydra)	2	0.01	2	0.03
Turbellaria (Flat-worms)	28	0.14	30	0.38
Oligochaeta (Sludgeworms)	19,580	96.59	5,512	70.71
Hirudinea (Leeches)	2	0.01	6	0.08
Amphipoda (Amphipods)	13	0.06	32	0.41
Trichoptera (Caddis flies)	0	0.00	2	0.03
Ceratopogonidae (Biting midges)	0	0.00	13	0.17
Chironomidae (Midge flies)	488	2.41	1,901	24.39
Gastropoda (Snails)	2	0.01	0	0.00
Pelecypoda (Clams)	156	0.77	297	3.81
Total	20,271	100.00	7,795	100.00

<sup>1</sup>Summary of data from Reference 1.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AII-2

AVERAGE NUMBER (N) PER SQUARE METER AND PERCENTAGE COMPOSITION (%) OF BENTHIC INVERTEBRATES FROM THE LITTLE CALUMET RIVER DURING 1989<sup>1</sup>

Benthic Invertebrate Group	Sample Station			
	Indiana Avenue		Halsted Street	
	N	%	N	%
Turbellaria (Flatworms)	9	0.11	0	0.00
Oligochaeta (Sludgeworms)	7,048	89.22	78,523	99.85
Hirudinea (Leeches)	2	0.03	21	0.03
Odonata (Dragonflies)	2	0.03	0	0.00
Chironomidae (Midge flies)	389	4.92	32	0.04
Pelecypoda (Clams)	450	5.70	63	0.08
Total	7,900	100.00	78,639	100.00

<sup>1</sup>Summary of data from Reference 1.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AII-3

AVERAGE NUMBER (N) PER SQUARE METER AND PERCENTAGE COMPOSITION (%) OF BENTHIC INVERTEBRATES FROM THE CAL-SAG CHANNEL DURING 1989<sup>1</sup>

Benthic Invertebrate Group	Sample Station					
	Western Avenue		Southwest Hwy.		Route 83	
	N	%	N	%	N	%
Turbellaria (Flatworms)	4	0.00	0	0.00	0	0.00
Oligochaeta (Sludgeworms)	95,350	97.63	121,774	96.64	39,790	86.51
Hirudinea (Leeches)	27	0.03	15	0.01	0	0.00
Odonata (Dragonflies)	0	0.00	28	0.02	4	0.01
Ceratopogonidae (Biting midges)	7	0.01	0	0.00	0	0.00
Chironomidae (Midge flies)	107	0.11	833	0.66	1436	3.12
Pelecypoda (Clams)	2,169	2.22	3,356	2.66	4,763	10.36
Total	97,664	100.00	126,006	100.00	45,993	100.00

<sup>1</sup>Summary of data from Reference 1.

APPENDIX AIII

NUMBER AND PERCENTAGE COMPOSITION OF THE ANNUAL CATCH OF FISH  
FROM THE CALUMET RIVER SYSTEM DURING 1989



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AIII-1

NUMBER (N) AND PERCENTAGE COMPOSITION (%) OF THE ANNUAL CATCH OF FISH FROM THE CALUMET RIVER DURING 1989<sup>1</sup>

Fish Species	Sample Station				Combined	
	130th Street		O'Brien Dam		Total	
	N	%	N	%	N	%
<u>Forage Fish</u>						
Alewife	20	3.74	638	53.12	658	37.90
Gizzard shad	156	29.16	136	11.32	292	16.82
Golden shiner	2	0.37	16	1.33	18	1.04
Emerald shiner	17	3.18	4	0.33	21	1.21
Spottail shiner	0	0.00	31	2.58	31	1.79
Bluntnose minnow	76	14.21	47	3.91	123	7.09
Fathead minnow	1	0.19	0	0.00	1	0.06
Total Forage Fish	272	50.84	872	72.61	1144	65.90
<u>Game Fish</u>						
Channel catfish	0	0.00	2	0.17	2	0.12
White bass	1	0.19	0	0.00	1	0.06
White perch	69	12.90	64	5.33	133	7.66
Green sunfish	14	2.62	39	3.25	53	3.05
Pumpkinseed	31	5.79	37	3.08	68	3.92
Warmouth	0	0.00	1	0.08	1	0.06
Orangespotted sunfish	1	0.19	8	0.67	9	0.52
Bluegill	35	6.54	45	3.75	80	4.61
Largemouth bass	42	7.85	27	2.25	69	3.97
Hybrid sunfish	1	0.19	6	0.50	7	0.40
Yellow perch	16	2.99	13	1.08	29	1.67
Total Game Fish	210	39.25	242	20.15	452	26.04
<u>Rough Fish</u>						
American eel	0	0.00	1	0.08	1	0.06
Goldfish	3	0.56	18	1.50	21	1.21
Carp	45	8.41	61	5.08	106	6.11
Carp x Goldfish hybrid	1	0.19	5	0.42	6	0.35
Quillback	1	0.19	0	0.00	1	0.06
White sucker	1	0.19	2	0.17	3	0.17
Freshwater drum	2	0.37	0	0.00	2	0.12
Total Rough Fish	53	9.91	87	7.24	140	8.06
Grand Total Fish	535	100.00	1201	100.00	1736	100.00
Number of Species	19		20		23	

<sup>1</sup>Summary of data from Reference 2.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AIII-2

NUMBER (N) AND PERCENTAGE COMPOSITION (%) OF THE ANNUAL CATCH OF FISH FROM THE LITTLE CALUMET RIVER DURING 1989<sup>1</sup>

Fish Species	Sample Station				Combined	
	Route I-94		Halsted Street		Total	
	N	%	N	%	N	%
<u>Forage Fish</u>						
Alewife	3	0.78	27	9.15	30	4.42
Gizzard shad	132	34.46	120	40.68	252	37.17
Golden shiner	9	2.35	5	1.69	14	2.06
Emerald shiner	20	5.22	3	1.02	23	3.39
Spottail shiner	2	0.52	0	0.00	2	0.29
Total Forage Fish	166	43.34	155	52.54	321	47.35
<u>Game Fish</u>						
Black bullhead	1	0.26	3	1.02	4	0.59
White perch	46	12.01	0	0.00	46	6.78
Green sunfish	1	0.26	0	0.00	1	0.15
Pumpkinseed	14	3.66	0	0.00	14	2.06
Orangespotted sunfish	2	0.52	0	0.00	2	0.29
Bluegill	7	1.83	3	1.02	10	1.47
Largemouth bass	2	0.52	1	0.34	3	0.44
Yellow perch	1	0.26	1	0.34	2	0.29
Total Game Fish	74	19.32	8	2.71	82	12.09
<u>Rough Fish</u>						
Goldfish	70	18.28	93	31.53	163	24.04
Carp	60	15.67	36	12.20	96	14.16
Carp x Goldfish hybrid	13	3.39	3	1.02	16	2.36
Total Rough Fish	143	37.34	132	44.75	275	40.56
Grand Total Fish	383	100.00	295	100.00	678	100.00
Number of Species	15		10		16	

<sup>1</sup>Summary of data from Reference 2.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AIII-3

NUMBER (N) AND PERCENTAGE COMPOSITION (%) OF THE ANNUAL CATCH OF FISH FROM THE CAL-SAG CHANNEL DURING 1989<sup>1</sup>

Fish Species	Sample Station				Combined Total	
	Cicero Avenue		Route 83		N	%
	N	%	N	%		
<u>Forage Fish</u>						
Alewife	1	1.09	0	0.00	1	0.63
Gizzard shad	19	20.65	9	13.43	28	17.61
Central mudminnow	1	1.09	0	0.00	1	0.63
Emerald shiner	1	1.09	1	1.49	2	1.26
Total Forage Fish	22	23.91	10	14.93	32	20.13
<u>Game Fish</u>						
Green sunfish	0	0.00	6	8.96	6	3.77
Pumpkinseed	0	0.00	1	1.49	1	0.63
Orangespotted sunfish	1	1.09	0	0.00	1	0.63
Bluegill	2	2.17	2	2.99	4	2.52
Largemouth bass	2	2.17	12	17.91	14	8.81
Total Game Fish	5	5.43	21	31.34	26	16.35
<u>Rough Fish</u>						
Goldfish	18	19.57	14	20.90	32	20.13
Carp	41	44.57	20	29.85	61	38.36
Carp x Goldfish hybrid	6	6.52	2	2.99	8	5.03
Total Rough Fish	65	70.65	36	53.73	101	63.52
Grand Total Fish	92	100.00	67	100.00	159	100.00
Number of Species	9		8		11	

<sup>1</sup>Summary of data from Reference 2.

APPENDIX AIV

RESULTS OF PERIPHYTON SAMPLING OF  
THE CALUMET RIVER SYSTEM  
DURING 1989

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AIV-1

PERIPHYTON SPECIES COLLECTED AT EACH STATION IN THE CALUMET RIVER SYSTEM DURING 1989

Family and Species	Calumet River		Little Calumet River		Cal-Sag Channel	
	Ewing Avenue	O'Brien Lock and Dam	Indiana Avenue	Halsted Street	Ashland Avenue	Route 83
<u>Bacillariophyceae</u>						
	Number Per Square Centimeter					
Achnanthes exigua var. heterovalvata	0	0	0	0	224	0
Achnanthes hauckiana	0	199	0	0	0	0
Achnanthes haukiana	0	0	0	894	0	0
Achnanthes lanceolata	863	895	0	32806	3829	3354
Achnanthes lanceolata var. dubia	0	0	0	0	1420	0
Achnanthes lemmermanni	0	0	0	0	0	1944
Achnanthes minutissima	715	149	0	0	0	0
Achnanthes wellsiae	0	1043	0	0	0	0
Amphipleura pellucida	5052	232	0	0	0	0
Amphora ovalis	331	0	0	0	0	0
Amphora submontana	192	0	0	0	0	0
Amphora veneta	0	37	0	0	0	0
Asterionella formosa	0	199	1789	373	1345	0
Caloneis amphisbaena	0	0	0	0	882	0
Capartogramma crucicula	0	852	0	0	0	0
Carpantogramma crucicula	0	0	0	0	0	1118
Cocconeis pediculus	2837	0	0	0	0	0
Cocconeis placentula	6410	128577	116780	35855	81558	37805
Cocconeis placentula var. lineata	5285	0	0	0	0	31301
Cocconeis placentula var. euglypta	179	75	3756	1789	0	0
Cocconeis placentula var. lineata	767	74843	0	28700	81510	0
Cocconeis placentula var. placentula	0	0	112882	0	0	0
Coscinodiscus rothii	0	3847	3899	0	8222	12765
Cyclotella antiqua	4408	33	0	1278	0	4472
Cyclotella bodanica	93	3726	179	0	0	0
Cyclotella catemata	0	0	0	0	2129	0

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METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AIV-1 (Continued)

PERIPHYTON SPECIES COLLECTED AT EACH STATION IN THE CALUMET RIVER SYSTEM DURING 1989

Family and Species	Calumet River		Little Calumet River		Cal-Sag Channel	
	Ewing Avenue	O'Brien Lock and Dam	Indiana Avenue	Halsted Street	Ashland Avenue	Route 83
<u>Bacillariophyceae</u>						
	Number Per Square Centimeter					
Cyclotella comta	3478	0	1420	1111	805	5832
Cyclotella glomerata	27208	7850	22580	50848	40580	88605
Cyclotella kuetzingiana var. planetophora	0	0	0	0	710	0
Cyclotella meneghiniana	0	5732	9821	35113	161704	127981
Cyclotella michiganiana	19871	265	741	25041	11179	0
Cyclotella ocellata	0	75	0	0	1420	0
Cyclotella stelligera	2677	6814	22	0	3407	6504
Cyclotella striata	0	0	0	0	370	0
Cymatopleura solea	0	232	0	0	0	0
Cymatopleura elliptica	0	0	0	0	24	0
Cymatopleura solea	224	0	0	0	0	0
Cymbella affinis	0	5110	0	0	0	0
Cymbella minuta	58377	6680	16866	0	1043	0
Cymbella minuta f. latens	186	0	0	0	0	0
Cymbella minuta var. silesiaca	58098	6680	16866	0	1043	0
Cymbella prostrata	544	0	0	0	0	0
Diatoma anceps	163705	440448	18970	153378	16397	211585
Diatoma tenue	100390	106472	311756	603372	163117	4074695
Diatoma tenue var. elongatum	100204	95674	311756	599795	163117	4074695
Diatoma vulgare	155781	57	8526	271	5761	3354
Diploneis smithii	224	0	0	0	0	0
Epithemia turgida	0	28	39	0	0	0
Epithemia zonata	0	0	0	0	24	0
Fragilaria brevistriata	0	0	0	0	224	0
Fragilaria crotonensis	816	0	0	0	123	0
Fragilaria leptostauron	0	426	0	0	24	0

AIV-2

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AIV-1 (Continued)

PERIPHYTON SPECIES COLLECTED AT EACH STATION IN THE CALUMET RIVER SYSTEM DURING 1989

Family and Species	Calumet River		Little Calumet River		Cal-Sag Channel	
	Ewing Avenue	O'Brien Lock and Dam	Indiana Avenue	Halsted Street	Ashland Avenue	Route 83
<u>Bacillariophyceae</u>						
	Number Per Square Centimeter					
Fragilaria pinnata	802	1732	7	0	119	0
Fragilaria vaucheriae	153188	466	4024	38421	28400	64045
Fragilaria virescens	0	0	0	894	3407	0
Frustulia rhomboides var. saxonica	0	0	0	0	0	250407
Frustulia rhomboides var. saxonica	0	0	7	0	0	0
Gomphonema olivaceum	162530	42049	76488	70596	85087	138801
Gomphonema olivaceum var. calcarea	0	0	0	0	0	25000
Gomphonema olivaceum var. calcarea	11133	1703	2525	6802	12776	8943
Gomphonema parvulum	81957	1393239	1845955	5017337	1161077	2312755
Gomphonema subtilis var. sagitta	0	0	0	271	0	0
Gyrosigma acuminatum	0	0	0	0	24	0
Gyrosigma attenuatum	0	241	0	0	0	0
Hantzschia virgata var capitellata	0	0	0	1789	0	0
Melosira islandica	2884	440	350	0	3333	0
Melosira italica	192	0	0	0	0	0
Melosira varians	2164	29769	21885	21047	75610	0
Navicula accomoda	0	33	0	0	0	0
Navicula canalis	224	5783	126	3833	73901	0
Navicula capitata	0	3724	3980	0	739	0
Navicula cincta	662	0	706252	258022	494340	2248964
Navicula cryptocephala	1000	175701	18780	41138	23255	5832
Navicula cymbella	358	0	0	0	0	0
Navicula elginensis var. lata	0	37	0	0	0	0
Navicula exiqua	203	440	0	0	1682	0
Navicula integra	0	33	0	0	215	5589
Navicula lanceolata	0	0	89	0	1341	5589

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METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AIV-1 (Continued)

PERIPHYTON SPECIES COLLECTED AT EACH STATION IN THE CALUMET RIVER SYSTEM DURING 1989

Family and Species	Calumet River		Little Calumet River		Cal-Sag Channel	
	Ewing Avenue	O'Brien Lock and Dam	Indiana Avenue	Halsted Street	Ashland Avenue	Route 83
<u>Bacillariophyceae</u>						
	Number Per Square Centimeter					
Navicula mutica	0	0	595	12041	15564	27055
Navicula mutica var. tropica	0	0	0	0	617	0
Navicula pseudoreinhardtii	0	108	0	0	0	0
Navicula pupula	0	0	0	373	0	0
Navicula pygmaea	0	37	0	0	0	0
Navicula radiosa	0	0	0	1789	0	0
Navicula securo	0	0	45073	373	1420	0
Navicula tripunctata	5004	22081	7959	271	95	3415
Navicula tripunctata var. schizonemoides	1789	0	0	0	0	0
Navicula viridula var. avenacea	0	7453	0	0	0	0
Nitzschia angustata	179	0	0	1789	123	0
Nitzschia clausii	0	0	37561	0	4259	0
Nitzschia dissipata	7658	4061	10552	4616	4483	0
Nitzschia fasciculata	0	0	0	0	3549	0
Nitzschia filiformis	6305	28343	106645	269846	384029	1214238
Nitzschia fonticola	993	335	0	1278	24	1789
Nitzschia hantzschiana	0	37	0	0	0	293567
Nitzschia hungarica	0	0	0	0	0	4472
Nitzschia linearis	0	0	0	0	0	1944
Nitzschia palea	16123	409775	31144	643187	367733	1911337
Nitzschia recta	426	0	0	0	0	0
Nitzschia romana	0	335	156	0	224	1789
Nitzschia stagnorum	0	37	0	0	123	0
Nitzschia sublinearis	0	33	0	0	0	0
Nitzschia thermalis	0	0	0	0	1049	0
Nitzschia tryblionella	0	0	1814	0	0	0

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METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AIV-1 (Continued)

PERIPHYTON SPECIES COLLECTED AT EACH STATION IN THE CALUMET RIVER SYSTEM DURING 1989

Family and Species	Calumet River		Little Calumet River		Cal-Sag Channel	
	Ewing Avenue	O'Brien Lock and Dam	Indiana Avenue	Halsted Street	Ashland Avenue	Route 83
<u>Bacillariophyceae</u>						
	Number Per Square Centimeter					
Opephora martyi	0	0	0	1789	48	0
Rhoicosphenia curvata	8157	6768	268	0	123	0
Stephanodiscus astraea	4295	14807	3631	42063	17643	17886
Stephanodiscus dubius	0	0	0	0	0	3888
Stephanodiscus tenuis	179	0	0	0	710	0
Surirella angustata	358	0	108	0	0	0
Surirella ovalis	0	0	0	0	0	1118
Surirella ovata	1031	15405	4740	271	8600	29126
Surirella ovata var. salina	0	0	0	271	0	0
Surirella ovata var. pinnata	0	0	0	0	167	0
Surirella ovata var. salina	852	3726	0	0	596	0
Synedra acus	13210	0	0	2023	493	22358
Synedra delicatissima	0	0	0	0	0	1944
Synedra fasciculata	11119	14905	15404	48620	23434	874362
Synedra fasciculata var. truncata	252	0	0	373	123	0
Synedra minuscula	152513	0	0	0	0	0
Synedra pulchella	0	11663	3756	20081	24891	137717
Synedra pulchella var. lanceolata	0	3726	0	0	0	0
Synedra radians	466	0	0	0	0	0
Synedra rumpens	0	0	0	1278	2839	0
Synedra rumpens var. familiaris	0	0	0	0	2839	0
Synedra ulna	8791	75909	231387	114224	93314	537184
Synedra ulna var. contracta	0	0	0	0	0	53659
Synedra ulna var. contracta	0	0	2443	0	14223	0
Tabellaria fenestrata	42626	3911	16995	5825	11814	10569
Tabellaria quadrisepa	3000	37	224	0	0	1944

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METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AIV-1 (Continued)

PERIPHYTON SPECIES COLLECTED AT EACH STATION IN THE CALUMET RIVER SYSTEM DURING 1989

Family and Species	Calumet River		Little Calumet River		Cal-Sag Channel	
	Ewing Avenue	O'Brien Lock and Dam	Indiana Avenue	Halsted Street	Ashland Avenue	Route 83
<u>Chlorophyceae</u>	Number Per Square Centimeter					
Ankistrodesmus falcatus	0	0	3293	0	0	0
Characium acuminatum	0	0	18949	4390	0	0
Characium ambiguum	0	0	0	0	0	1442
Characium obtusum	0	0	0	17561	0	12211
Chlamydomonas globosa	456	33943	259627	207149	99874	298878
Chlorella vulgaris	0	0	0	0	0	8303
Gloeocystis major	0	0	0	0	0	2346553
Gloeocystis vesiculosa	0	0	0	0	0	667024
Kirchneriella contorta	732	0	0	0	0	0
Kirchneriella lunaris var. irregularis	0	0	9878	0	0	0
Kirchneriella obesa	0	0	0	0	0	8303
Microspora pachyderma	0	0	0	0	0	66423
Microspora tumidula	0	0	6585	0	0	0
Mougeotia abnormis	0	253	0	0	0	0
Mougeotia genuflexa var. gracilis	0	0	0	0	0	115854
Mougeotia scalaris	62904	0	0	0	0	0
Mougeotia tumidula	1171	0	0	0	0	0
Protococcus viridis	0	0	213951	0	0	0
Scenedesmus abundans var. brevicauda	0	0	0	0	0	16606
Scenedesmus acuminatus	0	0	552	0	0	0
Scenedesmus bernardii	0	0	52683	0	0	0
Scenedesmus dimorphus	0	0	0	0	48130	0
Scenedesmus incrassatulus	0	0	0	22120	0	0
Scenedesmus quadricauda	394	24761	39512	0	49431	82057
Scenedesmus quadricauda var. longispina	0	0	0	0	0	33211
Scenedesmus quadricauda var. parvus	0	0	13171	0	49431	0

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METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AIV-1 (Continued)

PERIPHYTON SPECIES COLLECTED AT EACH STATION IN THE CALUMET RIVER SYSTEM DURING 1989

Family and Species	Calumet River		Little Calumet River		Cal-Sag Channel	
	Ewing Avenue	O'Brien Lock and Dam	Indiana Avenue	Halsted Street	Ashland Avenue	Route 83
<u>Chlorophyceae</u>						
	Number Per Square Centimeter					
Scenedesmus quadricauda var. quadrispina	0	24761	0	0	0	0
Scenedesmus quadricauda var. parvus	394	0	0	0	0	0
Scenedesmus quadricauda var. parvus	0	0	0	0	0	33211
Schizomeris leibleinii	0	0	0	3900292	4257450	5653171
Spirogyra longata	0	0	0	0	226816	0
Spirogyra Weberii	0	0	0	0	0	1113496
Stigeoclonium lubricum	0	14255	0	0	0	0
Stigeoclonium nanum	0	773315	0	0	0	0
Stigeoclonium pachydermum	0	154939	0	0	0	0
Stigeoclonium polymorphum	0	21083	0	0	0	0
Stigeoclonium lubricum	89341	0	543631	2185096	4115834	23337503
Stigeoclonium nanum	128780	0	911122	2622360	1374471	10994751
Stigeoclonium polymorphum	0	0	2759	0	0	0
Stigeoclonium subsecundum	0	0	0	535610	469593	0
Tetraedron regulare var. incus f. major	0	0	0	5530	0	0
Tetraedron regulare var. torsum	0	0	0	0	6179	0
Tetrastrum staurogeniaeforme	34341	0	0	0	0	0
Ulothrix aequalis	64390	0	0	127108	0	7210
Ulothrix subconstricta	49756	0	0	0	0	702439
Ulothrix subtillisima	0	0	0	0	61789	0
Ulothrix subtillissima	0	0	0	0	0	463415
Ulothrix tenerrima	26927	23492	681659	0	60163	0
Ulothrix variabilis	0	0	0	0	0	196951
Ulothrix variabilis	377220	0	132640	207972	0	0

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METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AIV-1 (Continued)

PERIPHYTON SPECIES COLLECTED AT EACH STATION IN THE CALUMET RIVER SYSTEM DURING 1989

Family and Species	Calumet River		Little Calumet River		Cal-Sag Channel	
	Ewing Avenue	O'Brien Lock and Dam	Indiana Avenue	Halsted Street	Ashland Avenue	Route 83
<u>Euglenophyceae</u>						
	Number Per Square Centimeter					
<i>Synura uvella</i>	206049	2376	0	0	0	0
<u>Myxophyceae</u>						
<i>Aphanocapsa endophytica</i>	0	0	0	0	123577	0
<i>Aphanothece microspora</i>	11688291	0	27286122	33633416	35520173	49271638
<i>Aphanothece nidulans</i>	0	20227790	0	0	0	0
<i>Chroococcus dispersus</i>	19223	674826	435945	169249	1203300	1279009
<i>Chroococcus dispersus</i> var. <i>minutus</i>	0	0	66802	0	0	0
<i>Chroococcus dispersus</i> var. <i>minor</i>	19223	586289	326742	121583	1193105	988424
<i>Chroococcus minor</i>	46454	0	0	0	0	0
<i>Chroococcus minutus</i>	0	5431	0	0	100348	0
<i>Chroococcus pallidus</i>	0	0	34829	0	0	0
<i>Coelosphaerium pallidum</i>	300488	0	0	0	0	0
<i>Cylindrospermum licheniforme</i>	0	0	0	3346689	350136	0
<i>Cylindrospermum licheniforme</i>	0	0	0	3346689	0	0
<i>Cylindrospermum minutissimum</i>	0	0	0	509268	111220	0
<i>Gleocapsa rupestris</i>	0	0	0	0	0	92683
<i>Lynngbya taylorii</i>	0	0	169171	0	0	0
<i>Marssoniella elegans</i>	0	0	0	3905	0	0
<i>Merismopedia elegans</i>	0	491707	0	0	0	0
<i>Merismopedia glauca</i>	0	0	49756	0	0	0
<i>Oscillatoria amoena</i>	0	63971	0	0	0	0
<i>Oscillatoria amphibia</i>	0	55423	0	0	0	0
<i>Oscillatoria angustissima</i>	213592	138753	175273	2076526	1343691	1803903
<i>Oscillatoria formosa</i>	0	464444	0	0	0	0
<i>Oscillatoria limnetica</i>	4211	3325772	1556906	1787232	3877491	15863

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METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AIV-1 (Continued)

PERIPHYTON SPECIES COLLECTED AT EACH STATION IN THE CALUMET RIVER SYSTEM DURING 1989

Family and Species	Calumet River		Little Calumet River		Cal-Sag Channel	
	Ewing Avenue	O'Brien Lock and Dam	Indiana Avenue	Halsted Street	Ashland Avenue	Route 83
<u>Myxophyceae</u>	Number Per Square Centimeter					
Oscillatoria subbrevis	0	1471921	0	0	0	0
Oscillatoria tenuis	542051	1363735	0	0	0	787805
Oscillatoria tenuis var. natans	3307	111424	0	0	0	0
Oscillatoria tenuis var. tergestina	538744	0	0	0	0	787805
Phormidium ambiguum	0	563312	0	0	0	0
Phormidium tenue	0	760	0	149312	132358	0
Spirulina major	5767	28213	0	0	0	0

AIV-9