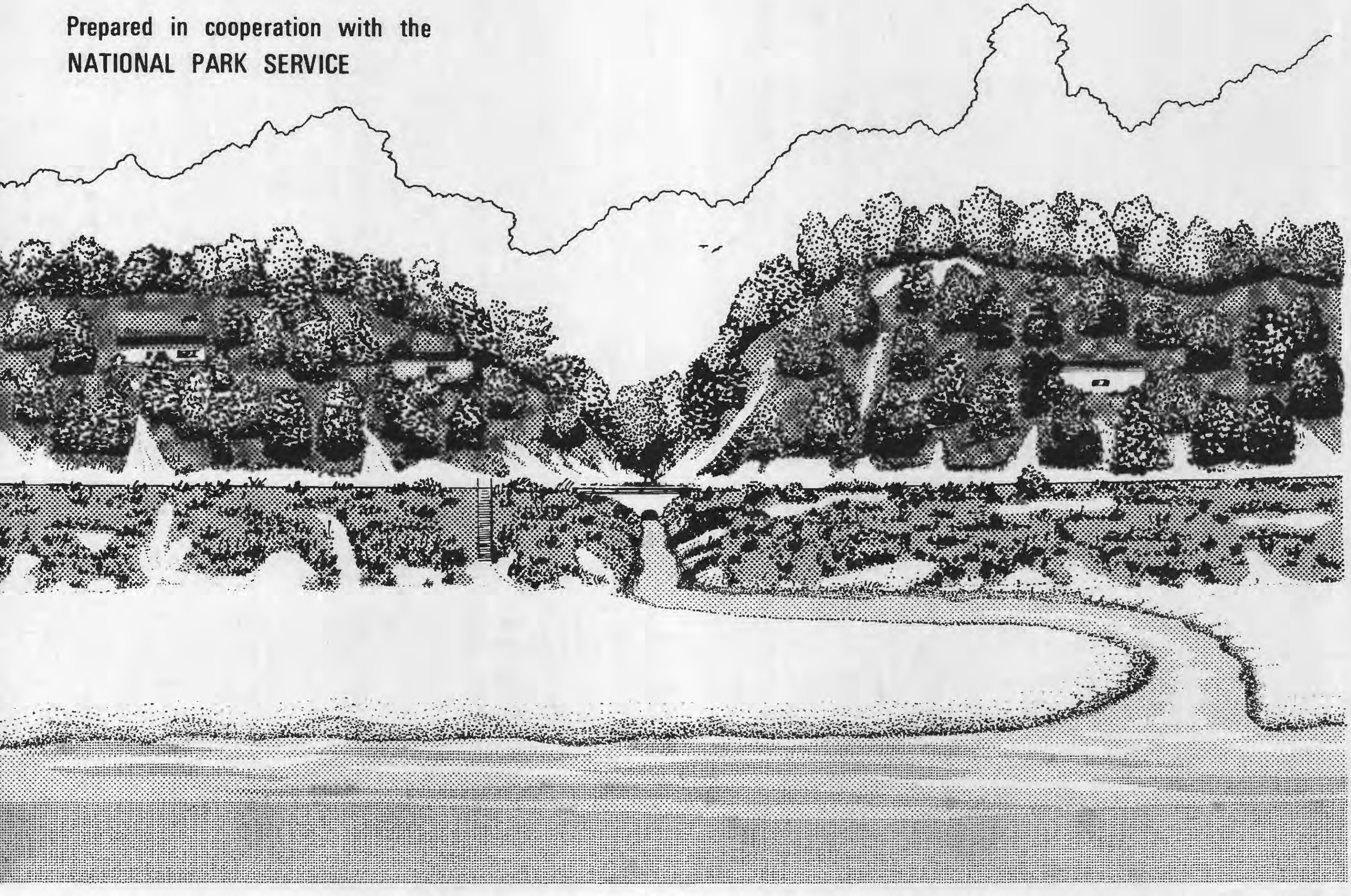
CHEMICAL AND BIOLOGICAL QUALITY OF STREAMS AT THE INDIANA DUNES NATIONAL LAKESHORE, INDIANA, 1978-80

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 83-4208

Prepared in cooperation with the
NATIONAL PARK SERVICE



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By Mark A. Hardy

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Indianapolis, Indiana

1984

UNITED STATES DEPARTMENT OF THE INTERIOR

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GEOLOGICAL SURVEY

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FACTORS FOR CONVERTING INCH-POUND UNITS TO INTERNATIONAL SYSTEM OF UNITS (SI)

The inch-pound and other units used in this report can be converted to units used in the metric system as follows:

Multiply inch-pound unit	By	To obtain SI unit
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square foot (ft^2)	0.0929	square meter (m^2)
acre	0.4047	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
cubic foot per second (ft^3/s)	0.0283	cubic meter per second (m^3/s)
micromho per centimeter at 25° C (μmho/cm)	1.0	microsiemens per centimeter at 25° C (μS/cm)

Degrees Celsius (°C) can be calculated from degrees Fahrenheit (°F) by

$$°C = 0.56\ (°F-32)$$

Degrees Fahrenheit (°F) can be calculated from degrees Celsius (°C) by

$$°F = 1.8\ °C + 32$$

DATUM

National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called mean sea level. NGVD of 1929 is referred to as sea level in this report.

TRADE NAMES

Any use of trade names in this report is for descriptive purposes only and does not imply endorsement by the U.S. Geological Survey.

ABBREVIATIONS AND SYMBOLS

BOD	biochemical oxygen demand
°C	degree Celsius
$CaCO_3$	calcium carbonate
cm	centimeter
col/100 mL	colonies per 100 milliliters
DDD	2,2-bis(p-chlorophenyl)-1,1-dichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane
°F	degree Fahrenheit
FC:FS	ratio of fecal coliform to fecal streptococcus
ft	foot
ft^3/s	cubic foot per second
g/m^2	gram per square meter
h	hour
in.	inch
L	liter
µm	micrometer
µg/g	microgram per gram
µg/kg	microgram per kilogram
µg/L	microgram per liter
µmho/cm	micromho per centimeter
mg/m^2	milligram per square meter
mg/L	milligram per liter
mi	mile
mi^2	square mile
N	nitrogen
NPS	National Park Service
P	phosphorus
PCB	polychlorinated biphenyl
PCN	polychlorinated naphthalene
temp	temperature

CHEMICAL AND BIOLOGICAL QUALITY OF STREAMS AT THE INDIANA DUNES NATIONAL LAKESHORE, INDIANA, 1978-80

By Mark A. Hardy

ABSTRACT

A variety of land uses affects water quality of streams at the Indiana Dunes National Lakeshore. Discharge from storm sewers and runoff from roads contributed lead, zinc, and chlorinated hydrocarbons (chlordane, DDT, DDD, DDE, and PCB's) to all streams except Derby ditch. In addition, the Little Calumet River received ammonia from industrial discharges, and organic materials, nitrogen, phosphorus, and fecal coliform from wastewater-treatment-plant and combined-sanitary- and storm-sewer discharges. As a result, water at some sites in the lower reaches of the Little Calumet River contained dissolved-ammonium-nitrogen concentrations exceeding 0.10 milligram per liter, dissolved-oxygen concentrations less than 3.0 milligrams per liter, and fecal coliform populations exceeding 2,000 colonies per 100 milliliters.

Seepage from two landfills may have caused the concentration of dissolved solids in the west Grand Calumet River lagoon to exceed that in the east lagoon. Ammonium concentrations in the west lagoon ranged from 13 to 16 milligrams per liter as nitrogen.

Pesticides used in agricultural areas were the major source of DDT, DDD, DDE, and dieldrin on streambed materials. Runoff from residential areas was a major source of nitrate, organic materials, and chlordane in Derby ditch and Dunes Creek.

Wetland drainage contributed significant amounts of organic materials to streams and at times increased concentrations of dissolved sulfate and iron. Dissolved-iron concentrations correlated with dissolved-organic-carbon concentrations in yellow-brown water of Kintzele and Derby ditches.

INTRODUCTION

The Indiana Dunes National Lakeshore (the Lakeshore) extends along the heavily industrialized south shore of Lake Michigan from Gary to Michigan City, Indiana. The Lakeshore consists of several parcels of land, totaling approximately 12,500 acres and including approximately 15 mi of shoreline. Five streams--the Grand Calumet River, the Little Calumet River, Kintzele ditch, Derby ditch, and Dunes Creek--either flow through or border parts of the Lakeshore (fig. 1). The water quality of these streams is influenced by various urban, industrial, and agricultural activities within the drainage basins.

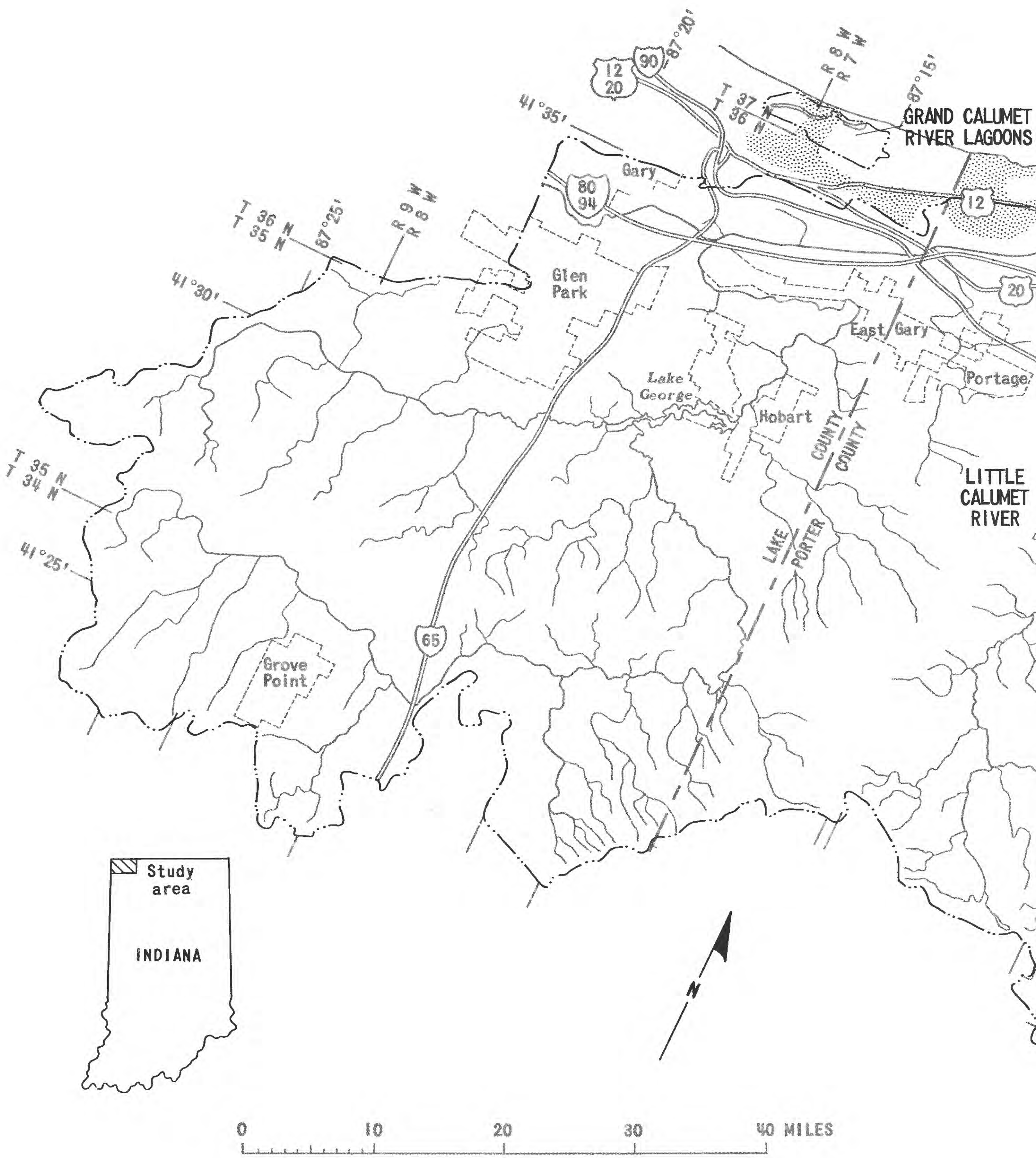
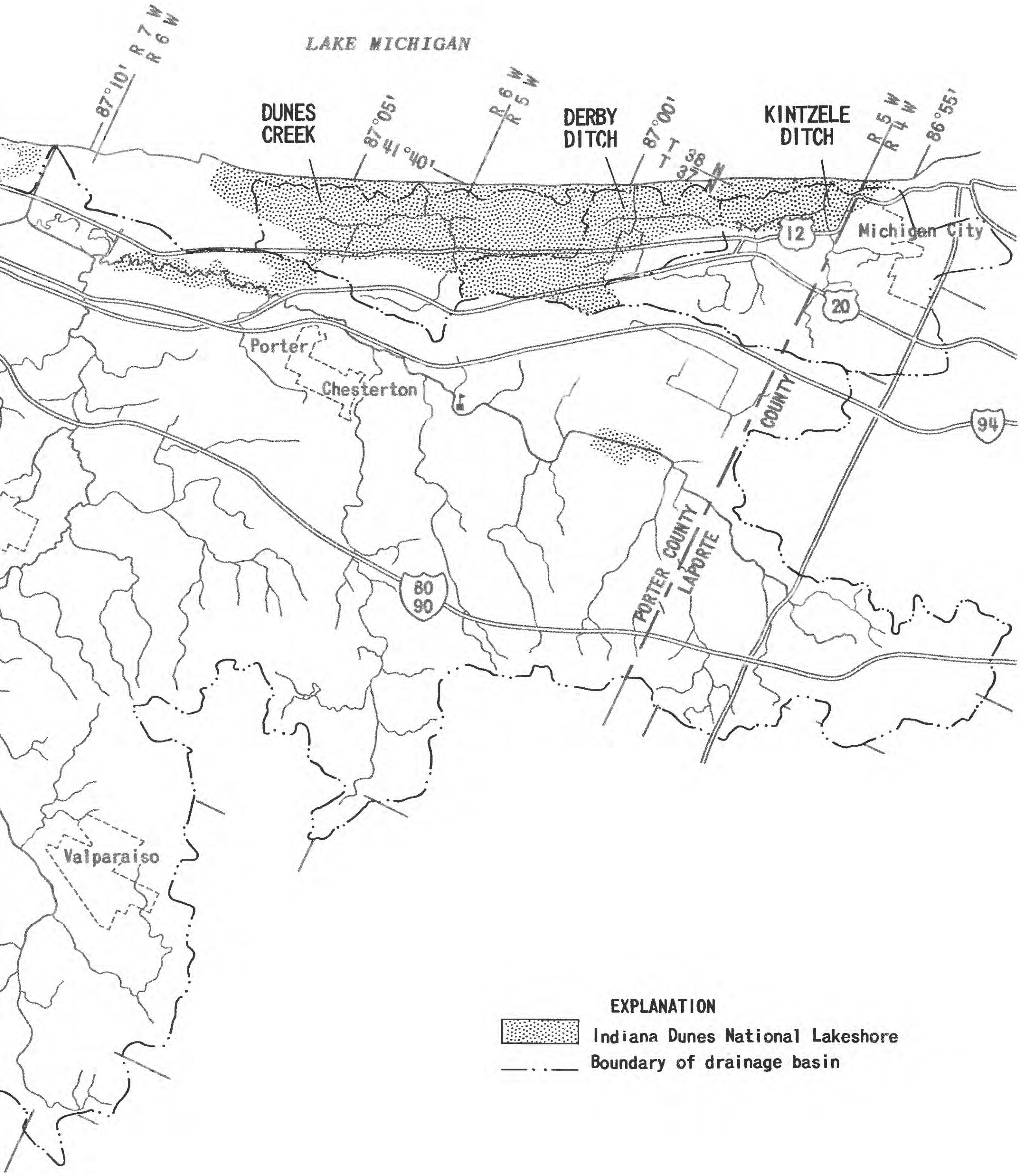


Figure 1.-- The Grand Calumet River lagoons, the Little Calumet River,



Dunes Creek, Derby ditch, and Kintzele ditch drainage basins, Indiana.

Purpose and Scope

The National Park Service (Park Service) is required to protect the water resources of streams in and adjacent to Lakeshore property. Although general water quality of most of the streams was assessed by Arihood (1975), he did not identify activities that affected water quality. The objectives of the current study, done in cooperation with the National Park Service, were to: (1) assess variations in stream water quality within each drainage basin and (2) determine causes and potential causes of water-quality variations.

Environmental Setting

Geography and Geology

The study area is in Lake, Porter, and LaPorte Counties in the northwest corner of Indiana (fig. 1). Drainage basins of the five streams, except the Little Calumet River, lie entirely within the Calumet Lacustrine Plain. This physiographic unit, an abandoned lake bottom that was the site of Lake Chicago near the end of the Wisconsin glacial period, is a compound lacustrine area where major stages of glacial Lake Chicago are represented by long, terraced sand ridges. Sand dunes and interdunal wetlands now cover many of these ridges. (See Schneider, 1966, p. 50-51.) The soils are generally sandy, except for organic soils (some contain marl deposits) in wetlands and former lake bottoms (Bushnell and Barrett, 1918; Ulrich and others, 1944; Persinger, 1972).

Most south tributaries to the Little Calumet River originate in the Valparaiso Moraine, immediately south of the Calumet Lacustrine Plain and nearly 150 ft higher. The Valparaiso Moraine is probably a compound moraine representing more than one termination of ice sheet advancement. Some ice block depressions within the rolling terrain of this moraine contain lakes and (or) peat soils. (see Schneider, 1966, p. 51) Silt and clay predominate in the moraine, and alluvial silt is deposited in and along the Little Calumet River and two of its tributaries, Salt Creek and Coffee Creek (Ulrich and others, 1944; Bushnell and Barrett, 1918; Persinger, 1972).

The Ellsworth Shale and Antrim Shale bedrock formations that underlie the drift consist primarily of shale and limestone rocks of Devonian and Mississippian age and do not crop out (Schneider and Keller, 1970). Bedrock formations are as deep as 275 ft beneath land surface (Reshkin and others, 1975, p. 348).

Climate

Mean daily minimum and maximum air temperatures in the study area range from 18° and 36° F in January, to 64° and 84° F in July (Schaal, 1966, p. 162). Lake Michigan warms the Lakeshore in the winter and cools it in the summer. As a result, this area has warmer winters, cooler summers, and a longer frost-free growing season than central Indiana (Schaal, 1966, p. 166).

Mean annual precipitation across the Lakeshore ranges from 36 in. in the west to more than 40 in. in the east. Maximum and minimum monthly precipitations are generally in April and February, respectively (Schaal, 1966, p. 157-158).

Stream Hydrology

Grand Calumet and Little Calumet Rivers.--Before 1870, the Grand Calumet and the Little Calumet Rivers (figs. 2 and 3, respectively) were the same river with two mouths that discharged sluggishly to Lake Michigan, one in Illinois and the other near today's Marquette Park at Gary. Development of a harbor at the Illinois mouth in 1870 resulted in increased discharge there and the permanent closure of the Indiana mouth (Cook and Jackson, 1978, p. 24-25). Construction of Burns ditch in 1924-26 created a channel that drained the Little Calumet River directly to Lake Michigan (Cook and Jackson, 1978, p. 63), reversed flow in the modified channel west of Burns ditch, and separated the Little Calumet River east of Gary from the Grand Calumet River. When the level of Lake Michigan is high, the lower reach of the west fork of the Little Calumet River may flow west rather than east. Burns ditch was dredged from Lake Michigan to Highway 12 between October and November 1978.

The headwater lagoons of the Grand Calumet River have no measurable velocity but slight flow to the west is detectable in the small channel connecting the two lagoons. A storm sewer empties into the east end of the east lagoon at Marquette Park. Water flows from the west side of the west lagoon through two drain pipes under a U.S. Steel Company access road to the open channel of the Grand Calumet River (D. C. Perkins, written commun., 1964).

Dunes Creek, Derby ditch, and Kintzele ditch.--Drainage ditches have significantly affected the hydrology of streams in and around the Lakeshore. Before Kintzele ditch and Derby ditches were constructed (figs. 4 and 5, respectively), no streams drained into Lake Michigan at these sites. In general, ditches were constructed to lower the water table so that the former wetlands would be acceptable for agriculture and other uses. Most ditches were constructed between about 1875 and 1925 (Cook and Jackson, 1978, p. 58-64). Dunes Creek (fig. 6) is a natural drainage, although ditches have been constructed within that drainage basin. Markowitz ditch, which drains into Dunes Creek, was constructed in the early 1950's to improve septic-tank operation for local residents (Cook and Jackson, 1978, p. 64). Striebel arm of Kintzele ditch was dredged between October 1978 and July 1979 from the mouth to Highway 20.

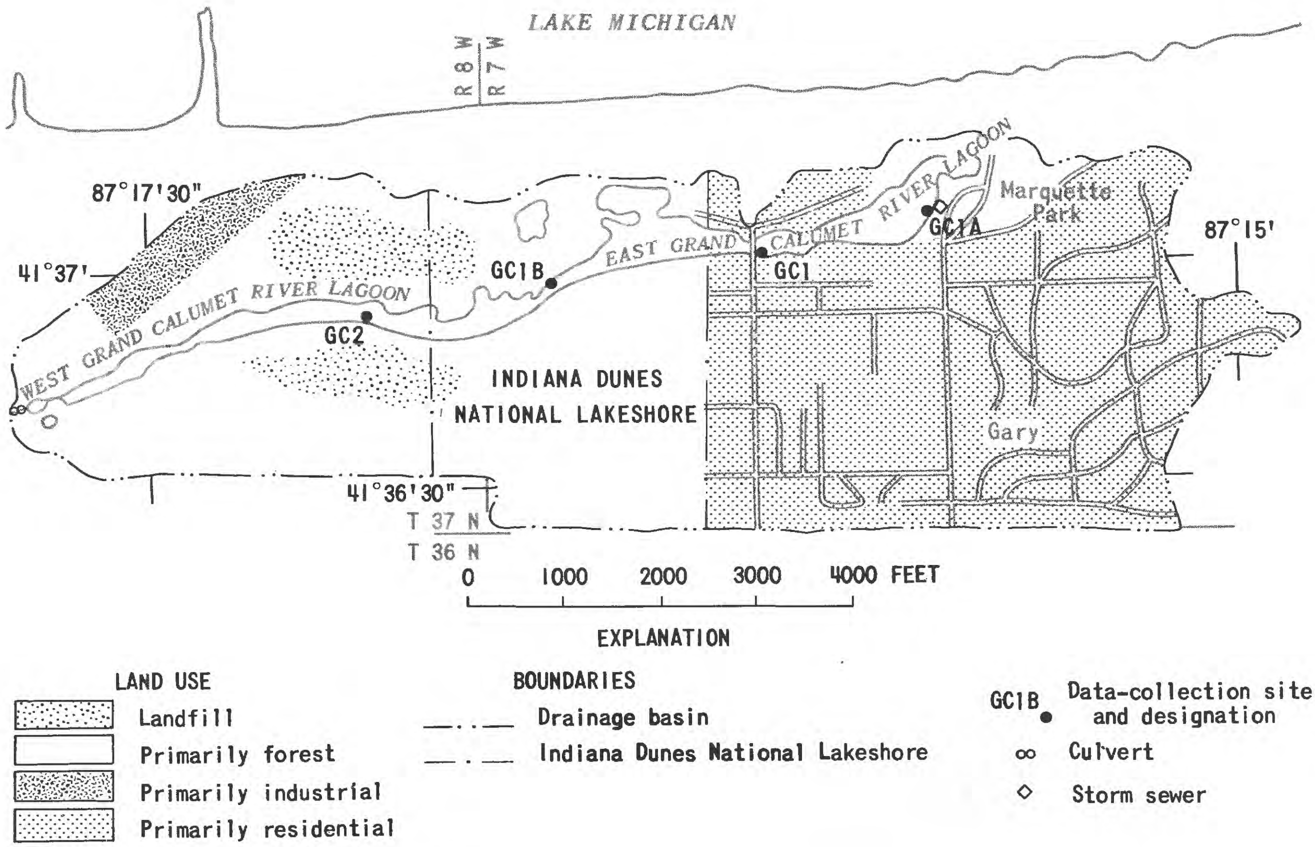


Figure 2.-- Data-collection sites and land uses in the Grand Calumet River lagoons drainage basin.

Land Use

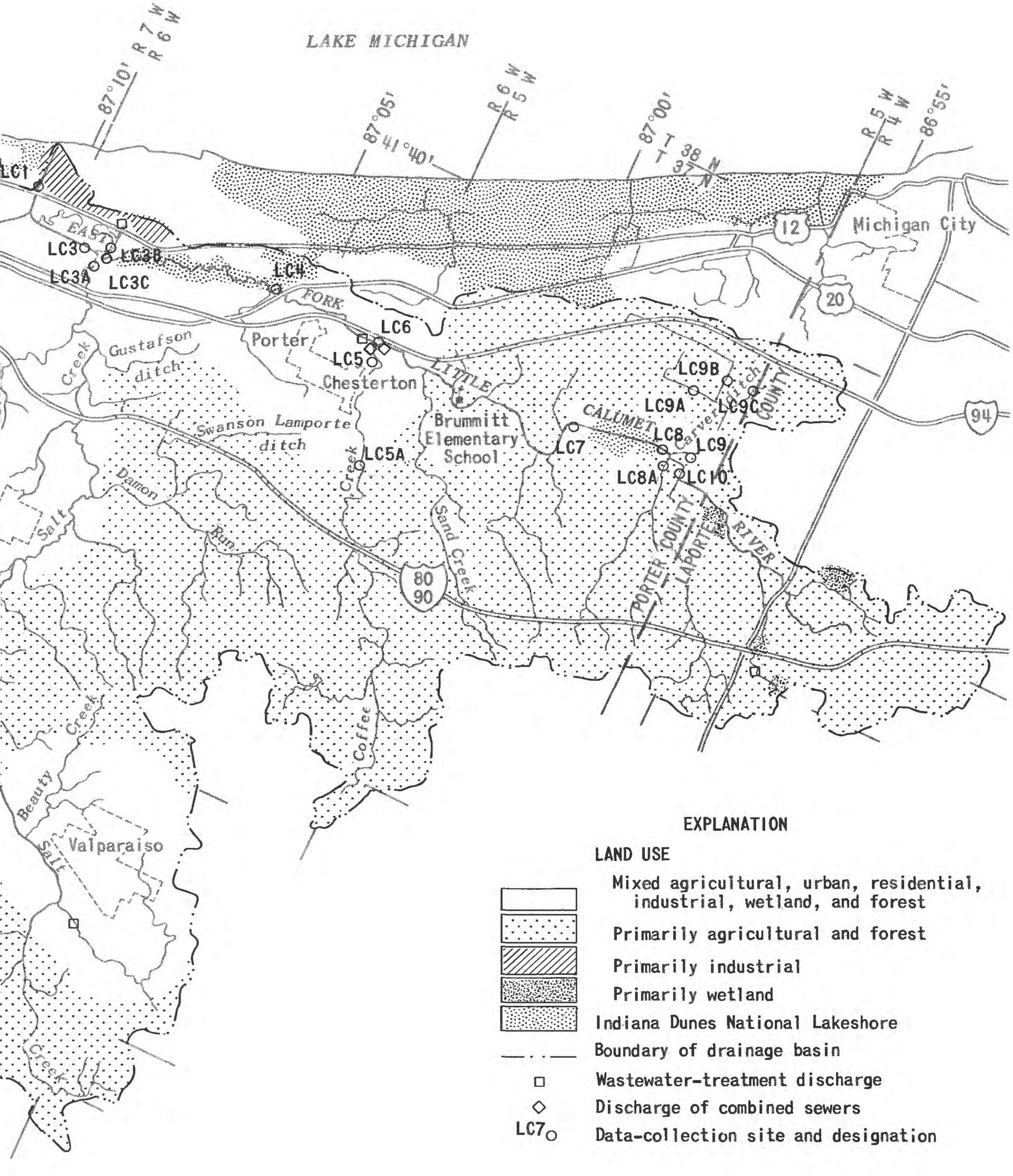
Reshkin and others (1975, p. 30) described the area surrounding the Lakeshore as one having the greatest concentration of iron and steel mills and electric-generating facilities in the world. But streams flowing through the Lakeshore are subject not only to the effects of industrial land use, but also urban, residential, and agricultural land uses. A summary of land use within each drainage basin is presented in table 1. Land-use estimates were made from land-use maps prepared by the Northwestern Indiana Regional Planning Commission and the LaPorte County Planning Office. The primary land-use patterns shown in figures 2-6 are generalized and, therefore, may contain small amounts of different land uses. However, the primary land use shown probably affects stream water quality most. A primary land use is not shown in many areas because land use was too variable to be shown practically at such small map scales.

Table 1.--Land use within drainage basins at the Indiana Dunes National Lakeshore

Drainage basin	Area (mi^2)	Land use (percentage of total area)					
		Public parks[1]	Wetland	Agriculture and forest	Urban[2]	Residencial	Industrial[3]
Grand Calumet River lagoons	1.35	9	1	45	9	29	7
Little Calumet River	331	2	1	75	8	11	3
Kintzele ditch	12.7	12	4	54	8	19	3
Derby ditch	4.64	50	7	33	2	6	2
Dunes Creek	7.37	56	10	19	4	8	3

[1]Public parks generally include wetlands and forest.
[2]Urban land use includes cities, towns, streets, and rail right of ways.
[3]Industrial land use includes landfills.

Figure 3.-- Data-collection sites and land uses



in the Little Calumet River drainage basin.

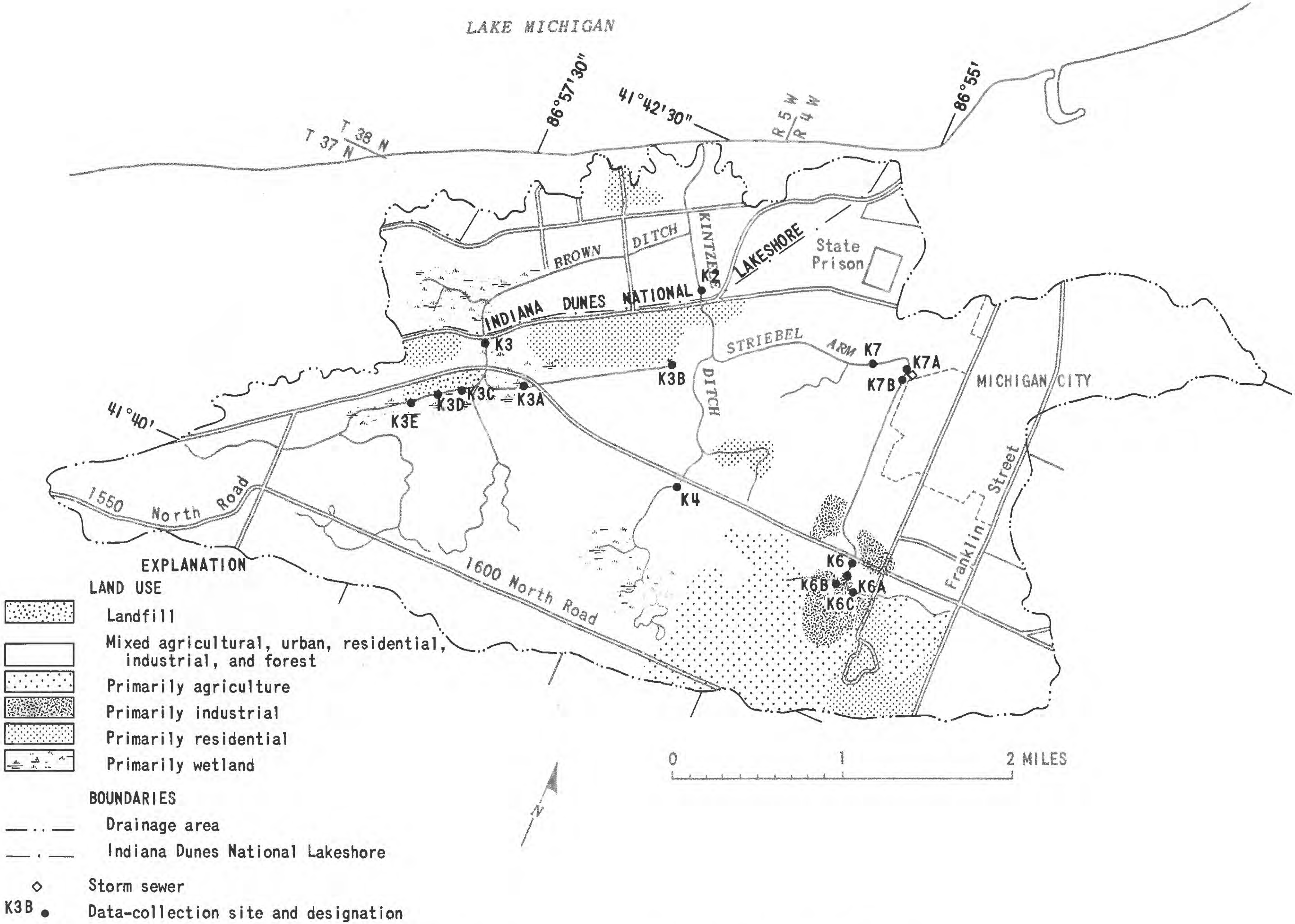


Figure 4.-- Data-collection sites and land uses in the Kintzele ditch drainage basin.

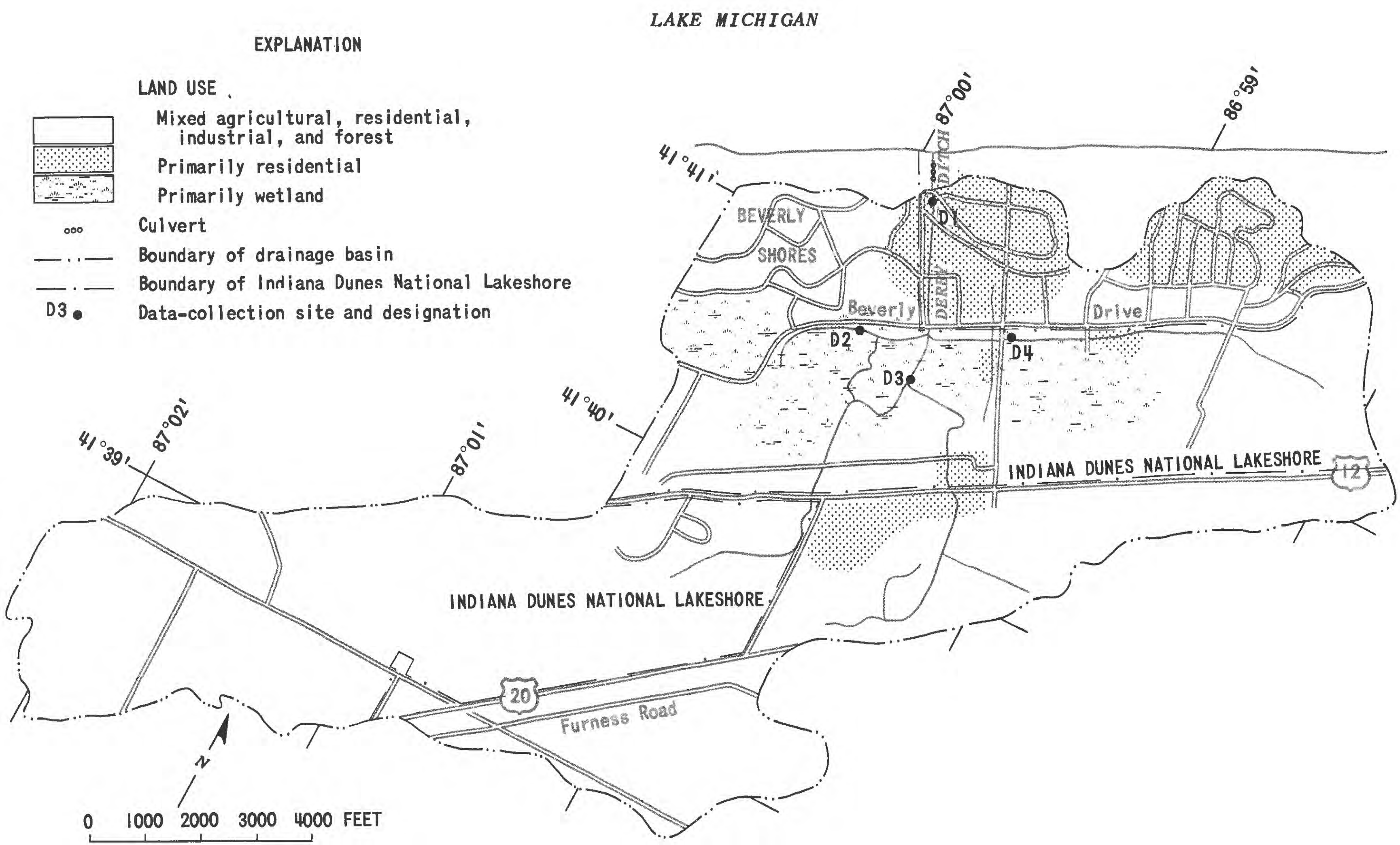


Figure 5.-- Data-collection sites and land uses in the Derby ditch drainage basin.

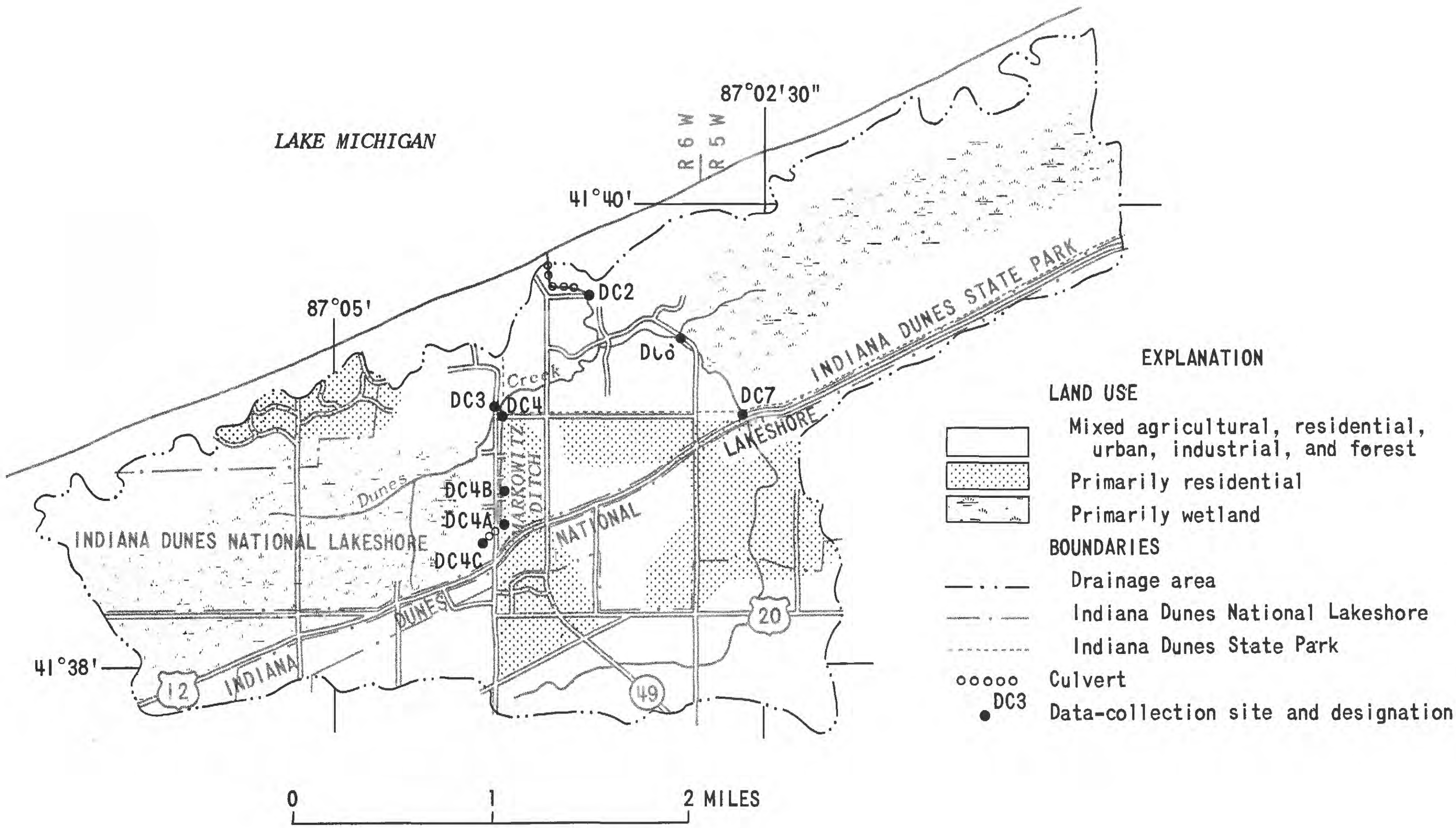


Figure 6.-- Data-collection sites and land uses in the Dunes Creek drainage basin.

More than 80 percent of land uses in the Grand Calumet River lagoons, Little Calumet River, and Kintzele ditch drainage basins are agricultural, urban, and residential. In the Derby ditch and Dunes Creek drainage basins, more than 55 percent of land uses are park and wetland and only 33 and 19 percent, respectively, are agricultural.

The Little Calumet River receives effluent from 19 industries (mostly process discharges) and 4 wastewater-treatment plants (Phillip Taylor, U.S. Environmental Protection Agency, written commun., April 28, 1980), as well as 24 public and private institutions (Northwestern Indiana Regional Planning Commission, 1978, p. III-7-III-14). Combined sewers at Chesterton, Gary, and Portage discharge sewage during runoff.

Two industrial landfills are within 500 ft north and south of the west Grand Calumet River lagoon.

Most of the agricultural, urban, and residential areas in the Kintzele ditch drainage basin (fig. 4) are in the Striebel arm drainage. Most of the park and wetland is south of the Striebel arm confluence with Kintzele ditch and on Brown ditch. Another landfill is near Brown ditch, a tributary of Kintzele ditch. Coal fly ash seems to be a major constituent of this landfill.

In the Dunes creek watershed (fig. 6), most of the residential and urban land use is along Markowitz ditch and south of the Indiana Dunes State Park.

METHODS

Sampling sites (figs. 2-6) were selected on the basis of water-quality data, locations of major tributary confluences, and land use. The stage of the Little Calumet River was used to determine when to collect water and biological samples Dates of sampling are shown on the flow-duration curve of the Little Calumet River (fig. 7). The curve was based on 22 years of mean daily discharge data from the Porter station, site LC4 (Rohne, 1972, p. 269). High-flow samples were collected at less than 35-percent flow duration after rainfall. Low-flow samples were collected at a base flow exceeding 90-percent flow duration in summer. Samples for determining concentrations of major dissolved cations, anions, and nutrients; and characteristics of periphyton and benthic-invertebrate communities were collected during high flows in November 1978 and August 1979 and during low flow in July 1980. Samples for fecal coliform and fecal streptococcus analyses were collected during high flows in November 1978 and in February, March, and August 1979.

Variations of discharge at each site for samplings on Kintzele ditch, Derby ditch, and Dunes Creek were similar to those of the Little Calumet River (fig. 8). Discharges at sites K2 and K7 on Kintzele ditch were less variable than those at other sites, possibly because the dredging of Striebel arm increased the streambed slope and the discharge of ground water to the stream.

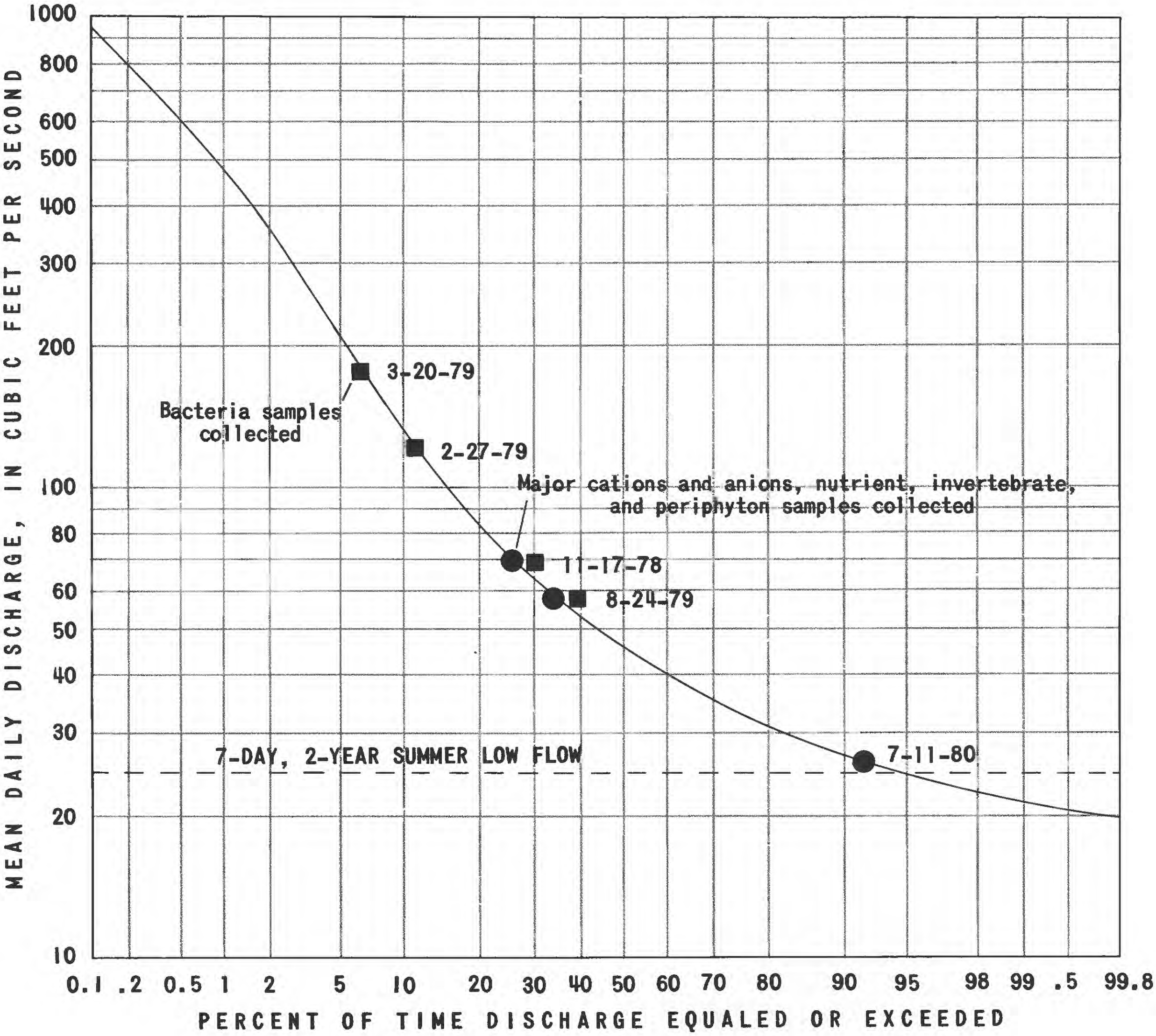


Figure 7.-- Flow-duration curve and sampling dates for the Little Calumet River near Porter (site LC4).

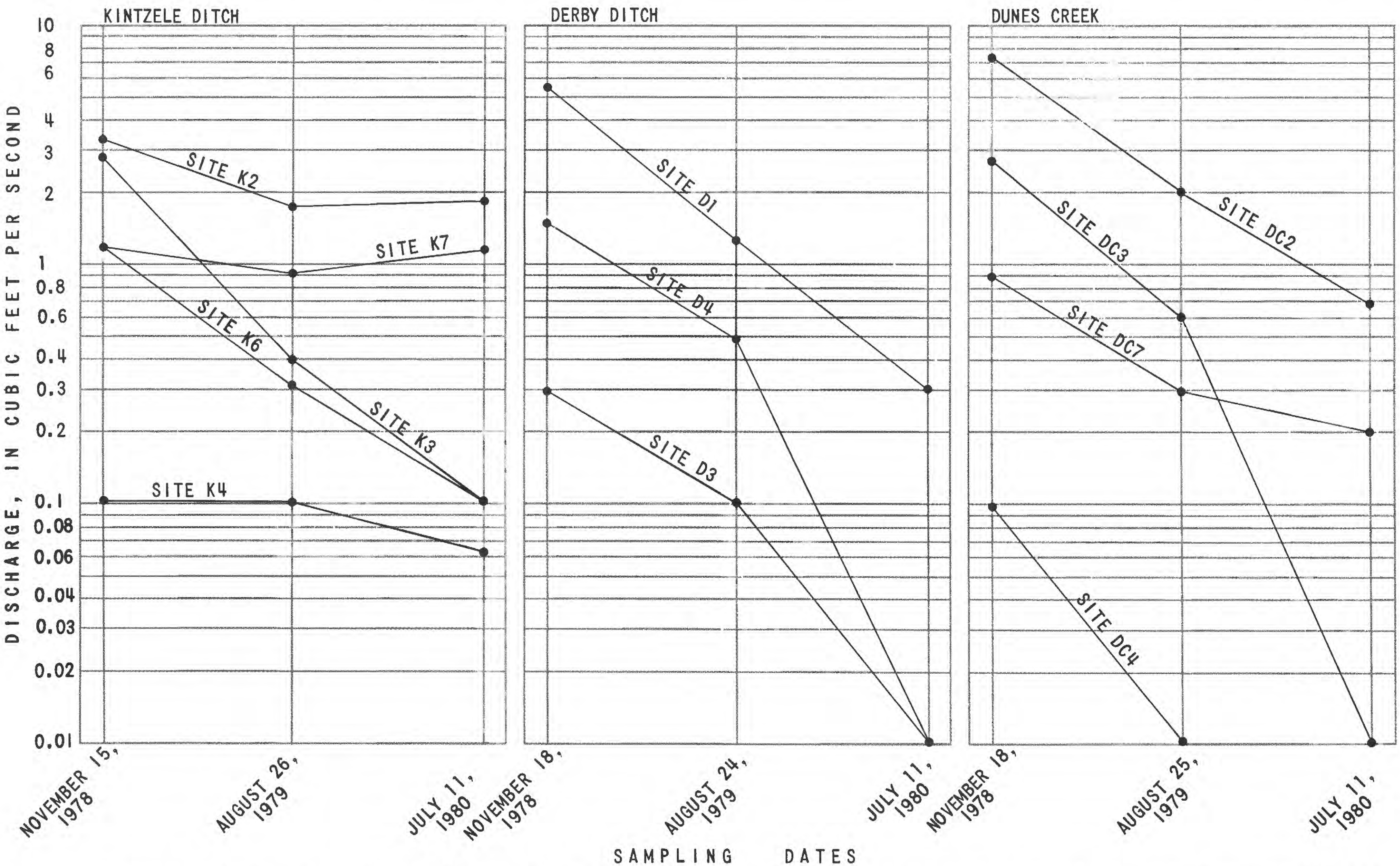


Figure 8.-- Discharges at sites on Kintzele ditch, Derby ditch, and Dunes Creek where biological and water samples were collected.

Streambed-material samples were collected in November 1978 and August 1979 to determine concentrations of selected trace elements and chlorinated hydrocarbons. Additional streambed samples were collected at upstream sites in December 1979 and April 1980 to improve indentification of sources of trace elements and chlorinated hydrocarbons.

Collection and Analysis of Water and Streambed Samples

Water samples for determining concentrations of dissolved chemical constituents and streambed materials for determining concentrations of sorbed trace elements were collected by the methods described in Brown and others (1970). Streambed materials less than 63 µm in diameter and from 250 to 500 µm in diameter were separated by sieving bulk samples dried at 105° C in stainless-steel sieves of 500, 250, and 63 µm mesh.

Concentrations of dissolved inorganic constituents and acid-soluble trace metals on streambed materials were determined by the methods described in Skougstad and others (1979). Concentrations of dissolved organic carbon and chlorinated hydrocarbons on streambed materials were determined by the methods described in Goerlitz and Brown (1972).

Collection and Analysis of Biological Samples

Biological community samples were collected and analyzed by the methods described in Greeson and others (1977). Periphyton samples were collected on mylar-strip artificial substrates, and benthic invertebrates were collected on jumbo-multiplate artificial substrates. The substrates were placed in the streams 6 weeks before removal for analysis. Fecal coliform and fecal streptococcus populations were measured by the membrane filtration method (Greeson and others, 1977, p. 53-62).

WATER-QUALITY CRITERIA AND SIGNIFICANCE

Field Measurements, Major Dissolved Constituents, and Nutrients

Adequate concentrations of dissolved oxygen are required for survival of certain aquatic fauna. The Indiana Stream Pollution Control Board (1977) requires an average concentration of 5 mg/L and a minimum concentration of 4 mg/L for protection of fish. Decomposition of organic materials in water reduces dissolved-oxygen concentrations. Water temperature can also affect concentrations. Solubility of oxygen varies inversely with temperature, and rate of organic decomposition varies directly with temperature.

The chemical compositions of water samples were plotted on trilinear diagrams and compared (Piper, 1944). Analyses grouped by this procedure indicated variations in chemical-composition in each stream. For example, figure 9 shows groups of sites where analyses differ mainly in percentages of sodium and chloride.

Phosphorus and inorganic nitrogen (ammonium, nitrite, and nitrate) are major nutrients for aquatic plants. High nutrient concentrations can cause undesirably high plant production. The maximum total phosphorus concentrations recommended for prevention of nuisance algal production in flowing and nonflowing waters are 0.10 and 0.05 mg/L, respectively (Mackenthun, 1969, p. 41). The concentration of inorganic nitrogen critical for stimulation of algal growth is 0.3 mg/L as nitrogen (Mackenthun, 1969, p. 156). In addition, ammonia is toxic to some aquatic animals. Normally, the concentration of ammonium as nitrogen in natural waters is less than 0.10 mg/L. Concentrations downstream from sewage and industrial discharges are somewhat higher (National Academy of Sciences and Natural Academy of Engineering, 1972, p. 55). In this report ammonia concentrations were calculated from the concentration of ammonium, temperature, and pH (U.S. Environmental Protection Agency, 1976, p. 16-21). The maximum concentration of ammonia recommended for protection of freshwater organisms is 0.02 mg/L (U.S. Environmental Protection Agency, 1976, p. 16).

Trace Elements on Streambed Materials

The elements discussed in this report that normally have concentrations less than 0.2 mg/L (except fluoride, nitrogen, and phosphorus) are referred to as trace elements. Because of low solubility, many of these elements concentrate on streambed materials. Therefore, although water may contain small quantities of trace elements, aquatic organisms living and feeding on the streambed material may accumulate these elements in tissues. Because trace elements are nonde-

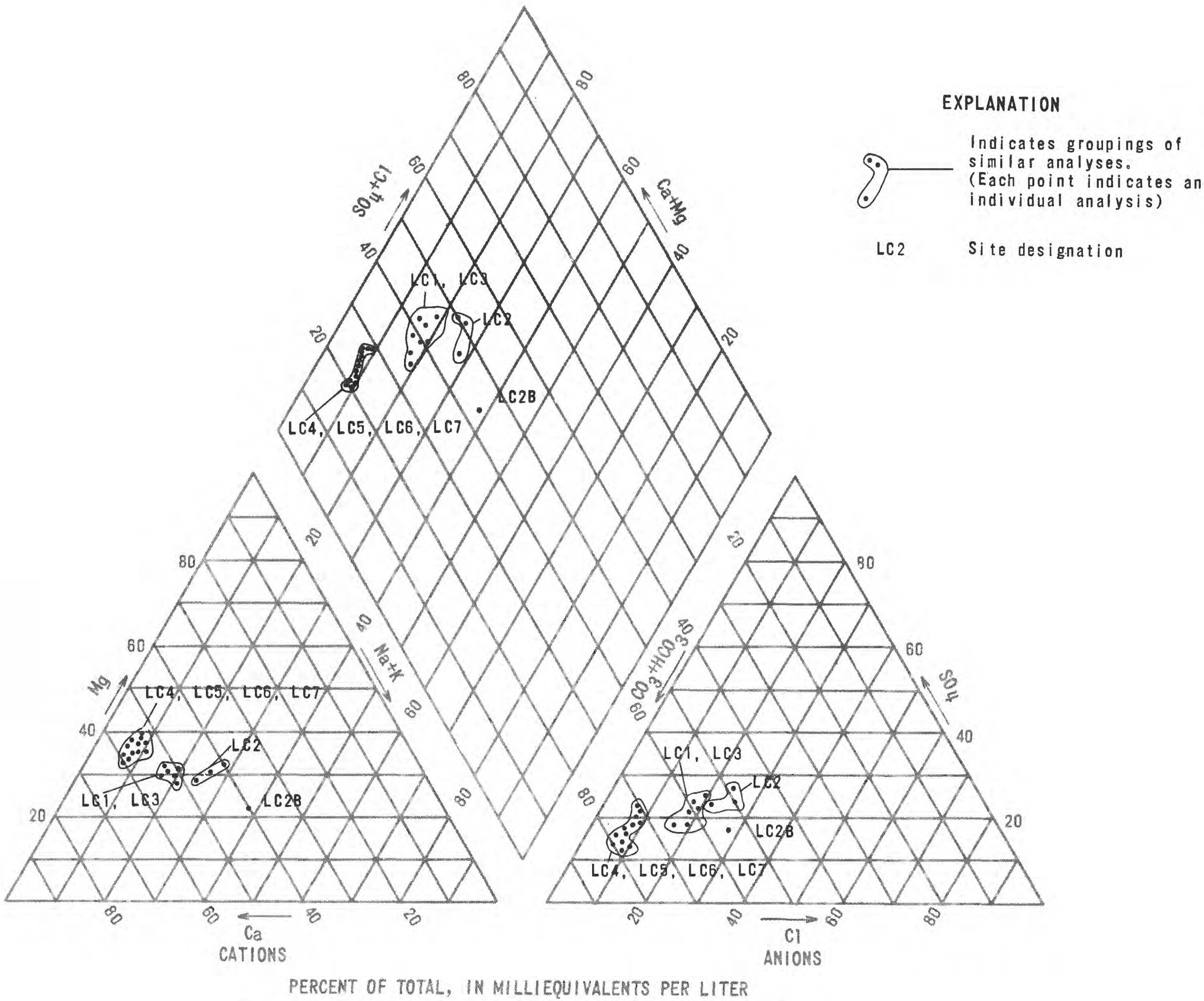


Figure 9.-- Analyses of Little Calumet River water samples.

gradable, their concentrations may be magnified in the upper trophic levels of food chains. Urban and industrial areas are common sources of trace metals in streams. Urban runoff is a particularly common source of lead, zinc, and copper (Wilber and Hunter, 1977).

Concentrations of arsenic, cadmium, chromium, cobalt, copper, lead, and zinc on unsorted streambed samples indicated that only copper, lead, and zinc concentration were greater than 30 µg/g. Sources of copper, lead, and zinc in flowing streams were defined by data collected at additional sampling sites near areas of high concentrations and, because the concentrations generally vary inversely with particle size, by comparing concentrations on specific particle size fractions. Concentrations of lead and zinc were determined for the Little Calumet River, Kintzele ditch, and Markowitz ditch (part of Dunes Creek), but copper was determined only for the east fork of the Little Calumet River. Iron concentrations were determined for Brown ditch (part of Kintzele ditch) because of high iron concentrations in runoff from an adjacent landfill.

The silt- and clay-sized particles (less than 63 µm in diameter) are more subject to fluvial transport than larger particles. Because these particles generally have the highest concentrations of trace elements, they help define sites where concentrations are highest. The largest particles common to all sampling sites are medium sands (250 to 500 µm in diameter). Although these particles normally have lower concentrations of trace elements than fine particles, they are less subject to fluvial transport and, therefore, help define locations where trace elements enter the stream (Wilber and Hunter, 1979).

Probability plots of data from all drainage basins were used to differentiate samples having enriched lead, zinc, and copper concentrations and background concentrations. (See Velz, 1970, p. 522-542.) An example of these plots (for lead) is shown in figure 10. Normal probability plots were used because the data conformed more closely to a normal distribution than to a log-normal distribution. The plots generally depict a two-stage curve. In this report, sites composing the first and second stages are defined as sites having background and enriched concentrations, respectively. Differences between the slopes of the two stages were nearly the same for lead and zinc. The second stage slope could not be defined for copper because only one site had an enriched concentration. Background concentrations are the result of processes such as geologic weathering and atmospheric deposition. Maximum background concentrations of copper, lead, and zinc are shown in table 2.

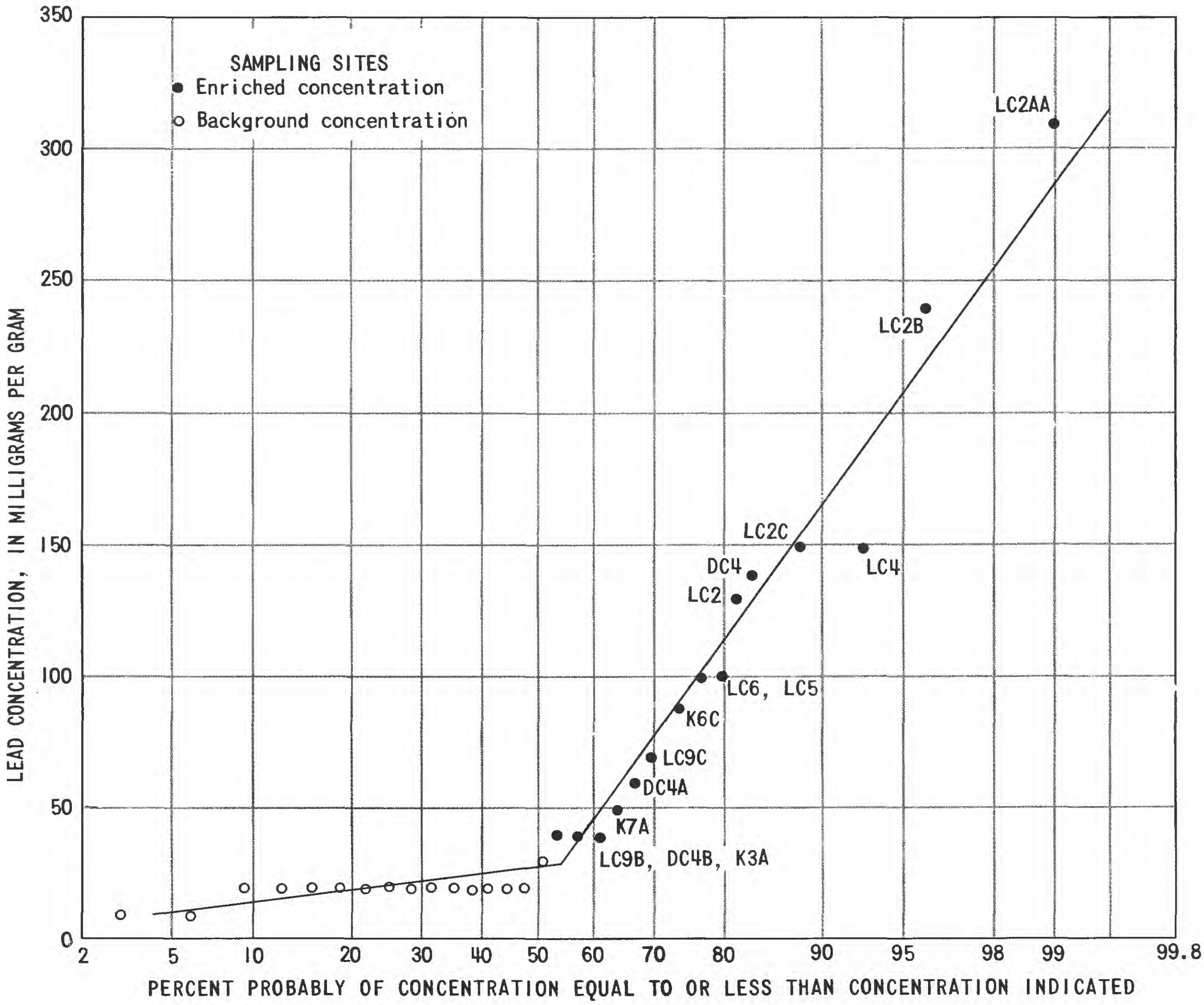


Figure 10.-- Probability plot of lead concentrations sorbed on streambed materials 250 to 500 micrometer in diameter collected from streams and ditches at the Indiana Dunes National Lakeshore.

Table 2.--Maximum background concentrations of acid-soluble copper, lead, and zinc on sieved streambed materials of the Little Calumet River, Kintzele ditch, and Dunes Creek

Particle size (μm)	Copper (μg/L)	Lead (μg/L)	Zinc (μg/L)
<63	30	60	60
250-500	30	30	40

Chlorinated Hydrocarbons on Streambed Materials

Chlorinated hydrocarbons are synthetic organic compounds that have been widely used, particularly as pesticides. They are generally toxic to and accumulated by aquatic biota (Thompson and Edwards, 1974, p. 357-360) and are persistent in the environment. Compounds common in the streams at the Lakeshore include chlordane, DDT and its decomposition products (DDD and DDE), dieldrin, heptachlor and its decomposition product (heptachlor epoxide), and PCB's. PCB's and DDT are the most toxic (Thompson and Edwards, 1974, p. 350) and persistent (Hiltbold, 1974, p. 214) of these compounds.

Chlordane is commonly used for pest control around livestock and lawns and for termite control. Use of DDT has been banned since 1972, but it was commonly used for a wide range of pest controls. Dieldrin is a microbial decomposition product of aldrin (Kaufman, 1974, p. 139). Both aldrin and dieldrin were formerly applied to corn fields for control of rootworm, but today their use is restricted. Before 1971, PCB's were widely used in products open to the environment--hydraulic fluids, lubricants, heat transfer fluids, carbonless carbon papers, dyes, pesticide extenders, adhesives, and surface coatings. Although production of PCB's has been banned in the United States, PCB use is still permitted in systems closed to the environment (electrical transformers and capacitors). Sources of PCB's in aquatic systems include industrial and municipal effluents, landfills and other soil disposal sites, and atmospheric deposition of incinerated refuse that contained PCB's (National Research Council, 1979, p. 3-16).

Major sources of chlorinated hydrocarbons in streams were determined by comparing concentrations on unsorted streambed materials. Extra sampling sites were sometimes added to help define sources. Because variables other than locations of discharges may influence accumulation of these compounds (for example, composition and particle-size distribution of streambed materials), only concentrations greater than 10 µg/kg (the upper 12 percent of concentrations of compounds detected in the Lakeshore streams) and greater than the concentrations at upstream sites were considered significant.

Bacteria

Fecal coliform and fecal streptococcus inhabit the intestines of warm-blooded animals and, therefore, can indicate fecal wastes in water. The ratio of fecal coliform to fecal streptococcus (FC:FS) is greater than 4.4 in human waste and generally less than 1.0 in other animal waste. Therefore ratios of these bacteria can indicate the source of recently discharged fecal wastes (Geldreich, 1966). Ratios between 1.0 and 4.4 may be caused by differences in the survival rate of the two bacteria or mixed sources of the bacteria.

For partial-body-contact recreation in water outside wastewater mixing zones, the monthly geometric mean population of fecal coliform (based on at least five samples per month) should not exceed 1,000 col/100 mL. No more than one of these samples should exceed 2,000 col/100 mL (Indiana Stream Pollution Control Board, 1977). Streams in the Lakeshore, especially where they flow across the Lake Michigan beach, are subject to the partial-body-contact criterion.

Periphyton

The periphyton community includes not only plants but all microorganisms attached to solid surfaces below water (Greeson and others, 1977, p. 127). Because survival of some of these microorganisms is dependent on water quality, the periphyton communities indicate the time-integrated effects of water quality in flowing systems.

The algal component of samples collected in November 1978 were identified, and the communities were grouped (fig. 11) by a clustering technique (Barr and others, 1979). Although the clustering technique revealed community differences, these differences did not indicate water-quality differences. Therefore, samples collected in August 1979 and July 1980 were analyzed for content of chlorophyll *a* and biomass, which included information from the algal and non-algal parts of the communities. The autotrophic index (the ratio of biomass and chlorophyll *a*) was used as an indicator of organic loading. An index greater than 100 usually represents a community having a high number of heterotrophs in comparison to autotrophs and indicates organic loading (Weber, 1973).

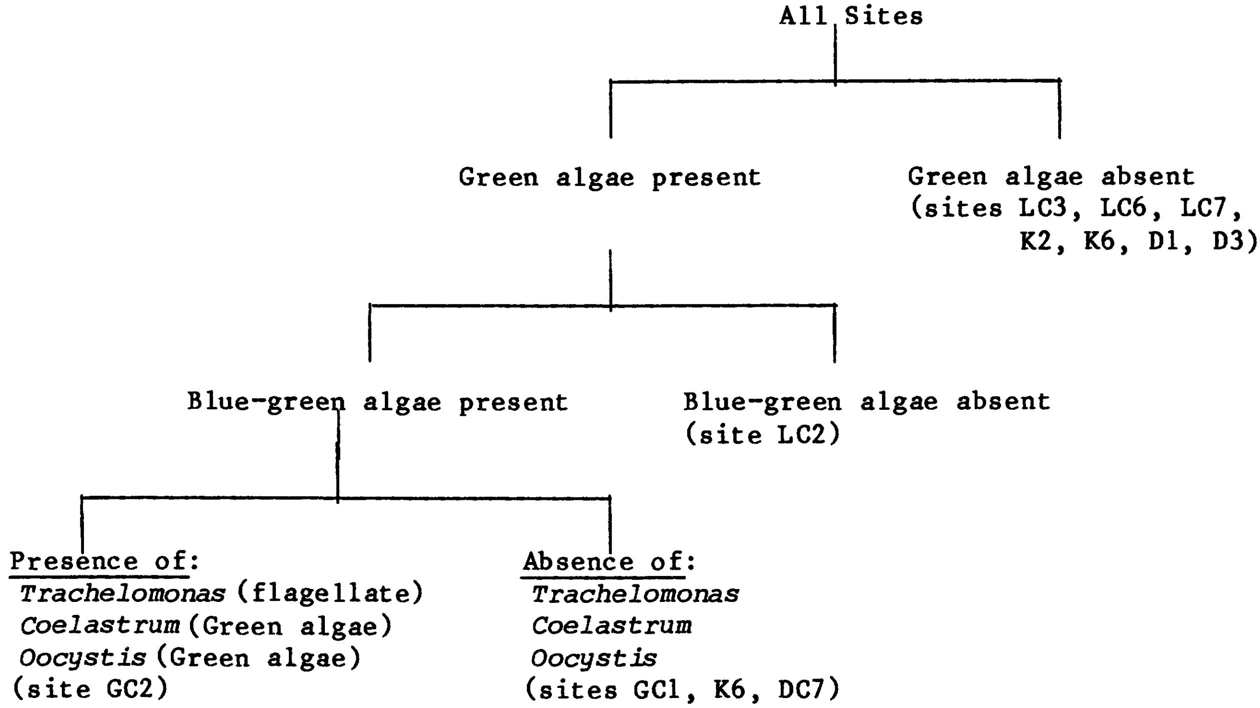


Figure 11.--Grouping of periphyton communities collected from streams at the Indiana Dunes National Lakeshore in November 1978.

Benthic Invertebrates

Many benthic invertebrates have specific requirements for survival and various environmental characteristics can determine the types of organisms in communities. Communities were collected on artificial substrates to minimize substrate variability and, therefore, to maximize the influence of water quality on community composition. Because these communities are fairly immobile, they indicate the time-integrated effects of water quality. A clustering technique (Barr and others, 1979) was used to identify the communities that differed markedly from others.

In general, community diversity and the quality of the aquatic habitat are directly related. A low diversity index indicates stress on the community. Organic material commonly causes the diversity index to decrease and the total number of organisms to increase. Two indexes of diversity were examined: the Shannon index (Wilhm and Doris, 1968) and the Brillouin index (Archibald, 1972). Both indexes showed similar trends in community diversity. Therefore, only the Shannon index, which is more widely used, was reported. In addition, equitability , a community-structure measurement more sensitive to sample size than the diversity indexes (Peet, 1974), was compared to the Shannon index. Equitability trends also duplicated Shannon-index trends and, therefore, were not reported.

RESULTS AND DISCUSSION

Grand Calument River Lagoons

Chemistry

Dissolved-oxygen concentrations were less than 1 mg/L in the east and west lagoons (sites GC1 and GC2) when ice and snow covered them in February 1979 (table 3 at end of report), probably because reaeration was low and photosynthetic production of oxygen was low owing to lack of penetration of light. Some aquatic fauna might not survive these low dissolved-oxygen concentrations. At other times, dissolved-oxygen concentrations exceeded 4 mg/L, although concentrations were probably lower than this during warm nights because of decreased oxygen solubility and respiration by algae.

The range in specific conductance, 235 to 1,378 μmho/cm (table 3 at end of report), indicates that the dissolved-solids concentration was variable and was generally higher in the west lagoon (site GC2) than in the east lagoon (site GC1). Calcium was the dominant cation at both sites (table 4 at end of report). Bicarbonate was the dominant anion in the west lagoon, but chloride and bicarbonate were codominant in the east. Storm-sewer discharge may be a source of chloride in the east lagoon. Constituent concentrations that were higher in the west lagoon than in the east lagoon included alkalinity (1.4 to 1.9 times), fluoride (2.0 to 2.3 times), magnesium (1.7 to 1.9 times), potassium (2.8 to 3.5 times) and silica (1.7 to 11 times). Seepage from the landfills north and south of the lagoon may have caused the higher concentrations, although the interaction between the local ground-water system and lagoon needs to be defined to verify this.

Total-dissolved-phosphorus concentrations (table 4 at end of report) were 0.02 mg/L or less as phosphorus. However, abundant phytoplankton in the water indicate that phosphorus availability was adequate for algal production.

The west lagoon had the highest concentrations of ammonium and organic nitrogen of all surface waters studied. Ammonium concentrations in the lagoon were from 130 to 160 times those common in surface water. Seepage from the landfills north and south of the lagoons may be a source of this ammonium. Calculations based on the concentrations of ammonium and pH indicate that ammonia concentrations greatly exceed 0.02 mg/L as ammonia.

The lead concentration on unsorted streambed materials of the east lagoon (Table 5 at end of report) ranged from 30 to 70 μg/g, probably because of runoff from road and parking areas. The sluggish flow prevents transport of lead-enriched particles to the west lagoon, where the lead concentration on streambed materials was 20 μg/g.

Concentrations of chlordane, DDD, DDE, DDT, and PCB's on streambed materials (table 6 at end of report) exceeded 10 µg/kg in the east lagoon at site GC1A. Concentrations of all these compounds except chlordane also exceeded 10 µg/kg at site GC1. Although runoff from the storm sewer is probably a primary source of these compounds, pesticides applied in the area surrounding the east lagoon may be an additional source.

Biology

Generally, fecal coliform populations in the lagoons (table 7 at end of report) were the lowest in all watersheds studied. The maximum population was 33 col/100 mL.

Autotrophic indexes of periphyton communities in the Grand Calumet River lagoons (table 8) indicate greater organic loading in the east lagoon than in the west, possibly because of storm-sewer discharges into the east lagoon. The high indexes (greater than 100) in both lagoons in July 1980 indicate that the effects of the organic loading in the lagoons (possibly decomposition of organic sediments) are greatest during dry periods.

Table 8.--Autotrophic indexes of of periphyton communities in the Grand Calumet River lagoons

Lagoon	Site	Index	
		August 1979	July 1980
East	GC1	109	584
West	GC2	58	322

The kinds of organisms in benthic invertebrate communities indicated differences between the physical habitats in the lagoons and the other streams in the Lakeshore. Dominant organisms in the lagoons included those preferring still water (Glyptotendipes; Pennak, 1978, p. 689) and abundance of rooted aquatics (Chromagrion, Ischnura, and Hirudinea; Pennak, 1978, p. 554; and Sawyer, 1974, p. 133-135).

Diversity indexes for the lagoons are shown in table 9. During wet periods (November 1978 and August 1979) indexes in the west lagoon were lower than those in the east lagoon. This condition indicates stress on the west lagoon community. The ammonium concentration in the west lagoon (table 4 at end of report) was highest when the index was lowest (November 1978, table 9), which suggests that ammonia may have contributed to this stress. Landfills north and south of the west lagoon may be the source of ammonia and other materials toxic to the invertebrate community. The index in the west lagoon was highest during the dry period (July 1980), when seepage from the landfills was probably lowest. The index in the east lagoon was lowest during this dry period, and number of organisms was highest. This condition suggests that the effects of organic enrichment (possibly from decomposition of organic sediments) are greatest during dry periods.

Table 9.--Diversity indexes and number of organisms in benthic invertebrate communities in the Grand Calumet River lagoons

Lagoon	Site	November 1978		August 1979		July 1980	
		Diversity index	Number of organisms per square meter of substrate	Diversity index	Number of organisms per square meter of substrate	Diversity index	Number of organisms per square meter of substrate
East	GC1	2.26	1,939	2.80	932	1.58	1,721
West	GC2	1.79	1,129	2.33	3,313	2.57	1,503

Little Calumet River Drainage Basin

Chemistry

Water temperature at site LC3 was slightly higher than that at site LC4 on each date (table 3 at end of report). Measurements upstream from site LC3 indicated that an unnamed tributary (site LC3B) that receives treated wastewater and industrial cooling water (Mr. John Sapia, Bethlehem Steel Corp., oral commun., December 5, 1980) caused this temperature increase in the Little Calumet River.

At site LC2, the dissolved-oxygen concentration was less than 3 mg/L on October 4, 1978 (table 3 at end of report). This low concentration was probably caused by high BOD effluents received upstream, possibly from storm and combined sewers and (or) the Portage wastewater-treatment facility.

Specific-conductance measurements indicate that dissolved solids concentrations were generally highest in the highly industrialized and urbanized west fork. The confluence of the unnamed tributary (site LC3B) with the east fork near Burns Harbor generally diluted dissolved-solids concentrations.

Calcium and bicarbonate were dominant ions at all sites, but sites can be grouped by the proportions of sodium and chloride in water. Percentages of sodium and chloride ranged from 5 to 11 in the upper segment of the east fork (sites LC4, LC5, LC6, and LC7), from 15 to 21 in the lower segment of the east fork (sites LC1 and LC3), and from 22 to 29 in the west fork (site LC2). Urban and industrial discharges are the sources of additional sodium and chloride in the stream.

Fluoride concentrations (table 4 at end of report) were slightly higher in the lower segment of the east fork (sites LC1 and LC3) than in the upper segment because of industrial discharge of fluoride upstream from site LC3B (Indiana State Board of Health, unpublished monthly discharge reports). However, all fluoride concentrations in the Little Calumet River were less than 1.4 mg/L, the maximum recommended in public water supplies (National Academy of Sciences and National Academy of Engineering, 1972, p. 66).

Dissolved-orthophosphate and total-dissolved-phosphorus concentrations in the Little Calumet River are shown in figure 12. Total-dissolved-phosphorus concentrations at site LC4, mostly orthophosphate, exceeded 0.10 mg/L as phosphorus in August 1979 and July 1980. Concentrations in the sluggish waters at sites LC1 and LC2 exceeded 0.05 mg/L for the same summer periods. Major sources of phosphorus in the Little Calumet River are the Chesterton and Portage wastewater-treatment facilities (Indiana State Board of Health, unpublished monthly discharge reports). Other sources include combined sewer overflows at Chesterton, Portage, and Gary, and effluent from the Brummit Elementary School (Northwestern Indiana Regional Planning Commission, 1978, p. IV-9). The concentration of total-dissolved phosphorus in effluent from a combined sewer at site LC2B was 0.62 mg/L April 8, 1980. The reduction in phosphorus concentrations, particularly orthophosphate, at site LC3 was probably the result of incorporation by algae.

Nitrogen concentrations in the Little Calumet River are shown in figure 13. Dissolved-inorganic nitrogen concentrations commonly exceeded 0.30 mg/L at sites LC3 and LC4 on the east fork, site LC2 on the west fork, and site LC1 at the mouth. The major sources of nitrogen are probably effluents from the Chesterton and Portage wastewater-treatment facilities; combined sewer overflows at Chesterton, Gary, and Portage; and discharge from the Brummit Elementary School (Northwestern Indiana Regional Planning Commission, 1978, p. IV-9). However, fertilizers applied in agricultural areas could also be a source. The concentration of total-dissolved nitrogen in effluent from the combined sewers at site LC2B was 29 mg/L April 8, 1980. Calculations indicate that some concentrations

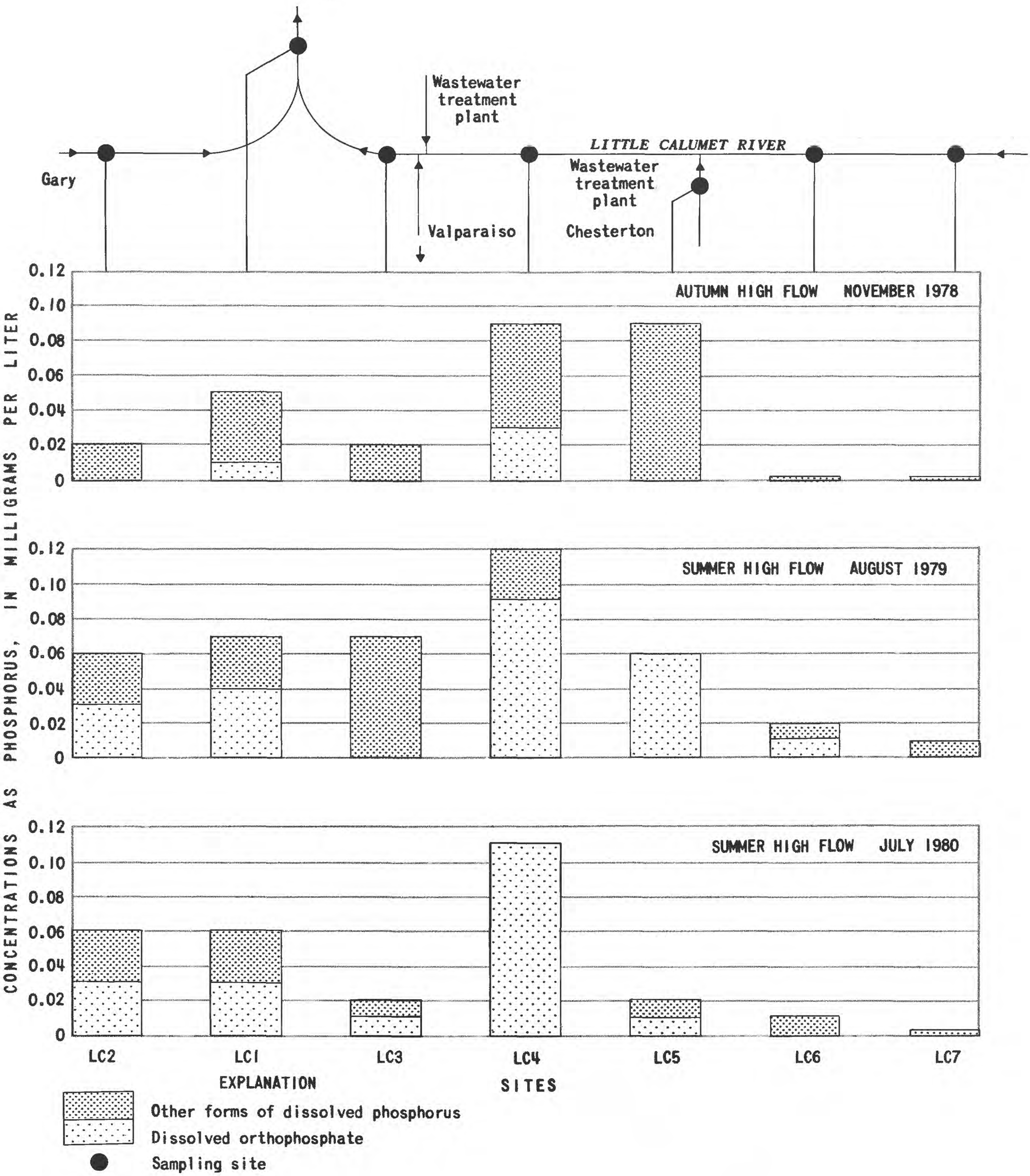


Figure 12.-- Total-dissolved-phosphorus concentrations in the Little Calumet River.

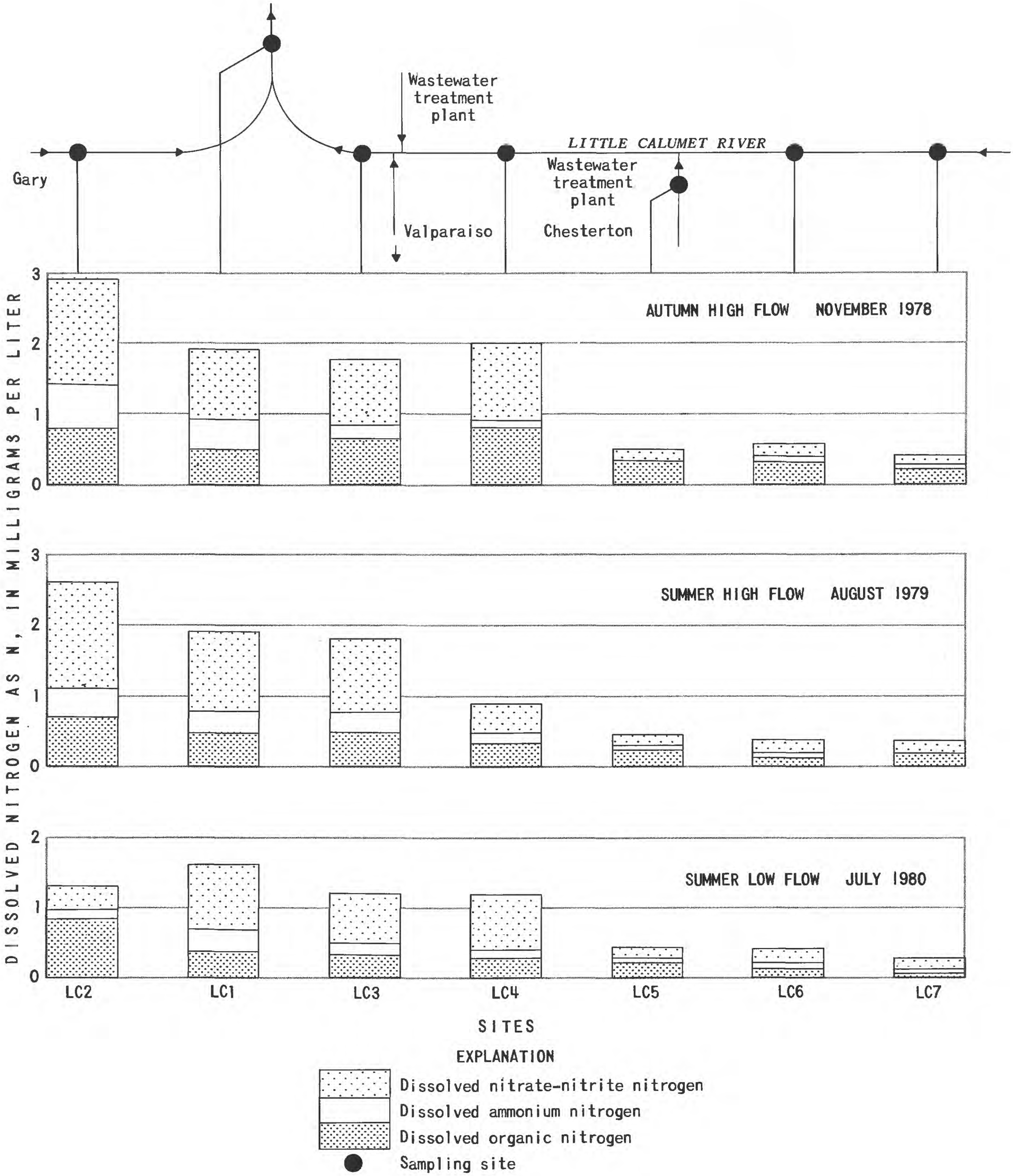


Figure 13.-- Total-dissolved-nitrogen concentrations in the Little Calumet River.

of ammonia at sites LC1, LC2, and LC3 exceeded 0.02 mg/L as ammonia. The Chesterton and Portage wastewater-treatment facilities and the Bethlehem Steel Corp. contributed ammonium to the Little Calumet River (Indiana State Board of Health, unpublished monthly discharge reports).

Copper, lead, and zinc concentrations on silt- and clay-sized streambed material are shown in figure 14. Sites LC9B and LC9C in the upper reaches of the east fork and sites LC2 and LC2AA on the west fork had the four highest concentrations of zinc. Sites LC2, LC2AA, and LC2B on the west fork and site LC3B on the east fork had the four highest concentrations of lead. Concentrations of copper were usually less than the maximum background concentration. Analysis of sand-sized particles indicated that runoff from road and railroad crossings were probable sources of lead and zinc in the upper reaches of the east fork (sites LC6, LC9A, LC9B, and LC9C). Downstream from Chesterton, discharges from storm and combined sewers are probably the major sources of copper, lead, and zinc in Coffee Creek and the Little Calumet River. Data from the west fork indicate many sources of lead and zinc. Possible sources of the metals include runoff from the many highway and railroad crossings and discharges from storm and combined sewers and wastewater-treatment faciltities. Total lead and zinc concentrations in effluent from the combined sewer at site LC2B were 590 and 510 μg/L, respectively, in samples collected April 8, 1980.

Concentrations of chlordane, DDT, DDD, DDE, dieldrin, and PCB's on streambed materials of the Little Calumet River exceeded 10 μg/kg and upstream concentrations at sites listed in table 10. The source of chlordane was probably sewer discharges from urban and residential areas. The source of dieldrin was probably runoff from agricultural fields that had been treated with the pesticide. DDT and PCB concentrations were significant in agricultural and urban areas. Significant concentrations of DDD and DDE sometimes accompanied those of DDT, probably the result of DDT breakdown. Runoff from road and railroad crossings are likely to be significant causes of PCB's in agricultural areas. In urban areas, storm sewers are probably the most significant sources of PCB's. Endrin was detected only at site LC2C, downstream from a combined sewer in Gary.

A sample was collected from a combined storm- and sanitary sewer at site LC2B on April 8, 1980, to define chlorinated hydrocarbons that could be attributed to it. However, high fuel oil concentrations in the discharge interfered with the analysis.

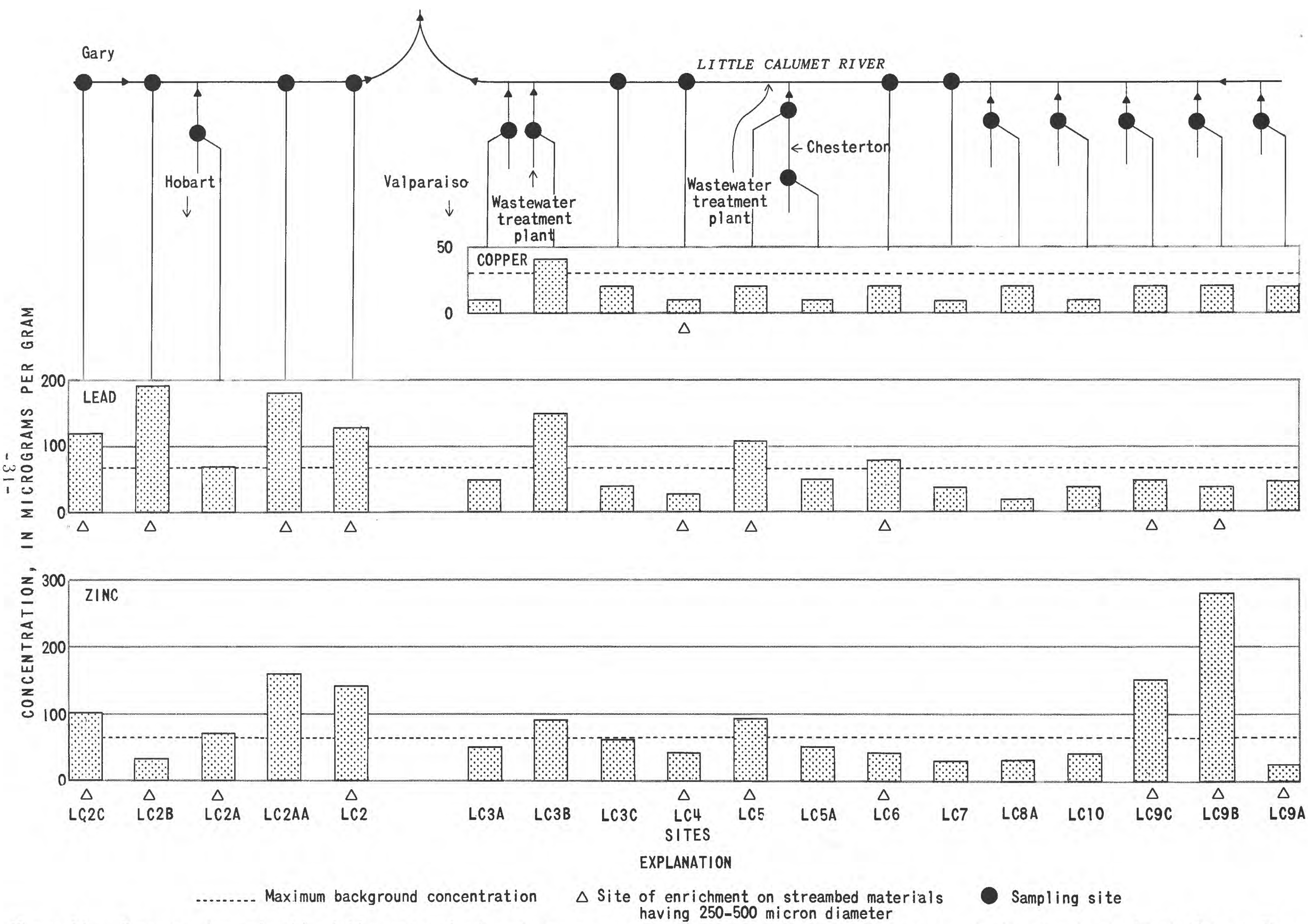


Figure 14.-- Concentrations of acid-soluble copper, lead, and zinc on streambed materials less than 63 micrometer in diameter in the Little Calumet River.

Table 10.--Sites where chlorinated hydrocarbons exceeded 10 micrograms per kilogram and exceeded upstream concentrations on streambed materials in the Little Calumet River

[Numbers indicate a single concentration or a range in micrograms per kilogram]

Compounds	Sampling sites and primary land use represented									
	LC1 Mixed	LC2 Mixed	LC2B Mixed	LC2C Urban	LC3 Mixed	LC3A Mixed	LC4 Mixed	LC5 Urban	LC7 Agri-cultural	LC9 Agri-cultural
Chlordane	--	--	110	47	---	--	14-24	29-32	--	--
DDD	--	--	100	34	---	--	--	--	--	--
DDE	--	--	68	46	---	--	--	--	--	--
DDT	--	--	180	46	---	--	--	--	--	14
Dieldrin	--	--	14	--	---	--	--	--	--	33
PCB's	43-88	4-18	79	71	44-100	13	40-48	22-58	4-31	--

Biology

Ranges of fecal coliform populations and FC:FS in the Little Calumet River are shown in figure 15. Sites LC2, LC3, and LC6 had populations equal to or greater than 2,000 col/100 mL. At sites LC2 and LC3, FC:FS's greater than 3 suggest that sewage was a source of the bacteria. Sewage from combined sanitary- and storm-sewers at Chesterton and Gary may have been primary sources of bacteria. In addition, the Portage wastewater-treatment plant has frequently discharged effluent having high fecal coliform populations (Indiana State Board of Health, unpublished monthly discharge reports). Bacterial monitoring by the Park Service during the summer of 1981 indicated that the Chesterton wastewater-treatment plant is also a source of fecal coliform, fecal coliform populations were generally larger in the west fork than in the east fork, and the bacteria discharged to the Little Calumet River sometimes caused high numbers of bacteria in Lake Michigan at the Lakeshore bathing beaches (Douglas Wilcox, National Park Service, written commun., April 20, 1982).

Because the FC:FS for all samples at site LC6 was less than 1, fecal coliform at this site are probably caused by local wildlife populations rather than sewer discharges.

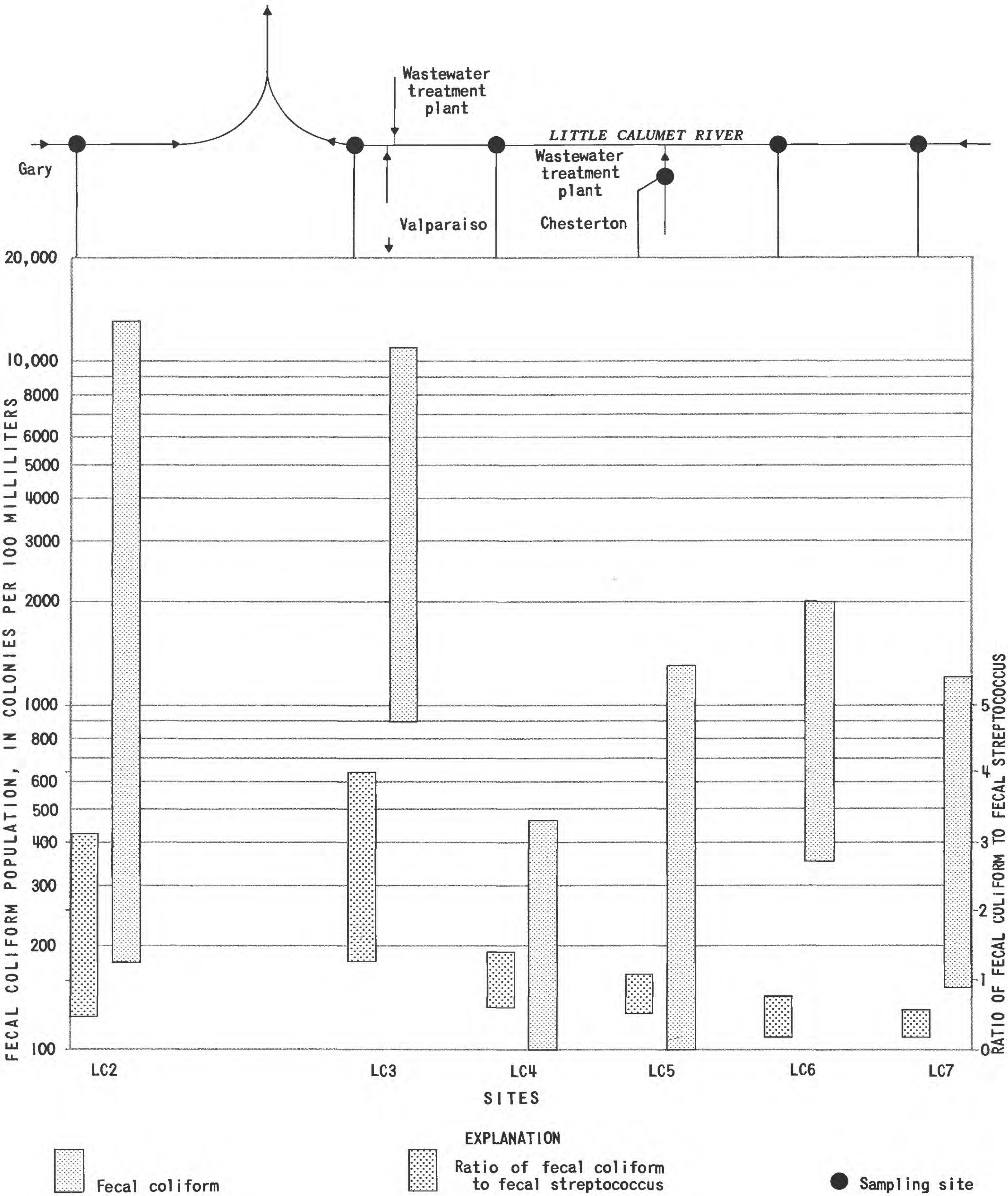


Figure 15.-- Ranges of fecal coliform populations and ratios of fecal coliform to fecal streptococcus in the Little Calumet River, November 1978 through August 1979.

Autotrophic indexes and chlorophyll a concentrations of periphyton communities in the Little Calumet River are shown in figure 16. The high indexes (greater than 400) at high flow in the upper reaches of the east fork (sites LC7 and LC6) are probably caused by organic materials flushed from wetlands. However, the high indexes at site LC3 during high and low flows are probably caused, in part, by storm-sewers, combined storm- and sanitary-sewers, and wastewater-treatment-plant discharges from Chesterton and local industries. Wastewater-treatment plants at Chesterton and Bethlehem Steel Corp. frequently report discharges having BOD in excess of 10 mg/L (Indiana State Board of Health, unpublished monthly discharge reports before 1980) that may not be diluted adequately at low flow.

Although indexes at site LC1 show community recovery from the organic load, high chlorophyll a concentrations indicate that algae ingest nutrients made available by the discharges.

Types of organisms in benthic invertebrate communities of the Little Calumet River were generally similar, except for the aggregations of Asellus during low flow at site LC6. This condition was probably not a result of water-quality change because large aggregations of Asellus are controlled by the streamflow characteristics. They prefer flowing water but require velocities slow enough for them to maintain footing (Pennak, 1978, p. 443).

Numbers of organisms and diversity indexes for benthic invertebrate communities in the Little Calumet River are shown in figure 17. The low diversity during low flow at site LC6 was caused by the high number of Asellus and, therefore, is probably not indicative of organic loading. The diversity index at site LC6 was also low during high flow in November 1978. Low numbers of organisms and silt clogging of the substrates indicate that the low diversity was the result of high suspended-sediment concentrations, possibly from cropland erosion. Higher diversity and numbers at site LC3 indicate recovery from this condition.

Kintzele Ditch Drainage Basin

Chemistry

Dissolved-oxygen concentrations were less than 4 mg/L (table 3 at end of report) during low flow in July 1980 at sites K3, K4, and K7 (fig. 4). Decomposition of organic streambed materials at these sites probably caused the low dissolved-oxygen concentrations.

Dissolved-solids concentrations were lowest at site K4, where calcium and bicarbonate were dominant ions (table 4 at end of report). Specific conductance of water at site K4 (table 3 at end of report) was less than two-thirds of that at other Kintzele ditch sites, except when dilution due to snowmelt reduced dissolved-solids concentrations at site K3 (February and March 1979). The

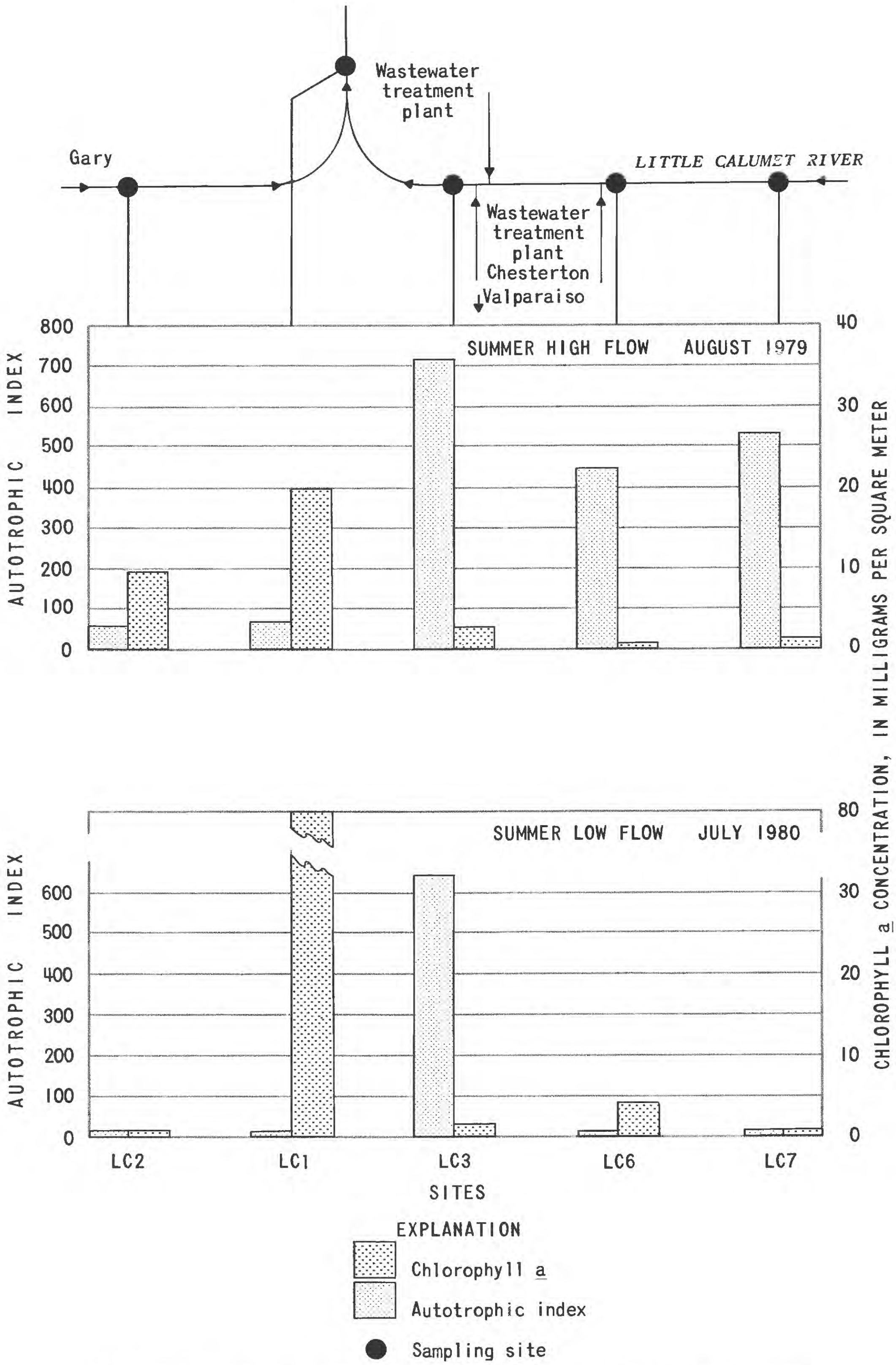


Figure 16.-- Autotrophic indexes and chlorophyll a concentrations of periphyton communities in the Little Calumet River.

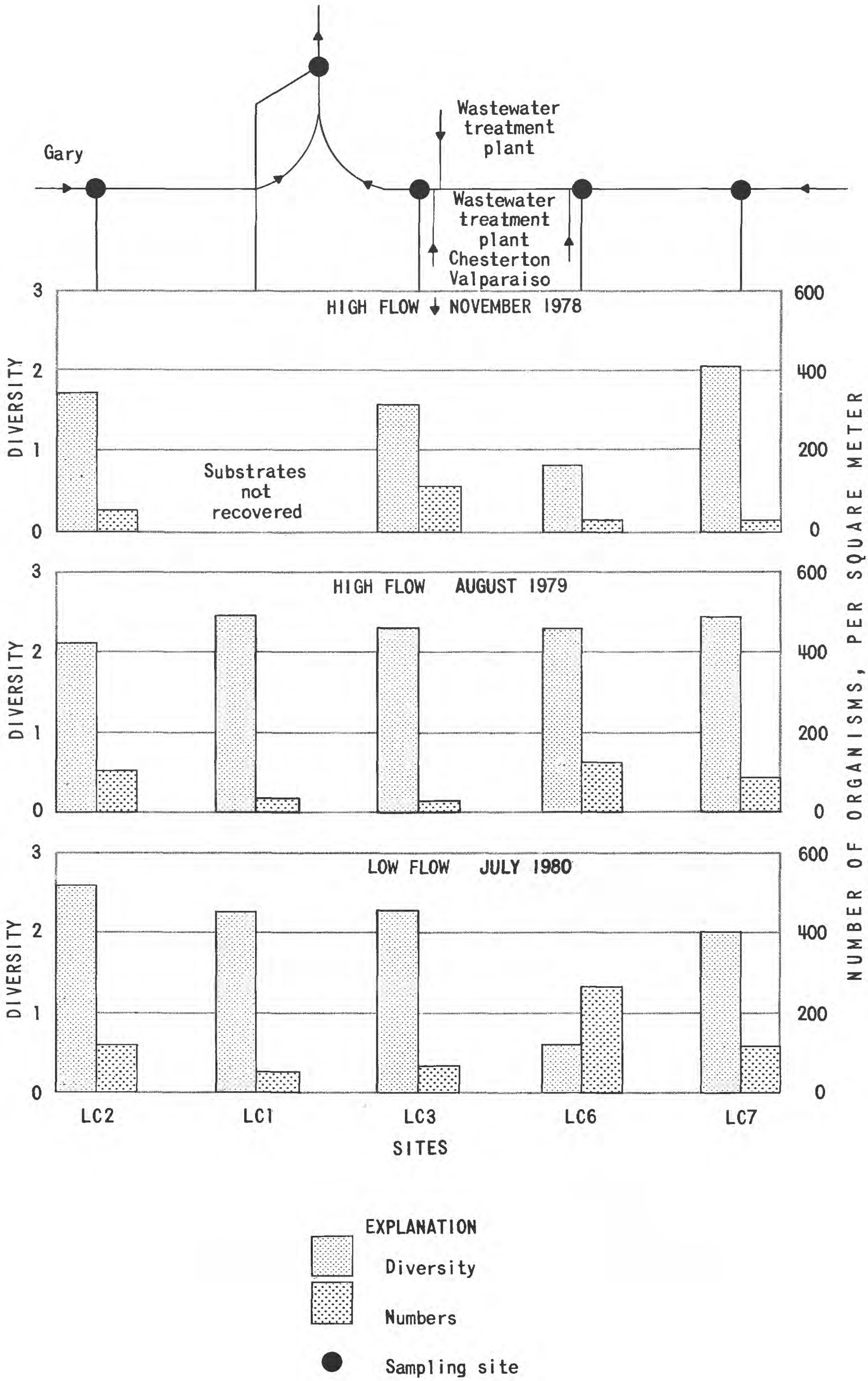


Figure 17.-- Diversity indexes and number of organisms in benthic invertebrate communities in the Little Calumet River.

higher dissolved-solids concentrations at the other sites included higher concentrations of sodium and chloride as a result of municipal, industrial (including a road-salt storage area near Striebel arm), and domestic discharge or seepage of septic systems to the stream. As a result, sodium and chloride ions were sometimes codominant with calcium and bicarbonate in Striebel arm at sites K6 and K7.

Compared with low flow in July 1980, percentages of sulfate in the yellow-brown water at sites K3 and K4 were higher in August 1979 and highest in November 1978. Flushing of adjacent wetlands probably caused these shifts in water type.

Natural wetland drainage was probably also the source of the high iron concentrations (450 to 710 µg/L) at sites K3 and K4. Iron concentrations at other sites, excluding site K3D, which receives landfill runoff, ranged from 40 to 430 µg/L. The correlation of the high-iron concentrations with organic carbon concentrations (fig. 18) suggests that the iron may have been complexed with organic materials in wetland drainage, as Lathwell and others (1969) demonstrated.

Although the concentration of boron (table 4 at end of report) in runoff from the landfill bordering Brown ditch (site K3D) was more than 13 times that upstream at site K3E, concentrations downstream did not increase significantly.

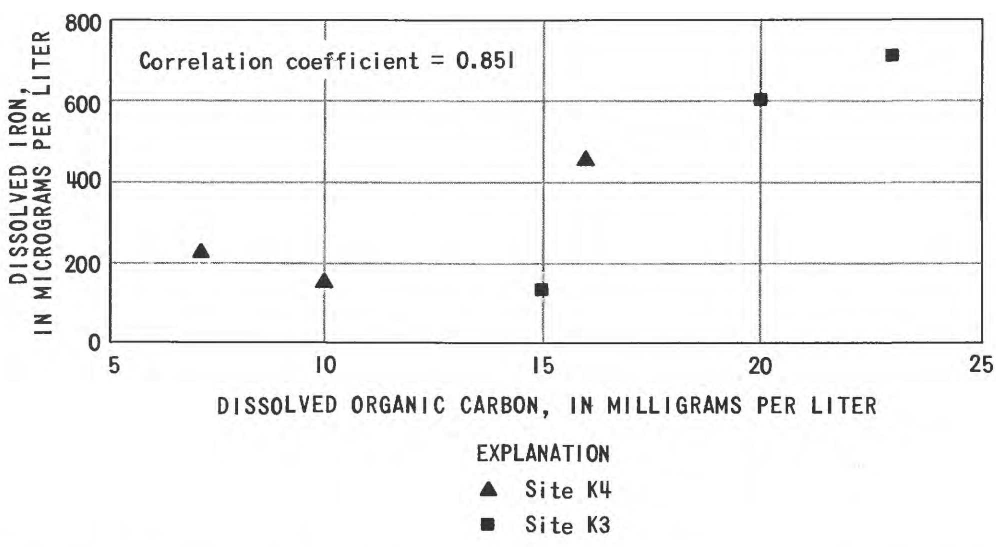


Figure 18.-- Relation of dissolved-iron and dissolved-organic-carbon concentrations in yellow-brown water in Kintzele ditch, November 1978 through July 1980.

Sites K7 and K6 on Striebel arm of Kintzele ditch had the highest concentrations of phosphorus and inorganic nitrogen (figs. 19 and 20, respectively). The phosphorus concentration at site K7, greater than 0.10 mg/L as phosphorus during high flow in August 1979, suggests that runoff from upstream may be a significant source of phosphorus.

The inorganic nitrogen concentrations, particularly those of ammonium, were highest at sites K6 and K7 during the November 1978 high flow. Animal wastes are probably the source of this nitrogen. (See "Biology.")

Lead and zinc concentrations on silt- and clay-sized streambed materials were greatest at sites K6B, K6C, and K7B on Striebel arm and at sites K3, K3A, and K3B on Brown ditch (fig. 21). Site K3A had the highest zinc concentration of all streams studied (650 μg/g).

Metal concentrations on sand-sized particles indicated that sources of lead and zinc in Striebel arm were upstream from site K6C, possibly runoff from the adjacent machinery and scrap-metal-storage yard, and between sites K7A and K7B, probably discharge from the storm sewer. One source of zinc upstream from site K6B may have been the galvanized culvert, a few feet upstream.

Although the sources of lead and zinc in Brown ditch were not identified, possible sources were runoff from roads and small businesses, including a recycling business, between sites K3B and K3A. Runoff from the landfill bordering Brown ditch contained several trace elements (table 11), but only iron was enriched on streambed materials downstream from the landfill.

Table 11.--Total concentrations of trace elements in runoff from a landfill near Brown ditch, November 30, 1978

[Data collected by U.S. Geological Survey]

Element	Concentration (μg/L)	Element	Concentration (μg/L)
Arsenic	56	Lead	17
Cadmium	1	Molybdenum	30
Copper	4	Nickel	13
Iron	5,700	Zinc	110

Chlorinated hydrocarbons having concentrations exceeding 10 μg/L on streambed materials of Kintzele ditch included chlordane, DDT, DDD, DDE, and PCB's (table 6 at end of report). Data suggest that chlordane and PCB's enter Striebel arm upstream from site K6C and between sites K6A and K6. Runoff from the industrial areas adjacent to this stream segment is a possible source. High

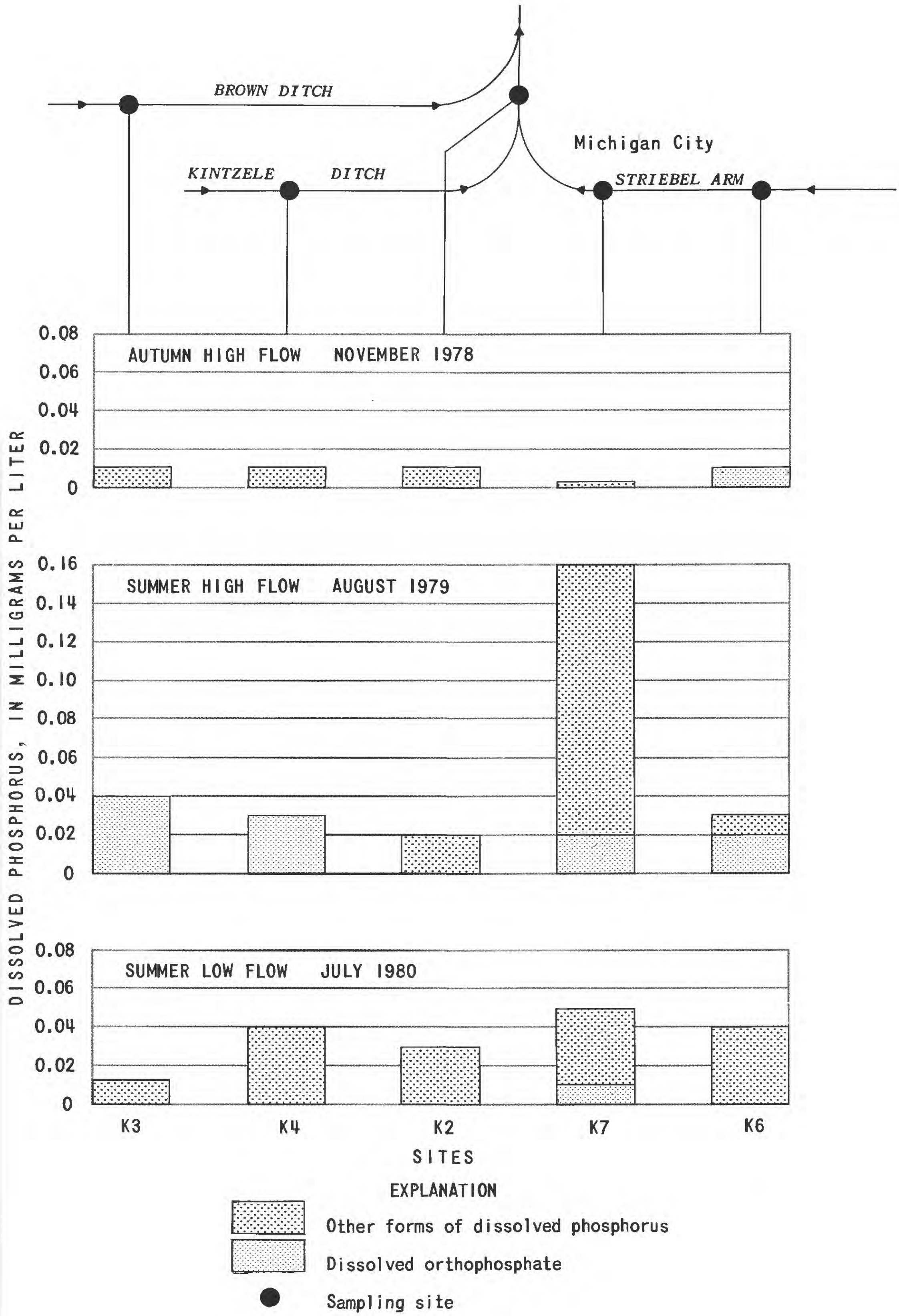


Figure 19.-- Total-dissolved-phosphorus concentrations in Kintzele ditch, Striebel Arm, and Brown ditch.

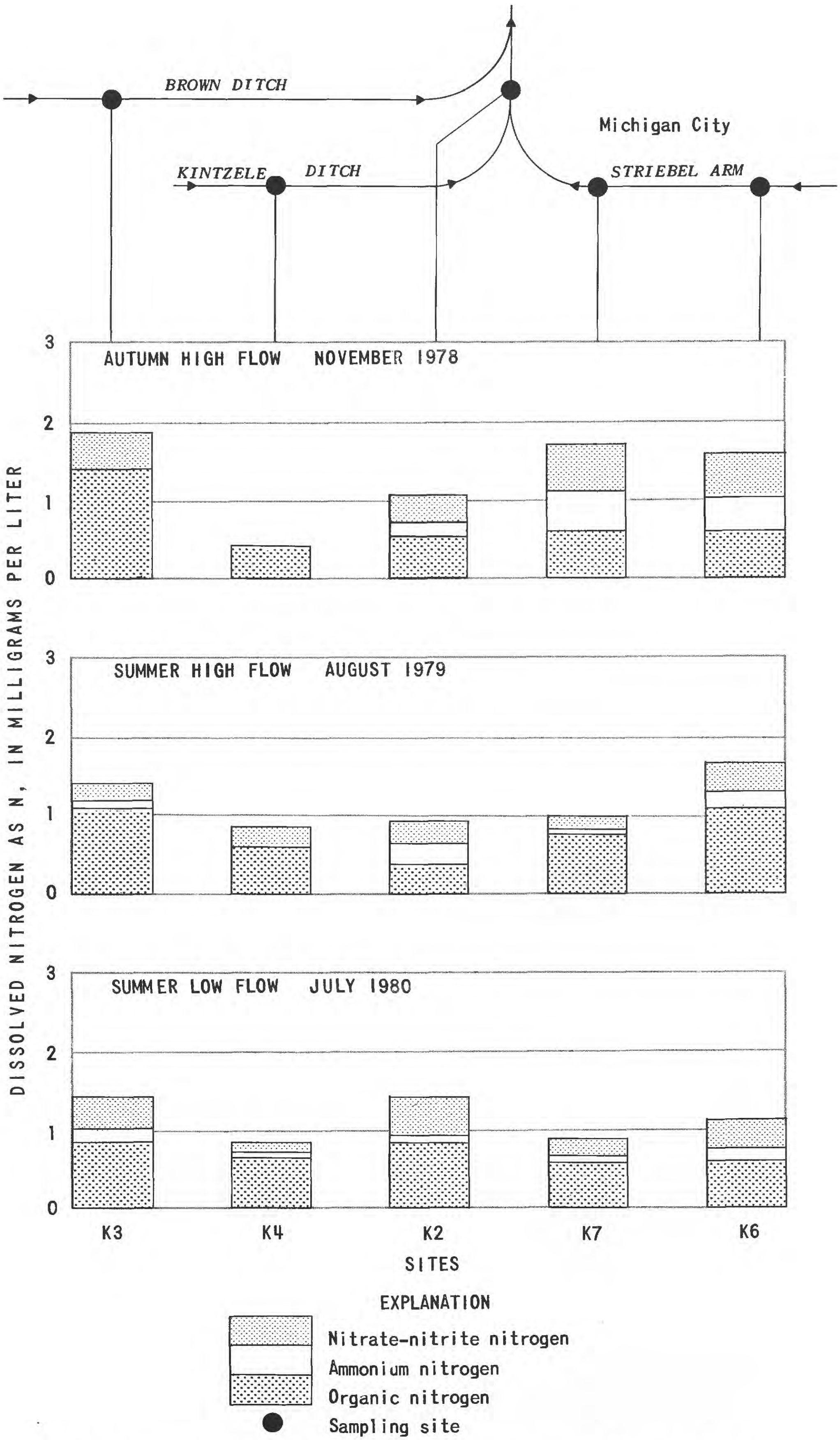


Figure 20.-- Total-dissolved-nitrogen concentrations in Kintzele ditch, Striebel Arm, and Brown ditch.

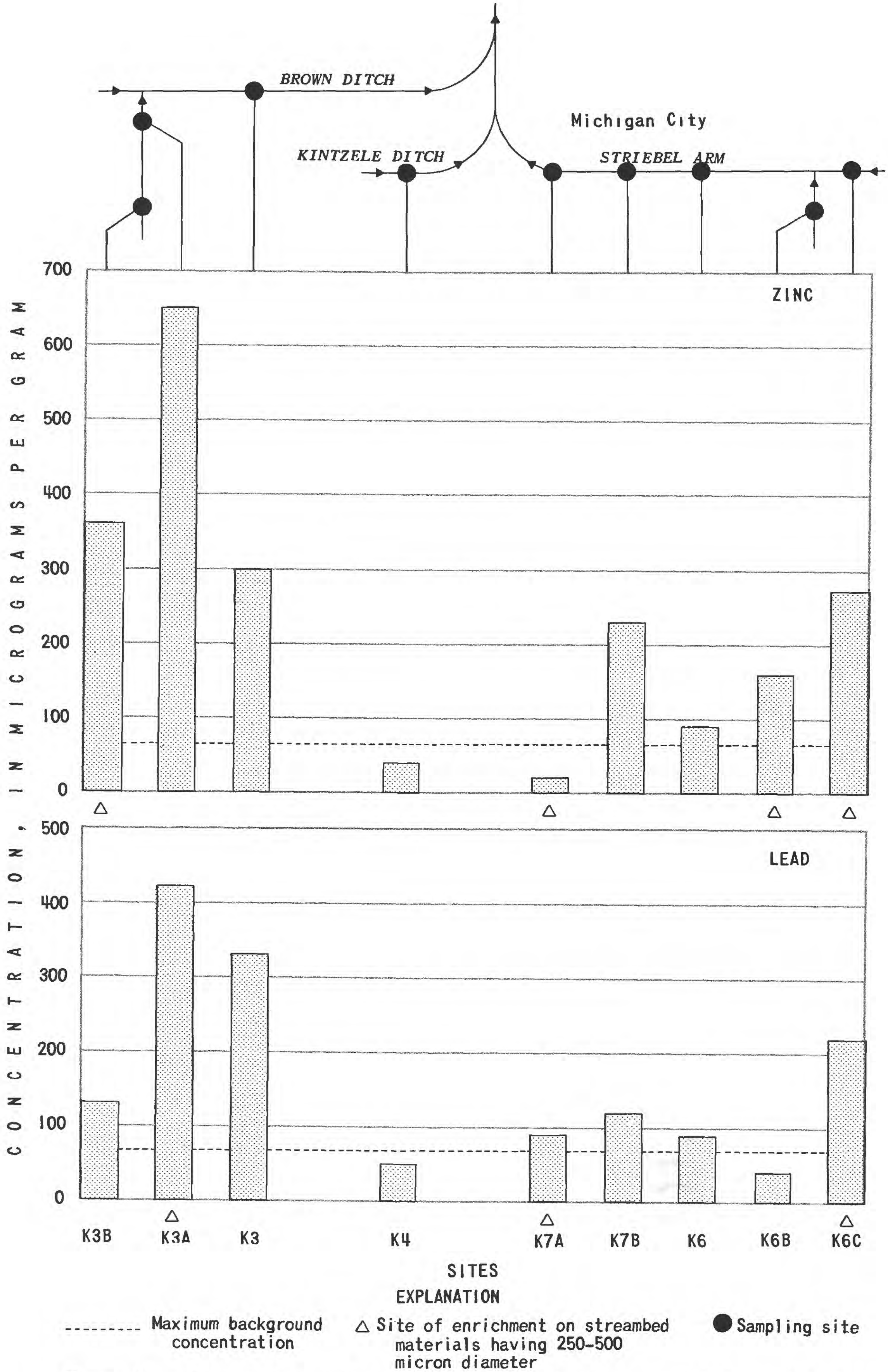


Figure 21 -- Concentrations of acid-soluble lead and zinc on streambed materials less than 63 micrometer in diameter in Kintzele ditch, Striebel Arm, and Brown ditch.

DDT concentrations (82 and 150 μg/kg) and higher DDD and DDE concentrations (each 260 μg/kg) farther downstream at site K7 suggest use of the insecticide in years past. Significant concentrations of DDT, DDD, and DDE at site K3B suggests use of these compounds near Brown ditch.

Biology

Ranges of fecal coliform populations and FC:FS in Kintzele ditch are shown in figure 22. Fecal coliform populations exceeded 2,000 col/100 mL at sites K6 and K2 in November 1978 and August 1979, respectively (table 7 at end of report). Because the corresponding FC:FS at site K6 was less than 1, the high population was probably caused by animal waste washed into the ditch at high flow. The agricultural area in the upper reaches of Striebel arm may be the source of the animal waste.

At site K2, the intermediate FC:FS of 1.8 corresponding to the high fecal coliform population did not definitely indicate a source of the bacteria. Several residential septic systems are near Kintzele ditch between sites K2 and K4.

Bacterial monitoring by the Park Service during the summers of 1980 and 1981 indicate that bacteria in Kintzele ditch caused high numbers of bacteria in Lake Michigan at the Lakeshore bathing beaches (Douglas Wilcox, National Park Service, written commun., April 20, 1982).

Autotrophic indexes and chlorophyll a concentrations of periphyton communities in Kintzele ditch are shown in figure 23. The autotrophic indexes suggest organic loading during high flow at site K3 in August 1979, probably because of wetland flushing, and at all sites during low flow. Chlorophyll a concentrations suggest greater availability of nutrients at low flow than at high flow, especially on Striebel arm, although scour of the communities at high flow may cause low chlorophyll a concentrations.

Benthic invertebrate communities indicate possible effects of animal wastes washed into Striebel arm upstream from site K6 during high flow. Although the diversity index at this site during high flow in November 1978 was similar to that at other sites, the community was dominated by (1) the Oligochaeta class (segmented worms), which tolerate anaerobic conditions and feed on bacteria (Brinkhurst and Cook, 1974, p. 146); (2) the Hirudinea class (leeches), which feed on the Oligochaeta (Sawyer, 1974, p. 133-135); and (3) the Zygoptera subfamily (damsel flies), which is generally insensitive to water-quality variations (Roback, 1974, p. 323). Bacterial data also suggest that animal wastes entered Striebel arm during this high flow.

During the high flow in August 1979, the diversity index at site K6 was extremely low, and the total number of organisms, all Oligochaeta, was high (fig. 24). This condition indicates that a large concentration of organic materials had recently entered the stream.

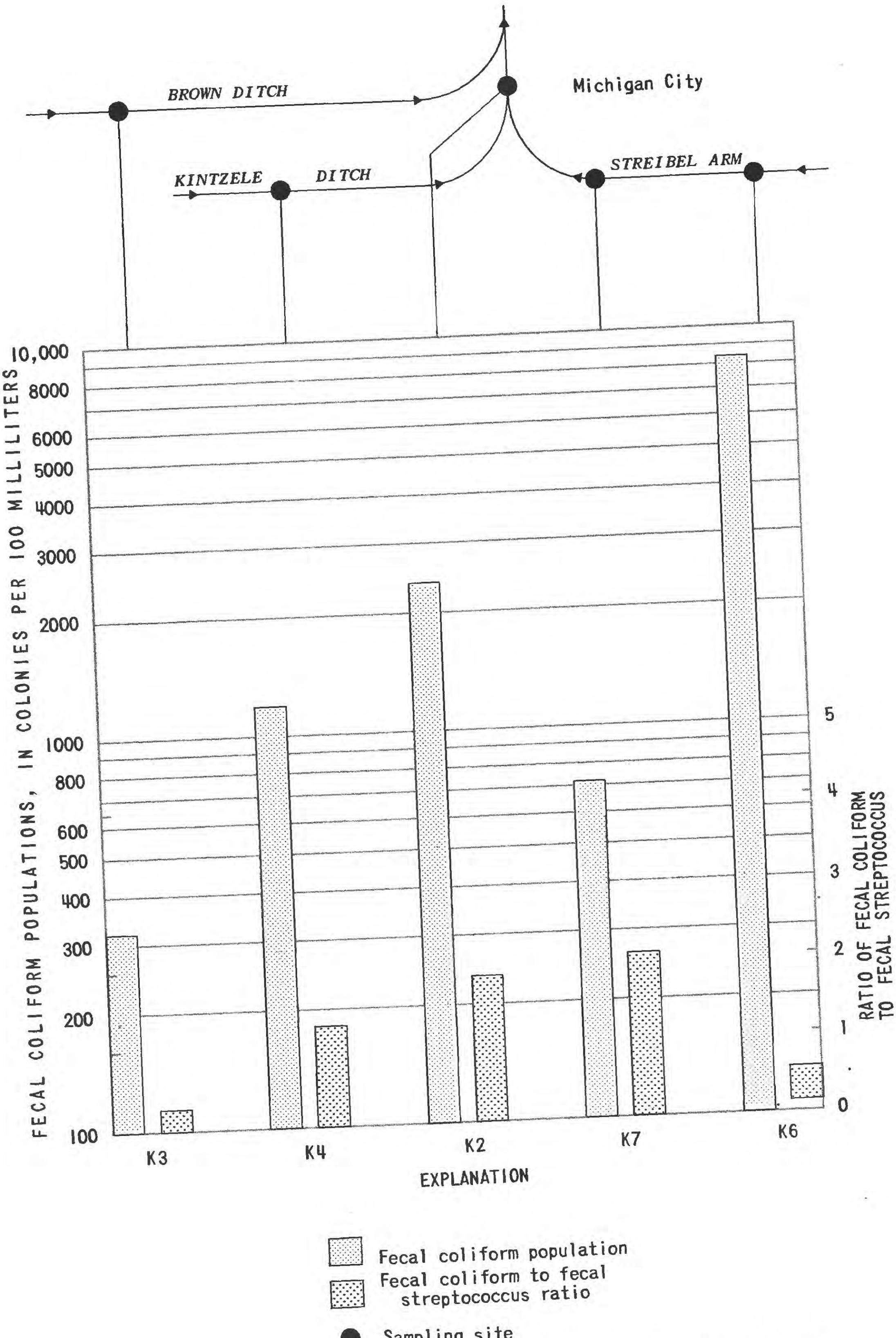


Figure 22.-- Ranges of fecal coliform populations and ratios of fecal coliform to fecal streptococcus in Kintzele ditch, Streibel Arm, and Brown ditch, November 1978 through August 1979.

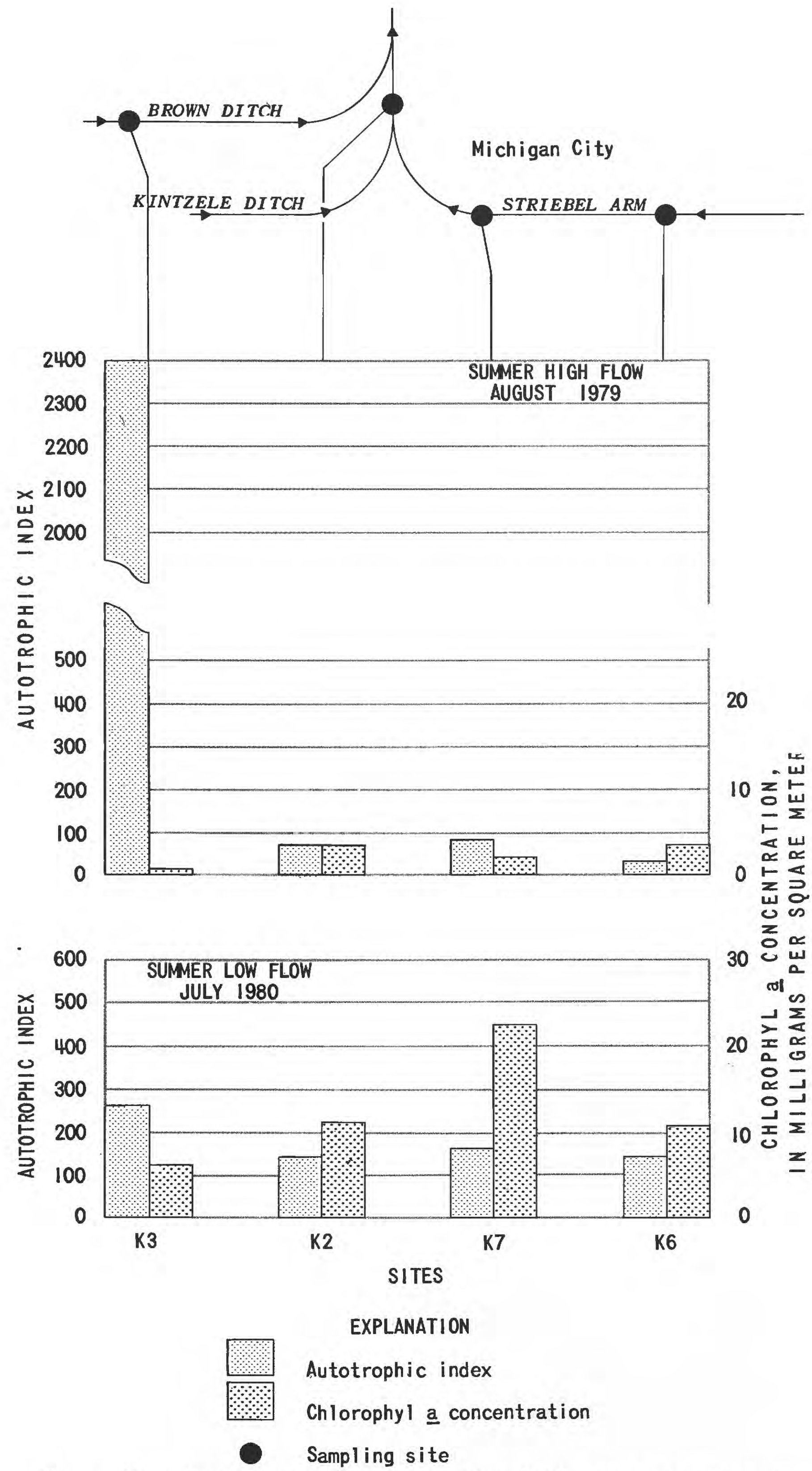


Figure 23.-- Autotrophic indexes and chlorophyll a concentrations of periphyton communities in Kintzele ditch, Striebel Arm, and Brown ditch.

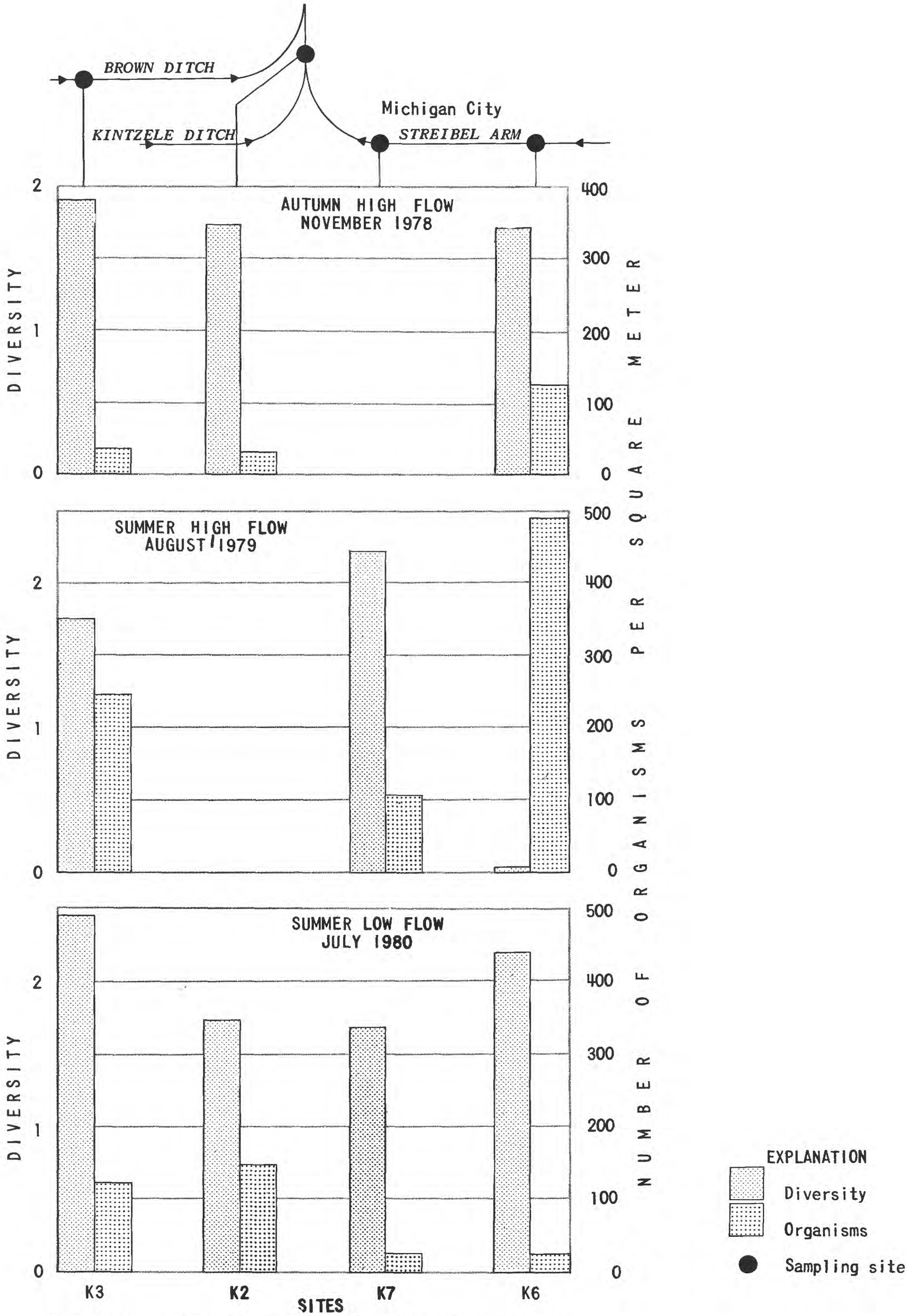


Figure 24.-- Diversity indexes and number of organisms in benthic invertebrate communities in Kintzele ditch, Striebel Arm, and Brown ditch.

Derby Ditch Drainage Basin

Chemistry

Water at all sites sampled was yellow brown. Specific conductance, ranging from 140 to 600 μmho/cm (table 3 at end of report), indicated that Derby ditch was the least mineralized stream studied. The range of specific conductance in the stream was generally lower than that in the other streams. Calcium and bicarbonate ions dominated, although sulfate concentrations increased at high flows because of wetland flushing. The sulfate concentrations were highest when wetlands were flushed in October 1978.

Dissolved-iron concentration ranged from 360 to 1,500 μg/L (table 4 at end of report). All iron concentrations at site D4 exceeded 1,000 μg/L, the maximum concentration recommended for protection of aquatic life (U.S. Environmental Protection Agency, 1976, p. 152-156). The correlation between dissolved-iron and organic-carbon concentrations (fig. 25) suggests that the iron may be complexed with organic materials in wetland drainage, as demonstrated by Lathwell and others (1969).

Phosphorus concentrations were less than 0.1 mg/L as phosphorus. Consequently, excessive algal production is unlikely in Derby ditch.

Generally, most of the total dissolved-nitrogen concentration was organic, probably from wetland drainage. The concentration range of nitrite-plus-nitrate nitrogen at sites D1 and D4, from 0.33 to 1.3 mg/L, was higher than the range at site D3, from 0.07 to 0.18 mg/L. Because land use near sites D1 and D4 is primarily residential, applications of fertilizer, and (or) seepage from septic systems are probable sources of additional nitrate. Concentrations of ammonium nitrogen at some sites in summer exceeded 0.10 mg/L, probably because of decomposition of organic materials in the surrounding wetlands.

All trace-element concentrations on unsorted streambed materials at site D1 were 20 μg/L or less. Because of these low concentrations, no additional samples were collected in Derby ditch.

Because data collected during 1974-76 indicated that chlorinated hydrocarbon concentrations on unsorted streambed materials of Derby ditch were 10 μg/kg or less, additional data were not collected.

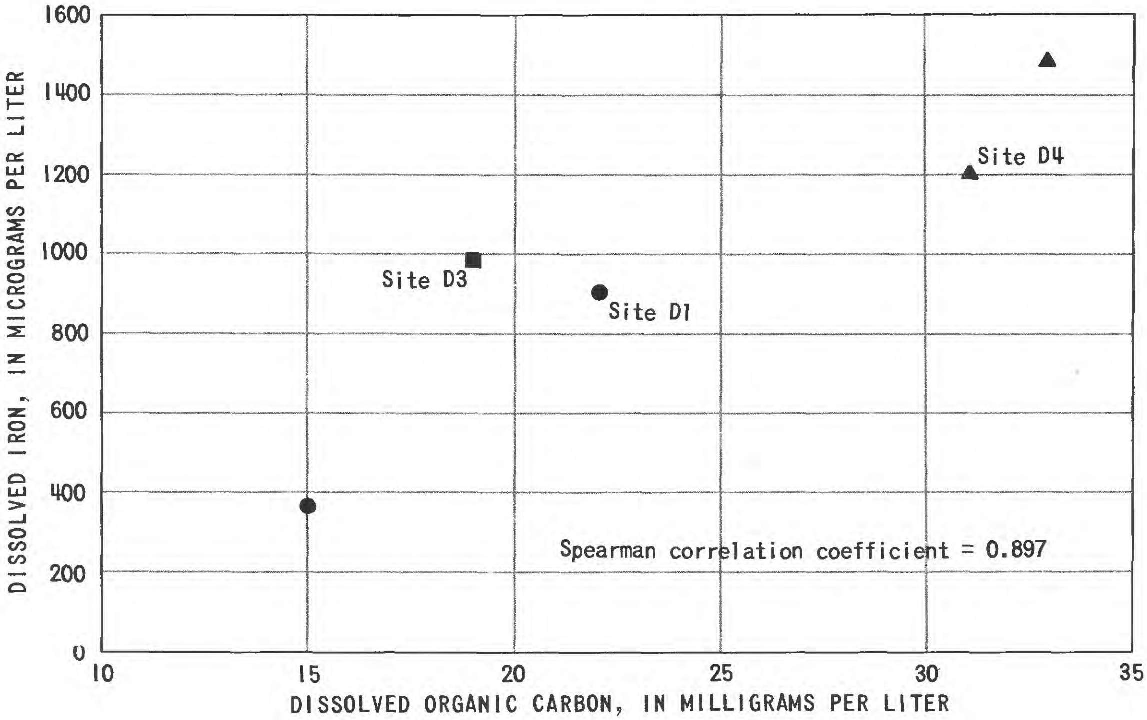


Figure 25. -- Relation of dissolved-iron and dissolved-organic-concentrations in Derby ditch, November 1978 through July 1980.

Biology

Fecal coliform populations in Derby ditch were less than 2,000 col/100 mL, except for the 2,300 col/100 mL during high flow in August 1979 at site D2 (table 7 at end of report). Because the corresponding FC:FS was less than 1, this high population was probably caused by local wildlife populations.

During the summers of 1979 and 1980, periphyton data were collected only at site D1 because site D3 was dry when substrates were installed. Autotrophic indexes for communities at site D1 were 48 and 340 for high flow in August 1979 and low flow in July 1980, respectively. The lower index was probably due to dilution of organic materials from adjacent wetlands. In contrast, indexes in Kintzele ditch and Dunes Creek were high during high flow because of the flushing of organic materials from wetlands. These conditions suggest that the interaction between wetlands and Derby ditch is different from wetland interactions with Kintzele ditch and Dunes Creek.

Diversity indexes and numbers of organisms in benthic invertebrate communities of Derby ditch are shown in table 12. The low index and low number of organisms at site D1 during the highest flow period (November 1978) was probably the result of the turbulent flow and scour by sand in the ditch at high flow. More than half of the community at site D3 consisted of amphipods, isopods, Chironomidae, *Hydroporus*, and Basommatophora. All these organisms burrow into the moist soil beneath the streambed to survive the absence of surface water (Hynes, 1970, p. 404-406). Some clams, which represented nearly all the remainder of the community, also burrow to survive dry periods.

Table 12.-- Diversity indexes and number of organisms in benthic invertebrate communities in Derby ditch

Site	November 1978		August 1979		July 1980	
	Diversity index	Number of organisms per square meter of substrate	Diversity index	Number of organisms per square meter of substrate	Diversity index	Number of organisms per square meter of substrate
D1	0.92	61	2.57	1,388	2.15	456
D3	2.01	592	DRY		DRY	

Dunes Creek Drainage Basin

Chemistry

Specific conductance ranging from 251 to 1,350 µmho/cm (table 3 at end of report) indicated highly variable dissolved-solids concentrations. Calcium and bicarbonate were normally dominant ions (table 4 at end of report). The two highest dissolved-solids concentrations were 853 mg/L (at site DC4) and 431 mg/L (at site DC7) during high flow in November 1978, primarily because of high concentrations of sodium (240 and 66 mg/L, respectively) and chloride (380 and 130 mg/L, respectively). Seepage from residential septic systems and runoff from a road-salt storage area near the intersection of U.S. Highway 20 and State Highway 49 were probably the sources of sodium and chloride. Specific-conductance measurements on April 8, 1980, another high discharge period, indicate that the two north tributaries of Markowitz ditch contribute high dissolved-solids concentrations to the ditch (fig. 26).

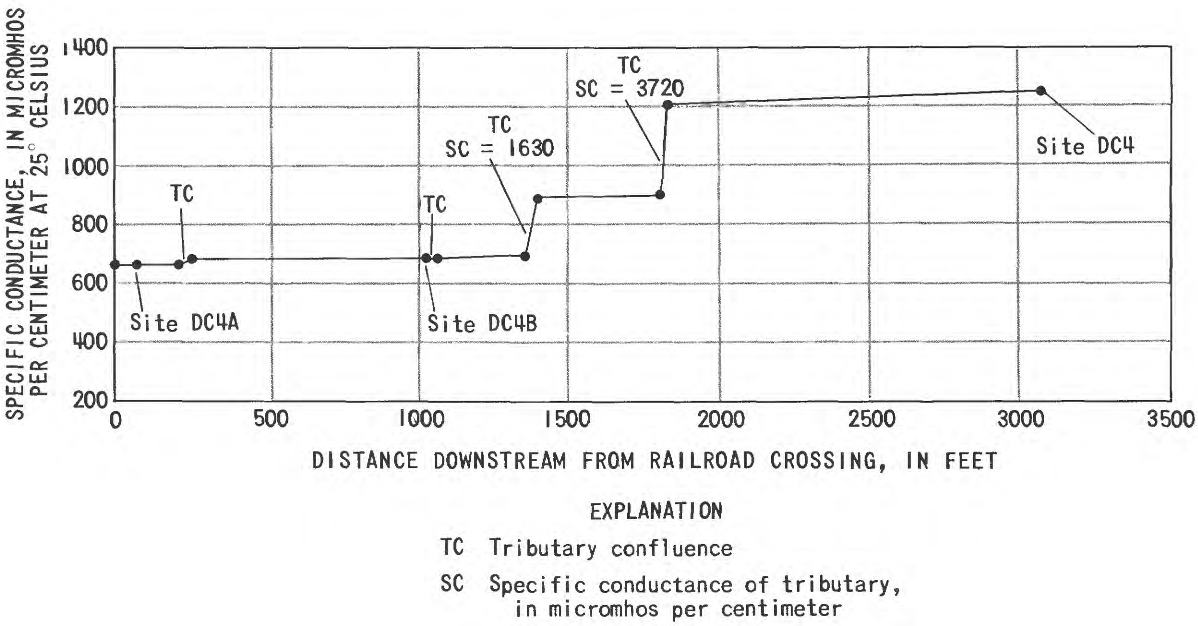


Figure 26.-- Specific conductance in Markowitz ditch and tributaries, April 8, 1980.

Water at sites DC2, DC3, and DC6 was yellow brown because of wetland drainage to the stream. However, concentrations of sulfate at Dunes Creek sites were lower (less than 40 mg/L) than those in the yellow-brown water at Kintzele ditch and Derby ditch sites (table 4 at end of report). Iron concentrations in Dunes Creek did not correlate with dissolved-organic-carbon concentrations.

Phosphorus concentrations were less than 0.1 mg/L as phosphorus. Generally, most of the total nitrogen concentration was organic and probably originated in the adjacent wetlands. However, high concentrations of nitrite plus nitrate (ranging from 0.33 to 1.3 mg/L, as nitrogen) at sites DC4 and DC7 suggest that the seepage from nonpoint sources such as septic systems and fertilized lawns in the upstream residential areas significantly increase nitrate in Dunes creek.

Trace-element concentrations in Dunes Creek exceeded background concentrations (table 2) only in Markowitz ditch. Lead and zinc concentrations on silt- and clay-sized and sand-sized streambed materials exceeded background at sites DC4, DC4A, and DC4B (fig. 27). Runoff from the road that parallels the ditch is probably the major source of these metals.

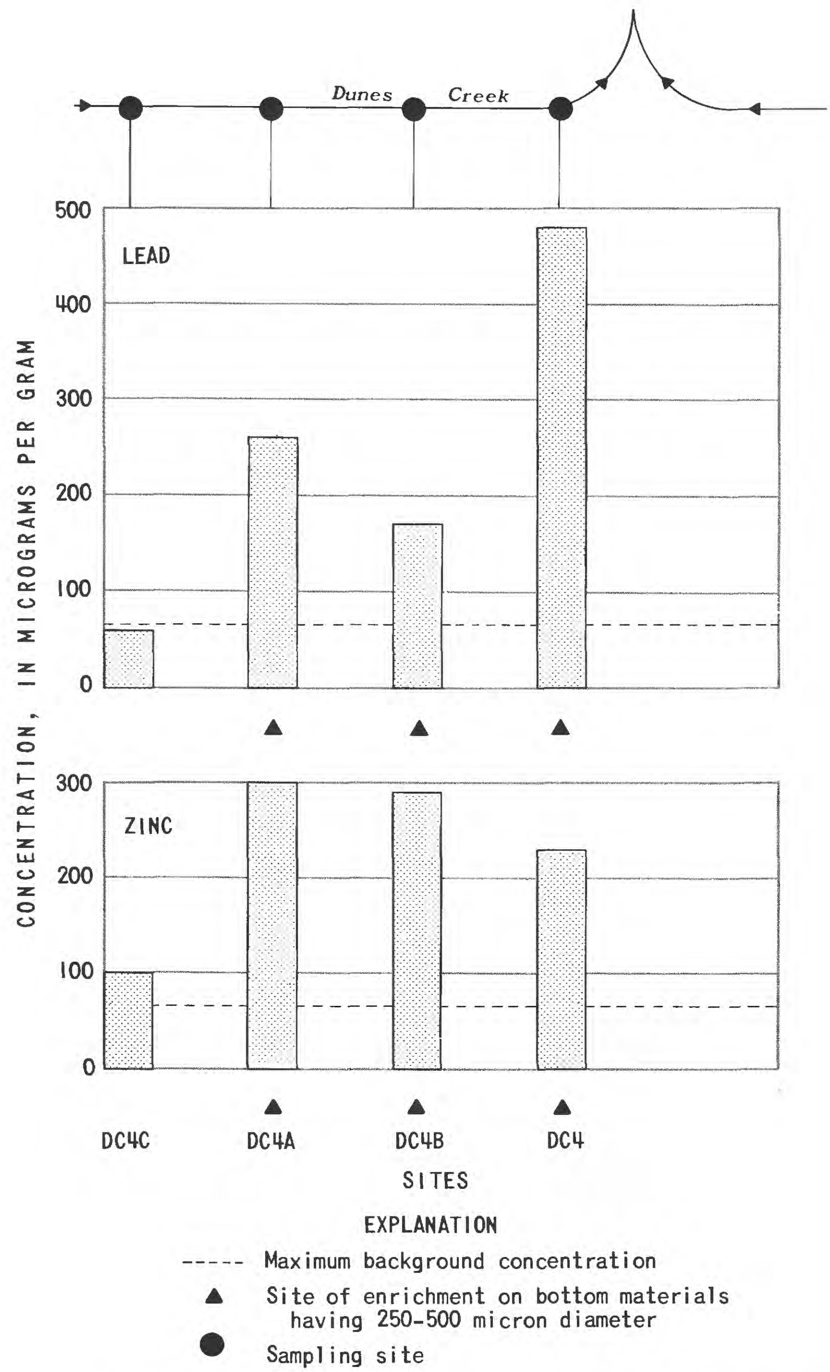


Figure 27.-- Concentrations of acid-soluble lead and zinc on streambed materials less than 63 micrometer in diameter in Markowitz ditch, April 1980.

Chlordane and PCB concentrations on streambed materials at site DC4 exceeded 10 μg/kg (table 6 at end of report). Because upstream samples did not indicate a point source of these compounds, runoff from the road and residential area that parallel the ditch is probably the source.

Biology

Fecal coliform populations did not exceed 800 col/100 mL in Dunes Creek (table 7 at end of report), although a tributary ditch south of the Indiana Dunes State Park boundary sometimes receives discharge from septic systems (Douglas Wilcox, National Park Service, written commun., April 20, 1982).

Autotrophic indexes and chlorophyll *a* concentrations for periphyton communities of Dunes Creek are shown in table 13. Flushing of organic material from wetlands probably caused the high indexes during high flow in August 1979, although local septic systems may also contribute organic material. Organic material from upstream septic systems may have caused the high index at site DC7 during low flow in July 1980. The high chlorophyll *a* concentrations of the periphyton communities indicate that abundant quantities of nutrients accompanied the organic material.

Table 13.--Autotrophic indexes and chlorophyll *a* concentrations of periphyton communities in Dunes Creek

Site	August 1979		July 1980	
	Autotrophic index	Chlorophyll *a* concentration (mg/m^2)	Autotrophic index	Chlorophyll *a* concentration (mg/m^2)
DC2	3,438	0.16	68	9.27
DC7	1,391	.23	248	15.4

Diversity indexes and number of organisms for benthic invertebrate communities of Dunes Creek are shown in table 14. The index at site DC7 was low in November 1978 and July 1980. The low number of organisms in November 1978 suggests that the low index may have been caused by turbulent flow and scour during high flow. However, the high number of organisms during low flow in July 1980 suggests an increase in organic materials, possibly by seepage from upstream septic systems.

Table 14.--Diversity indexes and number of organisms in benthic invertebrate communities in Dunes Creek

Site	November 1978		August 1979		July 1980	
	Diversity index	Number of organisms per square meter of substrate	Diversity index	Number of organisms per square meter of substrate	Diversity index	Number of organisms per square meter of substrate
DC2	Substrates vandalized		1.71	2,129	1.31	1,027
DC7	1.80	279	2.66	2,000	1.71	2,551

Indexes at site DC2 were lower than those at site DC7 in August 1979 and July 1980. The smaller number of organisms at site DC2 than at site DC7 in July 1980 suggests that the natural-wetland drainage entering the stream between the sites is toxic to some of the organisms. Populations of Asellus dominated the low-flow communities at both sites in July 1980. These populations were probably a result of different streamflow characteristics rather than different water-quality characteristics. Asellus prefer flowing water and tend to aggregate where velocities are slow enough for them to maintain footing (Pennak, 1978, p. 443).

SUMMARY AND CONCLUSIONS

Water quality of streams at Indiana Dunes National Lakeshore is affected by a variety of land uses, particularly urban and industrial. The streams and lagoons were sampled during high and low flows from 1978 to 1980 to assess variations in water-quality. Land uses within drainage basins were identified to help determine causes or potential causes of water-quality variations.

Grand Calument River Lagoons

Discharge from a storm sewer into the east lagoon was the primary source of phosphorus, nitorgen, lead, zinc, chlordane, DDT, DDD, DDE, and PCB's. Seepage from industrial landfills probably caused the high concentrations of dissolved solids in the west lagoon, where ammonia concentrations exceeded the maximum recommended for aquatic organisms. Organisms in the east and the west lagoons are probably subjected to a very low dissolved-oxygen concentration when the lagoons are covered with ice and snow.

Little Calumet River Drainage Basin

Urban, residential, and industrial discharges contributed sodium and chloride to the west fork and lower reaches of the east fork. Discharges from storm and combined storm- and sanitary-sewers at Chesterton, Portage, and Gary, and wastewater-treatment plants at Chesterton and Portage, were sources of organic materials, nitrate, ammonia, phosphorus, lead, zinc, chlordane, DDT, endrin, PCB's, and fecal coliform in the river. Some ammonia concentrations were greater than the maximum recommended for protection of aquatic life, and some fecal coliform populations may commonly exceed the maximum allowed for partial body contact. In addition, road runoff is also a significant source of lead, zinc, and PCB's and is probably the only significant source of these materials in the upper reaches of the east fork.

Generally, industrial discharges to the east fork had low dissolved-solids concentrations and diluted those in the lower reaches of the east fork. However, ammonia in these discharges may be a significant part of the high concentrations in the lower reaches of the east fork.

DDT and dieldrin enter the river in agricultural areas along the west and east forks. Benthic invertebrate communities in the east fork suggested that runoff from cropland at high flow caused sediment concentrations in the stream to increase significantly.

Kintzele Ditch Drainage Ditch

Urban, residential, and industrial areas on Striebel arm were sources of sodium and chloride, organic materials, phosphorus, nitrogen, lead, zinc, chlordane, DDT, and PCB's. Lead, zinc, DDT, and PCB concentrations on streambed materials of a small tributary of Brown ditch exceed background, possibly because of runoff from roads and residential areas and effluent from small businesses. A landfill near Indiana State Route 520 is a source of iron in Brown ditch.

Flushing of the agricultural area in the upper reaches of Striebel arm by high flow may cause high concentrations of nitrate, ammonia, and organic materials, as well as high populations of fecal coliform.

Natural flushing of wetlands during high flow in the upper reaches of Kintzele ditch and in Brown Ditch results in high concentrations of sulfate, iron, and organic materials. Correlation of dissolved-iron and dissolved-organic-carbon concentrations suggests that iron may be complexed with organic materials in wetland drainage.

Derby Ditch Drainage Ditch

Seepage from septic systems and fertilized lawns may have caused the increases in nitrate concentrations in the residential areas of Derby ditch. Wetland drainage caused increases in concentrations of sulfate, iron, ammonium, and organic materials. Correlation of dissolved-iron and dissolved-organic-carbon concentrations suggests that iron may be complexed with organic materials in wetland drainage. Sand scouring during high flow significantly reduced the numbers of benthic invertebrates near the mouth.

Dunes Creek Drainage Ditch

Seepage from septic systems and runoff from a road-salt-storage area probably caused the increases in sodium, chloride, and nitrate concentrations near residential areas. Periphyton and benthic invertebrate communities suggest that these septic systems may also increase concentration of organic material at low flow. Runoff from the road and the residential area adjacent to Markowitz ditch increased the concentrations of lead, zinc, chlordane, and PCB's on streambed materials.

Wetland drainage was a source of organic materials and iron. Unlike the other streams receiving wetland drainage, the sulfate concentration in Dunes Creek did not increase and iron concentrations did not correlate with organic-carbon concentrations.

Sand scour at high flow reduced the number of benthic invertebrates near the mouth.

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TABLES 3-7, 15-18

Table 3.--Field measurements in streams at the Indiana Dunes National Lakeshore, October 1978-July 1980

Site	Date of samp-ling	Time (h)	Water temp (°C)	pH	Specific conductance (μmho/cm at 25° C)	Dissolved oxygen (mg/L)	Dissolved oxygen (percent saturation)	Discharge (ft^3/s)
				Headwater lagoons of Grand Calumet River				
GC1	10-3-78	1450	17.5	7.9	660	7.4	78	---
	11-16-78	1510	7.2	8.1	655	9.8	82	---
(east	2-27-79	1630	3.2	7.5	860	.9	7	---
lagoon)	3-20-79	1155	4.8	7.1	235	11.2	89	---
	7-10-79	1205	25.2	8.2	755	8.8	107	---
	8-23-79	1140	24.1	8.2	308	9.4	113	---
	5-28-80	1205	22.8	8.7	782	12.2	144	---
	7-9-80	1420	25.3	8.3	668	11.5	140	---
GC2	10-3-78	1554	17.6	8.4	885	10.8	114	---
	11-16-78	1230	7.5	7.7	900	----	---	---
(west	2-27-79	1535	3.6	7.5	945	.6	5	---
lagoon)	3-20-79	1230	5.2	6.9	368	9.0	71	---
	7-10-79	1120	24.8	7.9	715	15.5	189	---
	8-23-79	1030	24.1	7.9	780	9.3	112	---
	5-28-80	1110	21.0	7.9	1,378	7.5	85	---
	7-9-80	1220	25.4	7.4	982	4.2	51	---
				Little Calumet River				
LC1	10-4-78	1145	19.4	7.9	525	7.1	78	---
	11-17-78	1715	11.5	8.0	645	8.2	76	---
	7-10-79	1345	23.3	8.0	584	7.2	85	---
	8-24-79	1355	23.1	7.7	570	8.2	96	---
	5-28-80	1535	22.7	7.9	760	10.0	118	---
	7-11-80	1420	26.6	7.8	615	9.2	114	---
LC2	10-4-78	1100	16.1	7.7	346	2.3	23	---
	11-18-78	0935	6.5	7.9	790	9.7	81	---
	2-27-79	1345	0.0	7.6	955	10.3	72	---
	3-20-79	1135	7.0	6.9	519	11.3	95	---
	7-10-79	1305	22.7	8.0	760	10.2	119	---
	8-24-79	1430	23.6	7.6	597	4.7	56	---
	5-28-80	1400	21.8	7.7	998	12.1	139	---
	7-11-80	1257	26.0	8.3	722	12.5	154	---
LC2B	4-8-80	1300	11.2	7.3	778	4.9	45	---
LC2C	4-7-80	1729	15.2	7.5	790	10.9	109	---
LC3	10-4-78	1240	21.3	8.2	460	8.6	98	---
	11-17-78	1635	14.2	8.1	555	8.8	86	---
	2-27-79	1310	5.1	8.0	626	10.4	83	---
	3-20-79	1100	9.4	7.1	550	11.1	98	---
	7-10-79	1415	25.5	8.1	599	7.3	90	---
	8-24-79	1320	23.9	8.2	549	6.9	83	---
	5-28-80	1635	23.9	7.7	665	8.4	100	---
	7-11-80	1230	26.0	8.3	520	11.2	138	---
LC3A	4-8-80	1126	11.1	7.6	678	8.2	73	---
	7-11-80	1510	23.4	8.1	933	8.0	94	---
	12-13-79	1130	15.4	8.0	465	8.3	84	---

Table 3.--Field measurements in streams at the Indiana Dunes National Lakeshore, October 1978-July 1980--Continued

Site	Date of samp-ling	Time (h)	Water temp (°C)	pH	Specific conductance (µmho/cm at 25° C)	Dissolved oxygen (mg/L)	Dissolved oxygen (percent saturation)	Discharge (ft^3/s)
				Little Calumet River--Continued				
LC3C	12-13-79	1140	3.4	8.5	720	11.6	89	-----
	7-11-80	1442	23.6	8.4	763	10.0	118	-----
LC4	11-17-78	1500	7.5	8.0	620	9.7	83	435
	2-27-79	1240	.3	7.7	686	10.7	75	768
	3-20-79	1040	8.1	7.1	490	10.8	93	947
	8-21-79	1230	19.7	8.1	635	7.6	84	430
	5-28-80	1705	19.8	8.1	784	9.6	104	34.0
	7-11-80	1153	21.8	8.1	746	8.7	100	25.9
LC5	11-17-78	1400	8.0	8.2	615	12.8	110	-----
	2-27-79	1035	0.0	7.7	806	11.0	76	-----
	3-20-79	1013	7.1	6.8	480	11.7	98	-----
	8-24-79	1035	18.8	7.8	580	8.1	88	-----
	7-11-80	1051	21.6	8.2	695	9.1	103	-----
LC6	10-4-78	1330	13.2	8.2	605	9.4	90	-----
	11-17-78	1445	7.2	8.2	630	10.2	86	-----
	2-27-79	1125	.0	7.7	590	10.4	72	-----
	3-20-79	1022	8.1	6.6	480	9.9	85	-----
	7-10-79	1500	20.5	8.0	688	7.9	89	-----
	8-24-79	1100	19.2	7.7	605	8.0	87	-----
	5-28-80	1730	18.7	8.4	718	14.1	152	-----
	7-11-80	1108	21.1	8.3	705	9.9	122	-----
LC7	10-3-78	1700	12.6	8.2	604	10.8	103	-----
	11-17-78	1305	8.5	8.2	650	10.1	88	-----
	2-27-79	1010	.0	7.7	655	11.6	81	-----
	3-20-79	0945	8.4	6.7	460	11.3	97	-----
	7-10-79	1845	19.4	8.2	685	8.3	91	-----
	8-24-79	1000	16.4	7.8	630	8.4	87	-----
	5-28-80	1830	18.7	8.5	770	11.4	123	-----
	7-11-80	1008	17.7	8.2	672	11.2	119	-----
				Kintzele ditch				
K2	10-2-78	1755	14.7	7.8	590	9.0	89	-----
	11-15-78	1200	6.5	8.3	620	10.2	85	3.3
	2-26-79	1820	.5	7.7	532	10.4	73	-----
	3-21-79	0925	4.6	7.4	496	12.3	97	-----
	7-11-79	1135	19.9	7.7	631	8.3	92	-----
	8-26-79	1545	18.6	7.7	607	9.2	99	1.7
	5-28-80	1105	18.3	7.5	545	5.5	59	-----
	7-11-80	2010	24.3	7.9	673	11.5	137	1.8
K3	10-3-78	0957	13.8	7.3	532	6.6	63	-----
	11-15-78	1535	6.0	7.4	595	8.3	68	2.7
	11-30-78	1630	3.9	7.2	609	9.5	73	-----
	2-26-79	1805	.0	7.0	387	7.4	51	-----
	3-21-79	0935	3.6	7.3	287	9.7	75	-----
	7-11-79	1225	22.1	7.4	635	5.8	67	-----

Table 3.--Field measurements in streams at the Indiana Dunes National Lakeshore, October 1978-July 1980--Continued

Site	Date of samp-ling	Time (h)	Water temp (°C)	pH	Specific conductance (µmho/cm at 25° C)	Dissolved oxygen (mg/L)	Dissolved oxygen (percent saturation)	Discharge (ft^3/s)
				Kintzele ditch--Continued				
K3	8-26-79	1610	18.2	7.0	454	4.2	45	0.4
	5-28-80	1153	20.0	7.4	437	6.8	75	----
	7-11-80	1848	24.7	7.1	688	3.8	46	0.1
K3B	4-9-80	1450	6.8	6.6	455	6.3	53	----
K3C	4-9-80	1550	6.6	7.0	313	8.5	71	----
K3D	11-30-78	1515	2.3	7.2	1,260	5.4	40	----
K3E	11-30-78	1530	3.4	7.3	547	11.1	85	----
	4-9-80	1555	6.5	7.1	326	8.4	70	----
K4	11-15-78	1400	5.5	8.0	365	11.4	90	0.12
	2-26-79	1840	0.6	6.7	337	6.4	45	----
	3-21-79	0906	2.9	6.7	219	9.9	73	----
	8-26-79	1630	18.4	7.7	298	4.7	51	0.10
	7-11-80	1919	22.3	7.2	289	3.6	41	0.06
K6	10-2-78	1525	18.6	7.2	763	10.5	113	----
	11-14-78	1455	10.3	7.5	640	9.2	82	1.2
	2-26-79	1850	0.0	7.3	683	8.0	56	----
	3-21-79	0855	4.2	6.6	695	10.1	80	----
	7-11-79	1000	21.8	7.2	778	5.3	61	----
	8-26-79	1450	13.5	7.4	904	9.2	89	0.3
	5-28-80	1030	20.1	7.5	570	6.5	71	----
	7-11-80	2035	25.1	7.2	589	6.6	80	0.1
K7	10-2-78	1645	14.2	7.6	749	7.4	73	----
	11-15-78	1030	7.5	7.6	735	8.8	75	1.2
	2-26-79	1830	1.1	7.6	707	9.5	68	----
	3-21-79	0930	5.0	7.1	904	11.0	87	----
	7-11-79	1100	20.0	7.7	718	8.1	90	----
	8-26-79	1510	18.7	8.7	775	10.8	116	0.9
	5-28-80	1045	20.8	7.8	755	6.4	72	----
	7-11-80	1950	27.8	7.9	815	3.6	46	1.1
				Derby ditch				
D1	10-3-78	1135	14.7	7.3	359	8.6	85	----
	11-18-78	1910	6.6	7.4	535	10.2	85	5.6
	2-26-79	1745	1.9	6.9	398	9.0	64	----
	3-21-79	1110	3.2	7.0	252	11.1	84	----
	7-10-79	1725	17.6	7.3	508	7.0	74	----
	8-24-79	1730	18.8	7.4	470	6.1	64	1.3
	5-28-80	1225	19.2	7.4	437	8.8	96	----
	7-11-80	1821	19.6	7.2	520	9.1	100	0.3
D2	2-26-79	1735	0.0	6.8	338	6.3	44	----
	3-21-79	1050	3.8	6.9	140	7.4	57	----

Table 3.--Field measurements in streams at the Indiana Dunes National Lakeshore, October 1978-July 1980--Continued

Site	Date of samp- ling	Time (h)	Water temp (°C)	pH	Specific conductance (µmho/cm at 25° C)	Dissolved oxygen (mg/L)	Dissolved oxygen (percent saturation)	Discharge (ft^3/s)
				Derby ditch--Continued				
D3	10-3-78	1045	14.0	7.0	392	6.1	60	----
	11-18-78	1830	8.0	7.2	465	----	-----	0.3
	2-26-79	1700	1.7	6.8	379	8.9	65	----
	3-21-79	1035	3.8	7.0	307	10.0	77	----
	7-10-79	1815	19.7	7.0	460	.8	5.6	----
	8-24-79	1650	17.1	7.3	437	5.6	58	0.1
	7-8-80	----	DRY	---	---	----	-----	----
D4	11-18-78	1845	7.1	7.0	510	7.7	65	1.5
	2-26-79	1720	0.0	6.5	406	4.1	28	----
	3-21-79	1040	2.7	6.9	235	8.9	67	----
	8-24-79	1705	19.7	7.2	476	5.6	62	0.5
	7-11-80	1800	26.0	6.9	600	2.4	30	0.01
				Dunes Creek				
DC2	10-3-78	1245	14.9	7.7	413	8.5	85	----
	11-18-78	1620	6.7	7.9	595	11.0	92	7.5
	2-27-79	1225	0.0	7.4	513	5.4	38	----
	3-20-79	1415	6.2	7.1	305	11.6	95	----
	7-10-79	1550	21.8	7.8	420	7.0	80	----
	8-25-79	1635	19.2	7.6	462	9.0	98	2.1
	5-28-80	1525	22.6	7.7	537	7.7	90	----
	7-11-80	1636	24.8	7.4	434	8.4	101	0.7
DC3	11-18-78	1445	7.6	7.8	635	10.0	85	2.8
	2-27-79	1205	0.0	7.5	437	6.6	46	----
	3-20-79	1403	6.6	6.3	323	11.4	95	----
	7-10-79	1615	16.4	7.6	357	8.5	88	----
	8-25-79	1550	18.9	7.7	615	8.5	92	0.6
	7-11-80	1542	24.2	7.9	844	6.9	82	0.01
DC4	11-18-78	1505	9.0	7.6	1,350	8.4	74	0.1
	2-27-79	1200	----	Frozen solid		----	---	----
	3-20-79	1400	7.1	7.0	1,085	12.2	103	----
	8-25-79	1540	----	DRY	-----	----	---	----
	12-12-79	1330	----	DRY	-----	----	---	----
	7-11-80	1550	----	DRY	-----	----	---	----
DC4C	4-8-80	1809	9.6	6.6	410	7.7	68	----
DC6	11-18-78	1640	7.0	7.3	280	7.9	66	0.7
	8-25-79	1612	19.8	6.6	251	2.3	26	----
	7-11-80	1605	25.5	6.4	291	.8	10	----
DC7	10-3-78	1210	13.9	7.6	262	9.0	88	----
	11-18-78	1720	7.5	7.7	810	9.6	82	0.9
	2-27-79	1140	.3	7.7	888	10.5	74	----
	3-20-79	1435	7.7	7.1	679	12.1	102	----
	7-10-79	1615	16.4	7.6	357	8.5	88	----
	8-25-79	1700	15.8	7.5	348	7.5	77	0.3
	5-28-80	1450	17.7	7.7	575	7.6	81	----
	7-11-80	1732	18.7	7.6	353	10.6	115	0.2

Table 4.--Chemical analyses of water samples from streams at the Indiana Dunes National Lakeshore, November 1978-July 1980

[All concentrations are for dissolved constituents in milligrams per liter except where "(a)" indicates micrograms per liter; data collected by U.S. Geological Survey; ND, not detectable]

Site	Date of sampling	Dissolved solids (sum of constituents)	Alkalinity as $CaCO_3$	Silica	Calcium	Magnesium	Sodium	Potassium	Bicarbonate	Sulfate	Chloride	Fluoride
Headwater lagoons of the Grand Calumet River												
GC1	11-16-78	355	160	9.0	53	18	46	4.0	195	43	84	0.3
(east	8-23-79	314	120	6.6	41	16	52	2.9	146	31	92	.3
lagoon)	7-09-80	305	110	1.6	35	16	54	3.2	134	34	94	.3
GC2	11-16-78	555	230	15	89	34	27	11	281	170	47	.6
(west	8-27-79	451	180	12	63	29	34	10	220	130	62	.6
lagoon)	7-09-80	483	210	18	76	27	37	9.8	256	120	66	.7
Little Calumet River												
LC1	11-17-78	351	170	6.1	67	21	29	3.7	207	72	44	0.6
	8-24-79	300	160	8.5	61	20	24	4.3	195	60	40	.6
	7-11-80	278	160	4.6	56	17	18	3.5	195	43	35	.5
LC2	11-18-78	454	190	7.4	72	29	45	5.8	232	110	63	.4
	8-24-79	337	140	11	59	20	32	4.2	171	72	47	.3
	7-11-80	424	210	.9	65	31	52	4.1	256	85	58	.4
LC2B	4-08-80	366	190	6.6	48	15	49	4.1	232	50	72	.5
LC3	11-17-78	305	160	5.7	60	20	20	3.6	195	61	33	.8
	8-24-79	281	150	8.0	60	20	21	4.1	183	52	34	.6
	7-11-80	241	140	4.2	46	17	18	2.8	171	39	26	.5
LC4	11-17-78	404	260	12	82	31	17	2.5	317	71	27	.2
	8-21-79	357	260	13	77	29	16	1.9	317	39	22	.2
	7-11-80	367	270	12	74	28	14	2.1	329	49	22	.2

Table 4.--Chemical analyses of water samples from streams at the Indiana Dunes National Lakeshore, November 1978-July 1980--Continued

Site	Date of samp-ling	Iron (a)	Manganese (a)	Boron (a)	Nitrate plus nitrite (as N)	Ammonium (as N)	Organic nitrogen (as N)	Ortho-phosphate (as P)	Total phosphorus (as P)	Dissolved organic carbon
					Headwater lagoons of the Grand Calumet River					
GC1	11-16-78	100	30	---	0.11	0.43	0.57	ND	ND	6.7
(east	8-23-79	90	10	100	.03	ND	.50	ND	0.01	11
lagoon)	7-09-80	100	3	---	.02	.03	.49	ND	.01	6.4
GC2	11-16-78	90	220	---	.37	16	7.00	ND	ND	13
(west	8-27-79	140	150	210	.40	13	1.00	ND	.02	11
lagoon)	7-09-80	170	270	---	.30	13	2.00	ND	.01	7.5
					Little Calumet River					
LC1	11-17-78	50	80	---	0.95	0.41	0.51	0.01	0.05	6.3
	8-24-79	30	90	---	1.1	.33	.47	.04	.07	6.1
	7-11-80	30	60	---	.88	.27	.43	.03	.06	3.8
LC2	11-18-78	140	40	---	1.5	.61	.79	ND	.02	10
	8-24-79	20	170	---	1.5	.40	.70	.03	.06	6.7
	7-11-80	10	40	---	.38	.09	.83	.03	.06	9.7
LC2B	4-08-80	360	150	---	1.4	.06	28	.14	.62	----
LC3	11-17-78	50	60	---	.95	.12	.70	ND	.02	10
	8-24-79	20	60	---	.99	.27	.50	ND	.07	5.1
	7-11-80	10	30	---	.66	.18	.32	.01	.02	2.6
LC4	11-17-78	70	90	---	1.1	.05	.84	.04	.03	5.3
	8-21-79	10	70	---	.48	.13	.28	.12	.09	7.3
	7-11-80	20	90	---	.81	.07	.30	.11	.11	2.4

Table 4.--Chemical analyses of water samples from streams at the Indiana Dunes National Lakeshore, November 1978-July 1980--Continued

Site	Date of samp-ling	Dis-solved solids (sum of consti-tuents)	Alkalinity as $CaCO_3$	Silica	Calcium	Magnesium	Sodium	Potassium	Bicarbonate	Sulfate	Chloride	Fluoride
Little Calumet River--Continued												
LC5	11-17-78	366	240	10	83	27	8.8	2.1	293	76	14	0.1
	8-24-79	326	250	13	78	28	7.1	1.7	305	39	8.5	.1
	7-11-80	368	280	13	79	30	8.8	1.7	342	52	14	.2
LC6	11-17-78	372	260	12	79	29	13	2.3	317	58	21	.2
	8-24-79	343	250	14	79	30	12	1.6	305	38	17	.1
	7-11-80	355	260	14	72	31	13	1.7	317	49	17	.2
LC7	11-17-78	372	260	12	83	28	11	2.0	317	62	17	.1
	8-24-79	358	260	14	79	29	15	1.7	317	39	23	.1
	7-11-80	366	270	14	74	31	12	1.5	329	54	16	.2
Kintzele ditch												
K2	11-15-78	333	150	11	54	16	40	6.2	183	61	52	0.3
	8-26-79	324	140	10	52	16	45	3.3	171	40	71	.3
	7-11-80	320	160	8.8	43	15	46	3.2	195	44	61	.3
K3	11-15-78	319	130	11	52	17	35	4.5	159	59	59	.1
	8-26-79	315	150	13	55	18	37	2.5	183	38	59	.2
	7-11-80	311	190	12	49	18	33	2.5	232	27	52	.2
K3D	11-30-78	694	130	13	72	26	120	16	159	95	270	.1
K3E	11-30-78	281	150	14	51	21	18	2.4	183	52	29	.1

Table 4.--Chemical analyses of water samples from streams at the Indiana Dunes National Lakeshore, November 1978-July 1980--Continued

Site	Date of samp-ling	Iron (a)	Manganese (a)	Boron (a)	Nitrate plus nitrite (as N)	Ammonium (as N)	Organic nitrogen (as N)	Ortho-phosphate (as P)	Total phosphorus (as P)	Dissolved organic carbon
					Little Calumet River					
LC5	11-17-78	120	60	-----	0.18	ND	0.31	0.00	0.09	10
	8-24-79	10	50	-----	.15	0.04	.26	.06	.06	9.1
	7-11-80	40	70	-----	.14	.04	.27	.01	.02	3.0
LC6	11-17-78	50	70	-----	.19	.06	.34	.00	.00	5.5
	8-24-79	40	100	-----	.17	.05	.14	.01	.02	13
	7-11-80	10	120	-----	.19	.03	.17	.00	.01	2.7
LC7	11-17-78	70	50	-----	.16	.06	.21	.00	.00	8.9
	8-24-79	60	40	-----	.13	ND	.21	.00	.01	8.0
	7-11-80	30	50	-----	.19	.01	.09	.00	.00	1.4
					Kintzele ditch					
K2	11-15-78	220	190	-----	0.34	0.18	0.56	ND	0.01	15
	8-26-79	410	50	210	.28	.29	.37	ND	.02	13
	7-11-80	430	40	301	.39	.02	.94	ND	.03	8.0
K3	11-15-78	710	90	-----	.45	ND	1.4	ND	.01	23
	8-26-79	600	270	370	.24	.06	1.1	.04	.04	20
	7-11-80	130	580	309	.42	.13	.87	ND	.01	15
K3D	11-30-78	5,700	1,900	3,300	.35	2.2	4.5	.08	.30	----
K3E	11-30-78	570	1,200	250	.20	.13	.51	ND	.01	----

Table 4.--Chemical analyses of water samples from streams at the Indiana Dunes National Lakeshore, November 1978-July 1980--Continued

Site	Date of samp-ling	Dis-solved solids (sum of consti-tuents)	Alkalinity as $CaCO_3$	Silica	Calcium	Magnesium	Sodium	Potassium	Bicarbonate	Sulfate	Chloride	Fluoride
Kintzele ditch												
K4	11-15-78	221	86	13	38	19	7.6	3.7	105	75	13	0.1
	8-26-79	169	71	13	30	12	9.3	3.1	87	43	14	.1
	7-11-80	132	68	11	22	8.3	6.5	3.5	83	28	11	.1
K6	11-15-78	337	130	7.8	55	17	37	5.4	159	73	60	.5
	8-26-79	512	180	12	70	23	73	6.2	220	77	140	.4
	7-11-80	266	120	4.4	43	15	27	3.5	146	51	48	.8
	11-15-78	399	200	10	57	21	60	3.7	244	52	73	.4
K7	8-26-79	460	160	9.0	62	19	70	4.1	195	78	120	.4
	7-11-80	385	190	5.6	37	16	79	4.0	232	30	97	.6
Derby ditch												
D1	11-18-78	278	90	11	43	15	37	2.8	110	65	60	0.2
	8-24-79	261	93	12	42	13	33	1.7	113	46	54	.2
	7-11-80	252	120	11	36	13	31	2.2	146	30	50	.2
D3	11-18-78	245	95	12	41	15	26	2.8	116	53	47	.9
	8-24-79	248	110	12	40	14	27	1.7	134	45	40	.9
	7-11-80	---	DRY	----	--	----	----	---	---	--	---	---
D4	11-18-78	274	63	11	42	15	37	3.0	77	76	63	.1
	8-24-79	259	72	11	42	11	36	1.6	88	53	58	.2
	7-11-80	275	130	16	50	13	36	2.0	159	13	60	.3

Table 4.--Chemical analyses of water samples from streams at the Indiana Dunes National Lakeshore, November 1978-July 1980--Continued

Site	Date of samp-ling	Iron (a)	Manganese (a)	Boron (a)	Nitrate plus nitrite (as N)	Ammonium (as N)	Organic nitrogen (as N)	Ortho-phosphate (as P)	Total phosphorus (as P)	Dissolved organic carbon
					Kintzele ditch					
K4	11-15-78	150	20	--	ND	ND	0.41	ND	0.01	10
	8-26-79	450	40	--	0.22	ND	.63	0.03	.03	16
	7-11-80	220	110	--	.17	0.01	.65	ND	.04	7.2
K6	11-15-78	130	140	--	.58	.39	.61	.01	.01	11
	8-26-79	280	250	--	.33	.23	1.1	.02	.03	16
	7-11-80	40	120	--	.29	.17	.59	ND	.04	5.7
K7	11-15-78	240	330	--	.19	.49	.61	ND	ND	8.6
	8-26-79	40	20	--	.18	.02	.78	.02	.16	10
	7-11-80	80	20	--	.26	.03	.59	.01	.05	5.9
					Derby ditch					
D1	11-18-78	910	90	--	0.38	0.07	1.4	ND	0.02	----
	8-24-79	900	60	--	.44	.05	1.4	.02	.03	22
	7-11-80	360	190	--	1.30	.19	.81	.01	.03	15
D3	11-18-78	510	60	--	.07	.05	.92	ND	ND	----
	8-24-79	980	110	--	.18	.16	1.1	ND	.01	----
	7-11-80	-----	DRY	--	----	----	----	---	----	----
D4	11-18-78	1,500	130	--	.44	.04	2.3	.01	.03	----
	8-24-79	1,500	60	--	.33	.02	2.2	.01	.05	33
	7-11-80	1,200	1,300	--	.93	.69	2.4	ND	.02	31

Table 4.--Chemical analyses of water samples from streams at the Indiana Dunes National Lakeshore, November 1978-July 1980--Continued

Site	Date of samp- ling	Dis- solved solids (sum of consti- tuents)	Alkalinity as $CaCO_3$	Silica	Calcium	Magnesium	Sodium	Potassium	Bicarbonate	Sulfate	Chloride	Fluoride
Dunes Creek												
DC2	11-18-78	314	150	12	44	21	43	3.5	183	39	72	0.2
	8-25-79	255	140	14	42	17	27	1.6	171	29	39	.2
	7-11-80	214	120	11	31	15	26	1.8	146	28	27	.2
DC3	11-18-78	328	180	14	51	24	40	3.4	220	37	63	.2
	8-25-79	350	220	19	60	24	35	1.5	268	31	46	.3
	7-11-80	407	250	16	54	27	64	2.3	305	17	74	.4
DC4	11-18-78	853	120	12	57	21	240	4.5	146	63	380	.2
	8-25-79	---	---	----	--	----	---	---	DRY	----	---	---
	7-11-80	---	---	----	--	----	---	---	DRY	----	---	---
DC6	11-18-78	150	120	10	31	14	10	2.4	146	5.0	14	.2
	8-25-79	130	91	6.9	25	9.9	11	.5	111	5.5	15	.2
	7-11-80	148	120	4.4	28	12	11	.4	146	4.8	14	.3
DC7	11-18-78	431	130	11	53	21	66	4.3	159	66	130	.2
	8-25-79	192	100	12	30	15	17	2.0	122	33	22	.1
	7-11-80	180	100	11	29	13	13	2.0	122	30	16	.1

Table 4.--Chemical analyses of water samples from streams at the Indiana Dunes National Lakeshore, November 1978-July 1980--Continued

Site	Date of samp-ling	Iron (a)	Manganese (a)	Boron (a)	Nitrate plus nitrite (as N)	Ammonium (as N)	Organic nitrogen (as N)	Ortho-phosphate (as P)	Total phosphorus (as P)	Dissolved organic carbon
					Dunes Creek					
DC2	11-18-78	270	30	--	0.09	0.01	0.99	ND	0.01	-----
	8-25-79	430	110	--	.18	.01	.91	0.04	.04	17
	7-11-80	440	110	--	.32	.06	.69	.03	.04	11
DC3	11-18-78	350	70	--	.08	.01	.95	ND	.01	-----
	8-25-79	220	120	--	.15	.00	1.2	ND	.02	26
	7-11-80	80	470	--	.30	.06	.89	ND	.03	16
DC4	11-18-78	200	40	--	.55	.07	.54	ND	.02	-----
	8-25-79	---	DRY	--	----	----	----	----	----	-----
	7-11-80	---	DRY	--	----	----	----	----	----	-----
DC6	11-18-78	880	40	--	.06	.21	1.7	ND	.04	-----
	8-25-79	560	180	--	.01	.02	1.3	ND	.04	23
	7-11-80	710	250	--	.02	.14	1.7	ND	.05	28
DC7	11-18-78	130	20	--	.33	.05	.52	ND	.01	-----
	8-25-79	90	40	--	1.3	.01	.16	.03	.03	4.6
	7-11-80	120	30	--	1.3	.01	.19	.02	.02	3.0

Table 5.--Concentrations of acid-soluble trace elements on unsorted streambed materials of streams at the Indiana Dunes National Lakeshore, November 1978 - December 1979

[All concentrations in micrograms per gram; data collected by U.S. Geological Survey; ND, not detected]

Site	Date of samp-ling	Arsenic	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Molybdenum	Nickel	Zinc
					Headwater lagoons of the Grand Calumet River						
GC1	11-16-78	ND	<10	20	<10	<10	--	30	---	--	30
	8-23-79	ND	<10	20	<10	<10	--	70	---	--	20
GC2	11-16-78	ND	<10	<10	<10	<10	--	20	---	--	10
	8-23-79	1	<10	<10	<10	<10	--	20	---	--	20
					Little Calumet River						
LC1	11-17-78	ND	<10	<10	<10	<10	--	<10	---	--	20
	8-24-79	1	<10	<10	<10	10	--	20	---	--	30
LC2	11-18-78	ND	<10	10	<10	10	--	70	---	--	30
	8-24-79	ND	<10	<10	10	<10	--	60	---	--	30
LC2A	12-11-79	---	---	---	---	---	--	30	---	--	20
LC2B	12-11-79	---	---	---	---	---	--	150	---	--	230
LC3	11-17-78	1	<10	30	<10	30	--	300	---	--	100
	8-24-79	3	<10	<10	20	20	--	20	---	--	70
LC3A	12-11-79	---	<10	---	---	<10	--	20	---	--	30
LC3B	12-11-79	---	<10	---	---	<10	--	10	---	--	20
LC3C	12-11-79	---	10	---	---	20	--	50	---	--	70

Table 5.--Concentrations of acid-soluble trace elements on unsorted streambed materials of streams at the Indiana Dunes National Lakeshore, November 1978 - December 1979--Continued

Site	Date of samp-ling	Arsenic	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Molybdenum	Nickel	Zinc
					Little Calumet River--Continued						
LC4	11-17-78	1	<10	10	20	40	-----	80	---	---	130
	8-24-79	2	<10	10	10	30	-----	40	---		110
LC5	11-17-78	1	<10	10	<10	20	-----	60	---	---	100
	8-24-79	3	<10	10	20	20	-----	70	---	---	120
LC6	11-17-78	1	<10	10	<10	20	-----	40	---	---	60
	8-24-79	3	<10	10	20	20	-----	30	---	---	80
LC7	11-17-78	1	<10	10	<10	20	-----	20	---	---	60
	8-24-79	1	<10	<10	10	10	-----	10	---	---	40
LC8	12-11-79	---	---	---	---	10	-----	20	---	---	40
LC9	12-11-79	---	---	---	---	10	-----	30	---	---	90
					Kintzele ditch						
K2	11-15-78	ND	<10	<10	<10	<10	-----	<10	---	---	30
	8-26-79	ND	<10	<10	<10	<10	-----	10	---	---	40
K3	11-15-78	2	<10	<10	<10	<10	-----	<10	---	---	30
	8-26-79	5	<10	10	<10	20	-----	70	---	---	200
K3A	12-12-79	ND	---	---	---	---	-----	20	---	---	70
K3C	12-12-79	--	---	---	---	---	2,500	10	<10	<10	20
K3E	12-11-79	ND	---	---	---	---	1,300	<10	<10	<10	10
K4	11-15-78	1	<10	10	<10	<10	-----	20	---	---	20
	8-26-79	ND	<10	10	<10	<10	-----	20	---	---	30

Table 5.--Concentrations of acid-soluble trace elements on unsorted streambed materials of streams at the Indiana Dunes National Lakeshore, November 1978 - December 1979--Continued

Site	Date of samp-ling	Arsenic	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Molybdenum	Nickel	Zinc
					Kintzele ditch						
K6	11-14-78	1	<10	10	<10	10	--	20	---	---	70
	8-26-79	ND	<10	10	<10	<10	--	[illegible]	---	---	20
K7	11-15-78	3	<10	10	<10	<10	--	50	---	---	130
	8-26-79	1	<10	10	<10	<10	--	60	---	---	130
					Derby ditch						
D1	11-18-78	ND	<10	10	<10	<10	--	20	---	---	10
	8-24-79	ND	<10	20	<10	<10	--	<10	---	---	<10
					Dunes Creek						
DC2	11-18-78	ND	<10	<10	<10	<10	--	<10	---	---	20
	8-25-79	ND	<10	<10	<10	<10	--	<10	---	---	10
DC4	12-12-79	--	---	---	---	---	--	130	---	---	60
DC7	11-18-78	ND	<10	10	<10	<10	--	<10	---	---	<10
	8-25-79	2	<10	<10	<10	<10	--	10	---	---	<10

Table 6.-- Chlorinated hydrocarbon concentrations on unsorted streambed materials of streams at the Indiana Dunes National Lakeshore, November 1978 - April 1980

[All concentrations in micrograms per kilogram; data collected by U.S. Geological Survey; ND, not detected]

Site	Date of sampling	Aldrin	Chlordane	DDD	DDE	DDT	Dieldrin	Endosulfin	Endrin	Heptachlor epoxide	Heptachlor	Lindane	Mirex	PCB	PCN	Perthane	Toxaphene
Headwater lagoons of the Grand Calumet River																	
GC1	11-16-78	ND	8	21	68	22	ND	ND	ND	ND	ND	ND	ND	27	ND	ND	ND
	8-23-79	ND	5	35	35	4.1	ND	ND	ND	ND	ND	ND	ND	9	ND	ND	ND
GC1A	12-11-79	ND	480	35	49	84	8.9	ND	ND	2.0	ND	ND	ND	88	ND	ND	ND
GC1B	12-11-79	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	ND	ND	ND
GC2	11-16-78	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4	ND	ND	ND
	8-23-79	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4	ND	ND	ND
Little Calumet River																	
LC1	11-17-78	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	88	ND	ND	ND
	8-24-79	ND	4	1.3	1.3	0.3	4.4	ND	ND	ND	ND	ND	ND	43	ND	ND	ND
LC2	11-18-78	ND	3	3.0	ND	.5	.6	ND	ND	ND	ND	ND	ND	18	ND	ND	ND
	8-24-79	ND	7	2.0	2.0	1.1	.9	ND	ND	ND	ND	ND	ND	4	ND	ND	ND
LC2A	12-11-79	ND	ND	ND	ND	ND	.1	ND	ND	ND	ND	ND	ND	3	ND	ND	ND
LC2B	12-11-79	ND	110	100	68	180	14	ND	ND	ND	ND	ND	ND	79	ND	ND	ND
LC2C	4-7-80	ND	47	34	46	46	5.2	ND	1.3	1.1	ND	ND	ND	71	ND	ND	ND
LC3	11-17-78	ND	9	2.4	ND	.5	1.6	ND	ND	ND	ND	ND	ND	100	ND	ND	ND
	8-24-79	ND	4	1.1	1.1	.6	1.4	ND	ND	ND	ND	ND	ND	44	ND	ND	ND
LC3A	4-8-80	ND	5	1.8	3.4	ND	2.9	ND	ND	.2	ND	ND	ND	13	ND	ND	ND
LC3B	4-9-80	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Table 6.-- Chlorinated hydrocarbon concentrations on unsorted streambed materials of streams at the Indiana Dunes National Lakeshore, November 1978 - April 1980--Continued

Site	Date of samp-ling	Aldrin	Chlordane	DDD	DDE	DDT	Dieldrin	Endo-sulfin	Endrin	Hepta-chlor epoxide	Hepta-chlor	Lindane	Mirex	PCB	PCN	Perthane	Toxa-phene
Little Calumet River--Continued																	
LC4	11-17-78	ND	24	4.2	1.3	1.0	2.8	ND	ND	ND	ND	ND	ND	48	ND	ND	ND
	8-24-79	ND	14	5.3	5.3	1.8	2.7	ND	ND	ND	ND	ND	ND	40	ND	ND	ND
LC5	11-17-78	ND	29	3.3	ND	6.6	1.2	ND	ND	ND	ND	ND	ND	58	ND	ND	ND
	8-24-79	ND	32	3.0	3.0	4.7	2.2	ND	ND	ND	ND	ND	ND	22	ND	ND	ND
LC5A	12-11-79	ND	2	.4	.2	ND	1.2	ND	ND	ND	ND	ND	ND	2	ND	ND	ND
LC6	11-17-78	ND	4	4.9	3.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	8-24-79	ND	2	6.9	6.9	5.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LC7	11-17-78	ND	3	9.3	6.3	6.6	ND	ND	ND	ND	ND	ND	ND	31	ND	ND	ND
	8-24-79	ND	ND	5.0	5.0	4.5	.9	ND	ND	ND	ND	ND	ND	4	ND	ND	ND
LC8	12-11-79	ND	2	1.6	1.5	.6	ND	ND	ND	ND	ND	ND	ND	4	ND	ND	ND
LC9	12-11-79	ND	3	1.7	4.6	14	33	ND	ND	0.6	ND	ND	ND	2	ND	ND	ND
LC9A	4-9-80	ND	4	1.3	2.4	.7	4.2	ND	ND	.3	ND	ND	ND	6	ND	ND	ND
LC9B	4-9-80	ND	2	.6	ND	.8	1.0	ND	ND	.6	.6	ND	ND	8	ND	ND	ND
LC9C	4-9-80	ND	2	1.1	ND	.8	.2	ND	ND	ND	ND	ND	ND	5	ND	ND	ND

Table 6.-- Chlorinated hydrocarbon concentrations on unsorted streambed materials of streams at the Indiana Dunes National Lakeshore, November 1978 - April 1980--Continued

Site	Date of samp-ling	Aldrin	Chlordane	DDD	DDE	DDT	Dieldrin	Endo-sulfin	Endrin	Hepta-chlor epoxide	Hepta-chlor	Lindane	Mirex	PCB	PCN	Perthane	Toxa-phene
Kintzele ditch																	
K2	11-15-78	ND	1	ND	ND	ND	0.1	ND	ND	ND	ND	ND	ND	23	ND	ND	ND
	8-26-79	ND	1	0.4	0.4	1.3	ND	ND	ND	ND	ND	ND	ND	10	ND	ND	ND
K3	11-15-78	ND	2	1.2	1.4	ND	ND	ND	ND	ND	ND	ND	ND	8	ND	ND	ND
	8-26-79	ND	5	1.9	1.9	ND	1.1	ND	ND	ND	ND	ND	ND	13	ND	ND	ND
K3A	12-12-79	ND	3	ND	ND	ND	.3	ND	ND	ND	ND	ND	ND	7	ND	ND	ND
K3B	4-9-80	ND	ND	120	20	57	.1	ND	ND	ND	ND	ND	ND	4	ND	ND	ND
K3C	12-12-79	ND	2	1.7	.7	2.4	.3	ND	ND	ND	ND	ND	ND	4	ND	ND	ND
K3E	4-9-80	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
K4	11-15-78	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	8-26-79	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
K6	11-14-78	ND	16	1.4	ND	.3	ND	ND	ND	ND	ND	ND	ND	42	ND	ND	ND
	8-26-79	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	11	ND	ND	ND
	12-12-79	ND	ND	12	ND	1.6	.8	ND	ND	ND	ND	ND	ND	86	ND	ND	ND
	4-9-80	ND	7	1.8	ND	ND	2.1	ND	ND	ND	ND	ND	ND	21	ND	ND	ND
K6A	12-12-79	ND	4	8.5	1.5	1.4	.7	ND	ND	ND	ND	ND	ND	19	ND	ND	ND
K6C	4-9-80	ND	17	5.2	.8	1.7	1.3	ND	ND	0.6	ND	ND	ND	44	ND	ND	ND
K7	11-15-78	ND	9	49	ND	150	.5	ND	ND	ND	ND	ND	ND	20	ND	ND	ND
	8-26-79	ND	17	260	260	82	.0	ND	ND	.2	ND	ND	ND	41	ND	ND	ND
K7A	12-12-79	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4	ND	ND	ND
K7B	12-12-79	ND	4	1.4	.2	.5	.6	ND	ND	ND	ND	ND	ND	15	ND	ND	ND

Table 6.-- Chlorinated hydrocarbon concentrations on unsorted streambed materials of streams at the Indiana Dunes National Lakeshore, November 1978 - April 1980--Continued

Site	Date of samp-ling	Aldrin	Chlordane	DDD	DDE	DDT	Dieldrin	Endo-sulfin	Endrin	Hepta-chlor epoxide	Hepta-chlor	Lindane	Mirex	PCB	PCN	Perthane	Toxa-phene
Dunes Creek																	
DC4	11-18-78	ND	12	6.9	ND	6.5	1.4	ND	ND	ND	ND	ND	ND	26	ND	ND	ND
	8-25-79	ND	15	3.5	3.5	4.8	1.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DC4A	12-12-79	ND	5	2.5	4.0	3.1	1.0	ND	ND	ND	ND	ND	ND	5	ND	ND	ND
DC4B	12-12-79	ND	7	ND	2.2	ND	1.0	ND	ND	ND	ND	ND	ND	3	ND	ND	ND
DC4C	4-8-80	ND	2	1.3	1.5	ND	.2	ND	ND	ND	ND	ND	ND	8	ND	ND	ND
DC7	11-18-78	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	8-25-79	ND	ND	.2	.2	3.0	.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Table 7.—Bacterial population of streams at the Indiana Dunes National Lakeshore, November 1978–August 1979

[All populations reported as colonies per 100 mL; data collected and analyzed by U.S. Geological Survey]

Site	Date of sampling	Fecal coliform	Fecal streptococcus
Grand Calumet River lagoons			
GC1	11-13-78	[1]7	[1]25
	2-27-79	[1]26	[1]38
	3-20-79	[1]4	[1]10
	8-22-79	33	19
GC2	11-13-78	[1]13	[1]80
	2-27-79	<2	[1]12
	3-20-79	[1]4	[1]4
	8-23-79	29	>1,700
Kintzele ditch			
K2	11-13-78	360	7,700
	2-26-79	290	310
	3-21-79	[1]71	180
	8-23-79	2,400	1,300
K3	11-13-78	[1]75	710
	2-26-79	[1]5	95
	3-21-79	[1]25	[1]43
	8-23-79	320	1,900
K4	11-13-78	<13	[1]190
	2-26-79	10	140
	3-21-79	9	[1]8
	8-23-79	1,200	1,400
K6	11-13-78	[1]8,400	>55,000
	2-26-79	310	440
	3-21-79	13	[1]45
	8-23-79	940	1,500
K7	11-13-78	[1]130	>27,000
	2-26-79	710	330
	3-21-79	[1]10	[1]20
	8-23-79	95	130
Dunes Creek			
DC2	11-13-78	[1]75	[1]70
	2-27-79	220	430
	3-20-79	100	70
	8-23-79	250	1,500
DC4	11-13-78	[1]130	[1]140
	3-20-79	150	150
	8-23-79	800	8,000
DC7	11-13-78	<13	[1]63
	2-27-79	[1]85	[1]180
	3-20-79	44	70
	8-23-79	210	1,300
Little Calumet River			
LC2	11-13-78	180	480
	2-27-79	13,000	4,200
	3-20-79	2,000	750
	8-22-79	2,000	1,200
LC3	11-14-78	[1]11,000	[1]8,600
	2-27-79	4,000	1,100
	3-20-79	2,900	1,300
	8-22-79	920	590
LC4	2-27-79	130	100
	3-20-79	90	150
	8-22-79	460	330
LC5	11-14-78	[1]1,500	3,300
	2-27-79	[1]170	[1]190
	3-20-79	95	100
	8-22-79	[1]1,400	1,300
LC6	11-14-78	[1]2,000	[1]10,000
	2-27-79	600	2,600
	3-20-79	350	400
	8-22-79	760	1,000
LC7	11-14-78	360	1,500
	2-27-79	1,200	6,600
	3-20-79	150	800
	8-22-79	740	1,500
Derby ditch			
D1	11-13-78	<13	290
	2-26-79	<11	[1]63
	3-21-79	[1]20	120
	8-23-79	360	1,500
D2	11-13-78	[1]14	[1]200
	2-26-79	[1]5	[1]52
	3-21-79	110	170
	8-23-79	[1]2,300	[1]4,100
D3	11-18-78	<13	[1]160
	2-26-79	<5	[1]24
	3-21-79	<2	[1]7
	8-24-79	140	1,400
D4	11-13-78	[1]38	[1]160
	2-26-79	<5	[1]52
	3-21-79	[1]4	87
	8-23-79	210	[1]2,100

[1]Based on nonideal plate count.

Table 15.—Concentrations of acid-soluble trace elements on sieved streambed materials of the Little Calumet River, Kintzele ditch and Dunes Creek, April 7-9, 1980

[All concentrations in micrograms per gram; data collected by U.S. Geological Survey]

Site	Particle size (micron)	Copper	Lead	Zinc	Iron
Little Calumet River					
LC2	<63	--	130	140	--
	250-500	--	130	90	--
LC2A	<63	--	70	70	--
	250-500	--	20	130	--
LC2AA	<63	--	180	160	--
	250-500	--	310	20	--
LC2B	<63	--	190	30	--
	250-500	--	240	290	--
LC2C	<63	--	120	100	--
	250-500	--	150	140	--
LC3A	<63	10	50	60	--
	250-500	10	20	20	--
LC3B	<63	40	150	90	--
	250-500	10	20	20	--
LC3C	<63	20	40	60	--
	250-500	10	30	30	--
LC4	<63	10	30	40	--
	250-500	40	150	170	--
LC5	<63	20	110	90	--
	250-500	10	100	50	--
LC5A	<63	10	50	50	--
	250-500	10	20	20	--
LC6	<63	20	80	40	--
	250-500	20	100	50	--
LC7	<63	10	40	30	--
	250-500	10	20	40	--
LC8A	<63	20	20	30	--
	250-500	10	10	10	--
LC9A	<63	20	50	20	--
	250-500	10	20	60	--
LC9B	<63	20	40	280	--
	250-500	10	40	240	--
LC9C	<63	20	50	150	--
	250-500	10	70	110	--
LC10	<63	10	40	40	--
	250-500	10	10	10	--

Site	Particle size (micron)	Copper	Lead	Zinc	Iron
Kintzele ditch					
K3	<63	--	330	310	-----
	250-500	--	20	30	-----
K3A	<63	--	420	650	-----
	250-500	--	40	40	-----
K3B	<63	--	130	360	-----
	250-500	--	20	70	-----
K3C	<63	--	---	---	7,700
	250-500	--	---	---	1,000
K3E	<63	--	---	---	6,800
	250-500	--	---	---	360
K4	<63	--	50	50	-----
	250-500	--	20	20	-----
K6	<63	--	90	90	-----
	250-500	--	20	30	-----
K6B	<63	--	40	160	-----
	250-500	--	20	160	-----
K6C	<63	--	230	280	-----
	250-500	--	90	100	-----
K7A	<63	--	90	20	-----
	250-500	--	50	50	-----
K7B	<63	--	120	240	-----
	250-500	--	20	20	-----
Dunes Creek					
DC4	<63	--	480	230	-----
	250-500	--	140	60	-----
DC4A	<63	--	270	320	-----
	250-500	--	60	80	-----
DC4B	<63	--	170	290	-----
	250-500	--	40	50	-----
DC4C	<63	--	60	100	-----
	250-500	--	20	20	-----

Table 16.--Identification of algae in periphyton communities collected from streams at the Indiana Dunes National Lakeshore, November 1978

[X, organisms present; D, dominate organism]

Organism	Grand River	Calumet lagoons	Little Calumet River				Derby ditch		Kintzele ditch			Dunes Creek
	Site GC1	Site GC2	Site LC2	Site LC3	Site LC6	Site LC7	Site D1	Site D3	Site K2	Site K3	Site K6	Site DC7
Bacillariophyceae (diatoms)												
Achnanthes	X	D	-	-	-	-	-	-	X	X	-	X
Amphora	X	-	-	-	-	-	-	-	-	-	-	X
Anomoeneis	-	-	X	-	-	-	-	-	-	-	-	-
Asterionella	D	-	-	-	-	-	-	-	-	-	-	-
Cocconeis	X	-	-	D	X	-	-	-	X	-	X	X
Cyclotella	-	X	X	-	-	-	-	-	-	-	-	X
Cymbella	-	X	-	X	-	-	-	-	-	-	X	-
Diatoma	-	-	-	X	-	-	-	-	-	-		X
Epithemia	-	-	-	X	-	-	-	-	-	-	-	-
Eunotia	-	-	-	-	-	-	-	-	-	-	-	X
Gomphonema	X	D	-	X	X	-	X	X	X	D	D	D
Gyrosigma	-	-	-	-	-	-	-	-	-	-	X	-
Melosira	D	-	D	X	-	-	-	-	-	-	X	X
Meridion	-	-	-	-	-	-	D	-	-	-	-	
Navicula	X	X	X	D	X	X	D	-	D	D	D	D
Nitzschia	-	-	D	X	X	X	-	-	X	X	X	X
Pinnularia	-	-	-	-	X	-	-	-	-	-	-	-
Rhopalodia	-	-	-	X	-	-	-	-	-	-	-	-
Rhousophenia	-	-	-	-	-	-	-	-	-	-	X	X
Stouronius	-	-	X	-	-	-	-	-	-	-	-	-
Surirella	-	-	X	-	-	-	-	-	-	-	D	-
Suririllecia	-	-	-	-	-	-	-	-	X	-	-	-
Synedra	X	-	X	-	X	-	-	-	-	X	X	X
Cyanophyta (blue-green algae)												
Lyngbya	-	X	-	-	-	X	-	D	-	X	-	-
Oscillatoria	X	X	-	D	D	D	X	X	D	X	X	X
Phormodium	-	-	-	-	-	-	-	-	-	X	-	-
Chlorophyta (green algae)												
Coelastrium	-	X	-	-	-	-	-	-	-	-	-	-
Mougeotia	-	-	-	-	-	-	-	-	-	-	-	X
Oedogonium	D	X	-	-	-	-	-	-	-	-	X	-
Oocystis	-	X	-	-	-	-	-	-	-	-	-	-
Pedastrum	-	-	X	-	-	-	-	-	-	-	-	-
Scenedesmus	-	X	D	-	-	-	-	-	-	-	X	-
Spirogyra	D	-	-	-	-	-	-	-	-	-	-	-
Ulothrix	X	-	-	-	-	-	-	-	-	-	-	X
Euglenophyta (Euglenoids)												
Trachelomonas	-	X	-	-	-	-	-	-	-	-	-	-

Table 17.--Chlorophyll a concentrations and biomass of periphyton communities in streams at the Indiana Dunes National Lakeshore, August 1979 - July 1980

[Data collected and analyzed by U.S. Geological Survey]

Site	Date of samp-ling	Chloro-phyll a (mg/m²)	Biomass (g/m²)	Site	Date of samp-ling	Chloro-phyll a (mg/m²)	Biomass (g/m²)
GC1	8-23-79	1.37	0.15	K2	8-26-79	3.14	0.23
	7-9-80	4.71	2.75		7-11-80	10.2	1.42
GC2	8-23-79	1.37	.08	K3	8-26-79	.100	.24
	7-9-80	8.33	2.68		7-11-80	5.43	1.42
LC1	8-24-79	19.6	1.3	K6	8-26-79	3.48	.08
	7-11-80	79.9	.2		7-11-80	10.4	1.49
LC2	8-24-79	9.32	.55	K7	8-26-79	1.95	.16
	7-11-80	.270	.00		7-11-80	22.60	3.60
LC3	8-24-79	2.26	1.60	D1	8-24-79	1.68	.08
	7-11-80	1.22	.78		7-11-80	1.39	.47
LC6	8-24-79	.180	.08	DC2	8-25-79	.160	.55
	7-11-80	4.01	.00		7-11-80	9.27	.63
LC7	8-24-79	1.19	.63	DC7	8-25-79	.230	.32
	7-11-80	.07	.00		7-11-80	15.4	3.82

Table 18.--Benthic invertebrates in streams at the National Lakeshore, November 1978 - July 1980

[All numbers indicate number of organisms per jumbo multiplate substrate; data collected by U.S. Geological Survey]

Organism	Grand Calumet River lagoons					
	East GC1			West GC2		
	Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980
Annelida (segmented worms)						
Hirudinea (leeches)	3	19	1	1	40	15
Oligochaeta (aquatic earthworms)	--	--	5	--	--	--
Arthropoda						
Arachnida						
Acarina (water mites)	--	--	---	---	4	---
Crustacea						
Isopoda (aquatic sow bugs)						
Assellus	--	--	3	---	18	14
Lirceus	26	4	1	---	---	---
Amphipoda (scuds)						
Crangonyx	--	--	---	---	---	---
Gammarus	--	--	---	---	---	---
Hyallela	81	22	8	155	249	18
Decapoda (crayfish)						
Orconectes	--	1	3	---	---	---
Insecta						
Coleoptera (beetles)						
Agabus	--	--	---	---	---	---
Ancyronyx	--	--	---	---	---	---
Deronectes	--	--	---	---	---	---
Dineutus	--	--	---	---	---	2
Dubiraphia	--	--	---	---	---	---
Haliplus	--	--	---	---	---	2
Hydroporus	--	--	---	---	---	---
Laccophilus	--	--	---	---	1	7
Stenelmis	--	--	---	---	---	---
Optioservus	--	--	---	---	---	---
Collembola						
Isotomurus	--	--	---	---	---	---
Diptera (two-winged flies)						
Ablabesmyia	--	--	---	---	3	1
Apsectrotanypus	--	--	---	---	---	---
Brillia	--	--	---	---	---	---
Chaoboris	--	--	---	---	---	---
Chironomus	--	--	2	---	---	37
Cladotanytarsus	--	2	---	---	---	---
Clinotanypus	--	--	---	---	---	---
Conchapelopia	--	--	---	---	---	---
Corynoneura	--	--	---	---	---	---
Cricotopus	--	--	---	---	---	3
Diplocladius	--	--	---	---	---	---
Endochironomus	--	--	---	---	---	---
Eukiefferiella	--	--	---	14	---	---
Glyptotendipes	32	7	1	64	---	101
Hemerdoromia	--	--	---	---	---	---
Labrundinia	--	--	---	---	1	---
Limnochironomus	--	1	4	---	3	17
Microspectra	--	--	---	---	---	---
Microtendipes	--	--	3	---	---	---
Orthocladius	--	--	---	---	---	---
Palpomyia	--	2	---	---	4	---
Phaenopsectra	--	--	7	---	---	2
Polypedilum	--	--	---	---	4	---
Procladius	--	--	---	---	---	---
Prodiamesa	--	--	---	---	---	---

Table 18.--Benthic invertebrates in streams at the National Lakeshore, November 1978 - July 1980--Continued

Little Calumet River														
LC1			LC2			LC3			LC6			LC7		
Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980
SUBSTRATE LOST BECAUSE SITE DREDGED	--	--	--	1	--	--	--	--	--	--	--	--	--	--
	--	6	--	--	41	9	--	--	--	--	--	--	--	76
	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	10	11	31	10	11	5	--	5	28	50	240	--	--	--
	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	1	--	--	--	--	--	--	--	--	--	--	--	--	--
	--	--	2	--	--	75	--	11	2	5	4	18	32	3
	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	1	3	--	--	2	1	1	--	--	--	3	1	2	--
	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	1	--	4	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	1	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	2	--	--	--	--	--	4	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	--	--	1	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	1	--	--	--	--	--	--	--	--	--	--
	2	3	--	18	21	2	3	--	--	2	--	--	2	1
	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	2	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	1	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	1	--	--	1	--	--	1	1	--
	--	1	10	51	11	--	--	5	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--	--	1	--
	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	6	1	--	12	8	--	--	3	--	--	--	--	--	2
	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	1	--	--	--	--	6	--	--	--	7
	--	--	--	--	--	--	1	1	--	--	--	--	--	2
	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	2	--	2	1	--	--	2
	2	--	--	--	1	--	14	--	--	9	--	--	2	1
	--	--	--	4	--	--	1	--	--	1	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 18.--Benthic invertebrates in streams at the National Lakeshore, November 1978 - July 1980--Continued

Organism	Derby ditch					
	D1			D3		
	Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980
Annelida (segmented worms)					D	D
Hirudinea (leeches)	-	1	--	--	R	R
Oligochaeta (aquatic earthworms)	-	--	--	--	Y	Y
Arthropoda						
Arachnida						
Acarina (water mites)	-	--	--	--		
Crustacea						
Isopoda (aquatic sow bugs)						
Assellus	-	52	17	27		
Lirceus	-	--	--	--		
Amphipoda (scuds)						
Crangonyx	-	--	--	--		
Gammarus	6	91	36	2		
Hyallela	-	--	--	--		
Decapoda (crayfish)						
Orconectes	-	--	1	--		
Insecta						
Coleoptera (beetles)						
Agabus	-	--	--	--		
Ancyronyx	-	--	--	--		
Deronectes	-	--	1	--		
Dineutus	-	--	--	--		
Dubiraphia	-	--	1	--		
Haliplus	-	--	--	--		
Hydroporus	-	--	--	1		
Laccophilus	-	--	--	--		
Stenelmis	-	--	--	--		
Optioservus	-	--	--	--		
Collembola						
Isotomurus	-	--	--	--		
Diptera (two-winged flies)						
Ablabesmyia	-	1	--	5		
Apsectrotahypus	-	--	--	--		
Brillia	-	--	--	--		
Chaoboris	-	--	--	--		
Chironomus	-	--	1	--		
Cladotanytarsus	-	--	--	--		
Clinotanypus	-	--	--	--		
Conchapelopia	-	--	--	--		
Corynoneura	-	7	--	--		
Cricotopus	-	--	--	--		
Diplocladius	-	--	--	1		
Endochironomus	-	1	3	--		
Eukiefferiella	-	--	--	--		
Glyptotendipes	-	--	--	--		
Hemerdoromia	-	--	--	--		
Labrundinia	-	--	--	--		
Limnochironomus	-	--	1	--		
Microspectra	-	--	--	2		
Microtendipes	-	5	2	--		
Orthocladius	-	4	1	--		
Palpomyia	-	--	--	--		
Phaenopsectra	-	--	--	--		
Polypedilum	-	3	1	--		
Procladius	-	--	--	--		
Prodiamesa	-	--	--	--		

Table 18.--Benthic invertebrates in streams at the National Lakeshore, November 1978 - July 1980--Continued

Kintzele Ditch												Dunes Creek					
K2			K3			K6			K7			DC2			DC7		
Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980
—	SUBSTRATES VANDALIZED	—	—	—	2	1	—	—	SUBSTRATES LOST BECAUSE SITE DREDGED	11	10	SUBSTRATES VANDALIZED	2	1	—	—	—
—		47	—	—	9	87	496	—		36	7		2	—	—	—	—
—		—	—	—	—	—	—	—		—	—		—	—	—	—	—
—		2	—	5	8	—	—	—		—	—		64	106	5	—	103
—		4	17	5	—	—	—	—		—	—		—	—	—	—	—
—		—	—	—	—	—	—	—		—	—		—	—	—	—	—
20		79	10	2	42	—	—	—		1	—		15	34	26	56	11
—		—	—	—	—	—	—	—		—	—		—	—	—	—	—
2		1	—	—	—	—	—	—		—	—		—	1	—	1	—
—		—	—	—	—	—	—	—		—	—		—	—	—	—	1
—		—	—	—	—	—	—	—		—	—		2	—	—	—	—
—		—	—	—	—	—	—	—		—	—		—	—	—	—	—
—		—	—	—	—	—	—	—		—	—		—	—	—	—	—
—		—	—	—	—	—	—	—		—	—		1	—	—	1	—
—		—	—	—	—	—	—	—		—	—		—	—	—	—	—
—		—	—	—	—	—	—	—		—	—		—	—	—	—	—
—		—	—	—	—	—	—	—		—	—		—	—	—	—	—
1		—	—	—	—	—	—	—		—	—		—	—	—	—	—
—		—	—	1	—	—	—	—		—	—		1	—	—	—	—
—		—	—	—	—	1	—	—		—	—		—	—	—	—	—
—		—	—	—	—	13	—	—		—	—		—	—	—	1	—
—		—	—	—	—	—	—	—		—	—		—	—	—	—	—
—		—	—	—	—	8	—	—		—	—		—	—	—	—	—
—		—	—	—	—	—	—	—		—	—		—	—	—	—	—
—		3	—	49	—	10	—	5		—	—		—	—	4	6	25
—		—	—	—	—	—	—	—		—	—		—	—	—	10	—
—		—	—	—	—	—	—	2		2	—		—	—	—	—	—
—		—	—	—	—	—	—	—		—	—		—	—	—	—	—
—		—	—	—	—	—	—	—		—	—		—	—	—	—	—
—		—	1	—	—	—	—	—		—	—		—	—	—	—	—
—		—	—	—	—	—	—	—		—	—		—	—	2	—	—
—		—	—	—	—	—	—	—		—	—		—	—	—	—	—
—		—	—	—	—	—	—	—		—	—		—	—	—	—	—
—		—	—	—	—	—	—	—		—	—		—	—	—	—	—
—		—	—	—	—	—	—	—		—	—		—	—	—	—	—
—		—	—	—	—	—	—	—		—	—		—	—	—	—	—
—		—	—	—	1	—	—	10		—	—		—	—	—	—	—
—		—	—	—	—	—	—	—		—	—		—	—	—	—	—
—		—	—	—	—	—	—	—		—	—		13	—	—	19	7
—		—	—	—	—	—	—	—		—	—		—	—	—	—	—
—		—	—	—	—	—	—	—		—	—		1	—	—	—	—
—		—	—	—	—	—	—	—		—	—		—	—	—	—	—
—		—	—	—	—	—	—	—		—	—		—	—	—	8	—
—		—	—	2	—	—	—	2		1	—		—	—	—	—	—
—		—	—	—	—	—	—	—		—	—		—	—	—	—	7

Table 18.--Benthic invertebrates in streams at the National Lakeshore, November 1978 - July 1980--Continued

Organism	Grand Calumet River lagoons					
	East GC1			West GC2		
	Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980
Arthropoda--continued						
Insecta--continued						
Diptera (two-winged flies)--continued						
Psectrocladius	--	--	---	---	---	---
Psectrotanypus	--	--	---	---	---	---
Rheotanytarsus	--	--	---	---	---	---
Simulium	--	--	---	---	---	---
Stictochironomus	--	--	---	---	---	---
Tanypus	--	--	---	---	---	---
Tanytarsus	--	--	---	---	---	---
Tipula	--	--	---	---	---	---
Unknown Empididae	--	--	---	---	---	---
Ephemeroptera (may flies)						
Baetis	--	--	---	---	---	1
Caenis	2	6	8	---	9	---
Stenacron	--	--	---	---	---	---
Stenonema	--	--	---	---	---	---
Hemiptera (true bugs)						
Lethocerus	--	--	---	1	---	---
Plea	--	--	---	---	---	1
Sigara	1	--	---	---	---	---
Megaloptera (hellgrammites)						
Chauliodes	--	--	---	---	---	---
Corydalus	--	--	---	---	---	---
Nigronia	--	--	---	---	---	---
Sialis	--	--	---	---	---	---
Odonta (dragonflies and damselflies)						
Agria	--	--	---	---	---	---
Calopteryx	--	--	---	---	---	---
Chromagrion	5	--	---	44	---	---
Helocordulia	--	--	---	---	---	---
Ischnura	--	7	---	---	110	---
Macromia	--	--	---	---	---	---
Neurocordulia	--	--	---	---	2	---
Pachlydiplax	--	--	---	---	---	---
Perithemus	--	--	---	---	---	---
Tetragoneuria	1	--	---	---	---	---
Plecoptera (stoneflies)						
Taeniopteryx	--	--	---	---	---	---
Tricoptera (caddisflies)						
Anthripsodes	--	--	---	---	---	2
Cheumatopsyche	--	--	---	---	---	---
Chimarra	--	--	---	---	---	---
Hydropsyche	--	--	---	---	---	---
Leptocerus	--	--	---	---	3	---
Nectopsyche	--	--	---	---	6	---
Neotrichia	2	--	---	---	---	---
Neureclipsis	--	--	---	---	---	---
Oecetis	--	--	---	4	15	---
Orthotrichia	--	1	---	---	---	---
Platycentropus	--	--	---	---	---	---
Ptilostomis	--	--	---	---	---	---
Pycnopsyche	--	--	---	---	---	---

Table 18.--Benthic invertebrates in streams at the National Lakeshore, November 1978 - July 1980--Continued

Little Calumet River														
LC1			LC2			LC3			LC6			LC7		
Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980
S	--	--	--	--	1	--	3	1	--	--	2	--	--	2
U	--	--	--	--	--	--	--	--	--	--	--	--	--	--
B	--	--	--	--	--	--	--	--	--	--	--	--	1	--
S	--	--	--	--	--	--	--	--	--	--	--	--	--	1
T	--	--	--	--	--	--	--	--	--	--	--	--	--	--
R	--	--	--	--	--	--	--	--	--	--	--	--	--	--
A	--	--	--	--	--	--	--	--	--	--	--	--	--	--
T	--	--	--	--	--	--	--	--	--	--	--	--	--	--
E	--	--	--	--	--	--	--	--	--	--	--	--	--	--
L	--	--	--	--	--	--	--	--	--	--	--	2	2	3
O	--	--	--	--	--	--	--	--	--	--	--	--	--	--
S	--	--	--	--	--	--	--	--	--	--	4	--	--	--
T	--	--	--	--	--	1	--	27	2	45	--	5	32	2
B	--	--	--	--	--	--	--	--	--	--	--	--	--	--
E	--	--	--	--	--	--	--	--	--	--	2	--	--	--
C	--	--	--	--	--	--	--	--	--	--	--	--	--	--
A														
U	--	--	--	--	--	--	--	--	--	--	--	1	--	--
S	--	--	--	--	--	--	--	--	--	--	--	--	--	2
E	--	--	--	--	--	--	--	--	--	--	--	--	2	--
	--	--	--	--	--	--	--	--	--	1	--	--	--	--
S														
I	--	--	--	--	--	--	--	--	--	--	--	--	--	--
T	--	--	--	--	--	4	--	--	--	--	--	--	--	--
E	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--	--	--	--
D	3	--	--	--	1	--	--	--	--	--	--	--	1	--
R	--	--	--	--	--	--	--	--	--	--	--	--	--	--
E	--	--	--	--	--	--	--	--	--	--	--	--	--	--
D	--	--	--	--	--	--	--	--	--	--	1	--	--	--
G	--	--	--	--	--	--	--	--	--	--	--	--	--	--
E	--	--	--	--	--	--	--	--	--	--	--	--	--	--
D														
	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--	--	7	2
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Table 18. -- Benthic invertebrate in streams at the National Lakeshore, November 1978 - July 1980--Continued

Organism	Derby ditch					
	D1			D3		
	Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980
Arthropoda-continued						
Insecta-continued						
Diptera (two-winged flies)-continued						
Psectrocladius	-	5	--	--	D	D
Psectrotanypus	-	--	--	--	R	R
Rheotanytarsus	-	1	--	--	Y	Y
Simulium	-	--	--	--		
Stictochironomus	-	--	--	--		
Tanypus	-	--	--	--		
Tanytarsus	-	1	--	--		
Tipula	-	--	1	--		
Unknown Empididae	-	2	--	--		
Ephemeroptera (may flies)						
Baetis	-	8	--	--		
Caenis	-	--	--	--		
Stenacron	-	--	--	--		
Stenonema	-	--	--	--		
Hemiptera (true bugs)						
Lethocerus	-	--	--	--		
Plea	-	--	--	--		
Sigara	-	--	--	--		
Megaloptera (hellgrammites)						
Chauliodes	-	--	--	1		
Corydalus	-	--	--	--		
Nigronia	-	--	--	--		
Sialis	-	--	--	--		
Odonta (dragonflies and damselflies)						
Agria	-	1	--	--		
Calopteryx	-	--	--	--		
Chromagrion	-	--	--	--		
Helocordulia	-	--	--	--		
Ischnura	-	--	--	--		
Macromia	-	--	--	--		
Neurocordulia	-	--	--	--		
Pachlydiplax	-	--	--	--		
Perithemus	-	--	--	--		
Tetragoneuria	-	--	--	--		
Plecoptera (stoneflies)						
Taeniopteryx	-	--	1	--		
Tricoptera (caddisflies)						
Anthripsodes	-	--	--	--		
Cheumatopsyche	-	--	--	--		
Chimarra	-	--	--	--		
Hydropsyche	-	--	--	--		
Leptocerus	-	--	--	--		
Nectopsyche	-	--	--	--		
Neotrichia	-	--	--	--		
Neureclipsis	-	--	--	--		
Oecetis	-	--	--	--		
Orthotrichia	-	--	--	--		
Platycentropus	-	--	--	--		
Ptilostomis	-	--	--	--		
Pycnopsyche	-	--	--	--		

Table 18. -- Benthic invertebrate in streams at the National Lakeshore, November 1978 - July 1980--Continued

Kintzele ditch												Dunes Creek					
K2			K3			K6			K7			DC2			DC7		
Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980
—	S	—	—	—	—	—	—	—	S	—	—	S	—	—	—	2	—
—	U	—	—	—	—	—	—	—	U	1	—	U	—	—	—	—	—
—	B	—	—	—	—	—	—	—	B	—	—	B	—	—	—	—	—
—	S	—	1	—	—	—	—	—	S	—	—	S	—	—	—	—	—
—	T	—	—	—	—	—	—	—	T	—	—	T	8	1	—	119	216
—	R	—	—	—	—	—	—	1	R	11	—	R	—	—	—	—	—
—	A	—	—	3	—	—	—	—	A	—	—	A	—	—	—	13	—
3	T	—	—	—	—	1	—	—	T	—	—	T	—	—	—	—	—
—	E	—	—	—	—	—	—	—	E	—	—	E	—	—	—	—	—
	S								S			S					
—		7	—	—	—	—	—	—		—	—		2	—	—	—	—
—	V	—	—	—	—	—	—	—	L	—	—	V	—	—	—	—	—
—	A	—	—	—	—	—	—	—	O	—	—	A	—	—	—	—	—
—	N	2	—	—	—	—	—	—	S	—	—	N	201	3	1	—	—
	D								T			D					
—	A	—	—	—	—	—	—	—		—	—	A	—	—	—	—	—
—	L	—	—	—	—	—	—	—	B	—	—	L	—	—	—	—	—
—	I	—	—	—	—	—	—	—	E	—	—	I	—	—	—	—	—
	Z								C			Z					
—	E	—	—	—	—	—	—	—	A	—	—	E	—	—	—	—	—
—	D	—	—	—	—	—	—	—	U	—	—	D	—	—	—	—	—
—		—	—	—	—	—	—	—	S	—	—		—	—	—	—	—
—		—	—	—	—	—	—	—	E	—	—		—	—	—	—	3
—		—	—	—	—	—	—	—	S	—	—		—	—	—	—	—
—		—	—	—	—	—	—	—	I	—	—		1	—	—	—	—
—		—	—	—	—	6	—	—	T	—	—		—	—	—	—	—
—		—	—	—	—	—	—	—	E	—	—		—	—	—	1	—
—		—	—	6	—	—	—	—		3	—		—	—	—	—	—
—		—	—	—	—	—	—	—	D	—	—		—	1	—	—	—
—		—	—	—	—	—	—	—	R	—	—		—	—	—	—	—
—		—	—	—	—	—	—	—	E	—	—		—	—	—	—	—
—		—	—	—	—	—	—	—	D	—	—		—	—	—	3	—
—		—	—	—	—	—	—	—	G	—	—		—	—	—	—	—
									E								
—		—	—	—	—	—	—	—	D	—	—		—	—	—	—	—
—		—	—	—	—	—	—	—		—	—		—	—	—	—	—
3		—	—	—	—	—	—	—		—	—		—	—	—	—	—
—		—	—	—	—	—	—	—		—	—		—	—	—	—	—
2		—	—	—	—	—	—	—		—	—		—	—	—	—	—
—		—	—	—	—	—	—	—		—	—		—	—	—	—	—
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—		—	—	—	—	—	—	—		—	—		—	—	—	—	—
—		—	—	—	—	—	—	—		—	—		—	—	—	—	—
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—		—	—	—	—	—	—	—		—	—		—	—	—	—	—
—		—	—	—	1	—	—	—		—	—		—	—	—	—	—
—		—	—	2	—	—	—	—		—	—		—	—	1	1	—
—		—	—	—	—	—	—	—		—	—		—	—	—	—	—

Table 18. -- Benthic invertebrate in streams at the National Lakeshore, November 1978 - July 1980--Continued

Organism	Grand Calumet River Lagoons					
	East GC1			West GC2		
	Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980
Mollusca						
Bivalva (clams)						
Sphaerium	--	--	---	---	---	---
Gastropoda (snails)						
Amnicola	--	1	---	---	---	---
Ferrissia	1	58	194	---	---	---
Gyraulus	--	2	12	---	---	---
Helisoma	--	--	---	---	---	---
Limnaea	--	--	---	---	---	---
Physa	3	1	---	2	14	---
Planorbula	9	--	---	---	---	---
Promenetus	--	1	---	---	---	---
Valvata	--	2	1	---	---	---
Viviparus	--	--	---	---	---	---
Platyhelminthes (flatworms)						
Turbellaria	--	--	---	---	---	---

Table 18. -- Benthic invertebrate in streams at the National Lakeshore, November 1978 - July 1980--Continued

Little Calumet River														
LC1			LC2			LC3			LC6			LC7		
Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980
SUBSTRATE LOST SITE DREDGED	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	--	--	5	2	1	6	--	--	--	--	--	--	1	--
	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	--	--	1	--	--	--	--	--	--	--	--	--	--	--
	--	--	1	--	--	--	--	--	--	--	--	--	--	--
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	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	1	--	--	--

Table 18. -- Benthic invertebrate in streams at the National Lakeshore, November 1978 - July 1980--Continued

Organism	Derby ditch					
	D1			D3		
	Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980
Mollusca					D	D
Bivalva (clams)					R	R
Sphaerium	-	--	---	42	Y	Y
Gastropoda (snails)						
Amnicola	-	--	---	---		
Ferriasia	3	16	---	---		
Gyraulus	-	--	---	---		
Helisoma	-	--	---	---		
Limnaea	-	2	---	---		
Physa	-	--	---	6		
Planorbula	-	--	---	---		
Promenetus	-	--	---	---		
Valvata	-	--	---	---		
Viviparus	-	--	---	---		
Platyhelminthes (flatworms)						
Turbellaria	-	--	---	---		

Table 18. -- Benthic invertebrate in streams at the National Lakeshore, November 1978 - July 1980--Continued

Kintzele ditch												Dunes Creek					
K2			K3			K6			K7			DC2			DC7		
Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980	Nov. 1978	Aug. 1979	July 1980
	S V								S S			S V					
	U A								U I			U A					
--	B N	--	2	---	--	--	---	--	B T	--	--	B N	---	--	--	---	---
	S D								S E			S D					
--	T A	--	--	---	--	--	---	--	T	--	--	T A	---	--	--	---	---
--	R L	--	4	158	33	--	---	1	R D	--	1	R L	---	--	--	1	---
--	A I	--	--	---	2	--	---	--	A R	--	--	A I	---	--	--	---	---
--	T Z	--	--	5	2	--	---	--	T E	--	--	T Z	---	--	--	---	---
--	E E	--	--	---	--	--	---	--	E D	--	--	E E	---	--	--	---	---
--	S D	--	--	5	11	1	---	1	S G	39	5	S D	2	3	--	4	2
--		--	--	---	--	--	---	--	E	--	--		---	--	--	---	---
--		--	--	---	--	--	---	--	L D	--	--		---	--	--	---	---
--		--	--	---	--	--	---	--	O	--	--		---	--	--	---	---
--		--	--	---	--	--	---	--	S	--	--		---	1	--	---	---
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