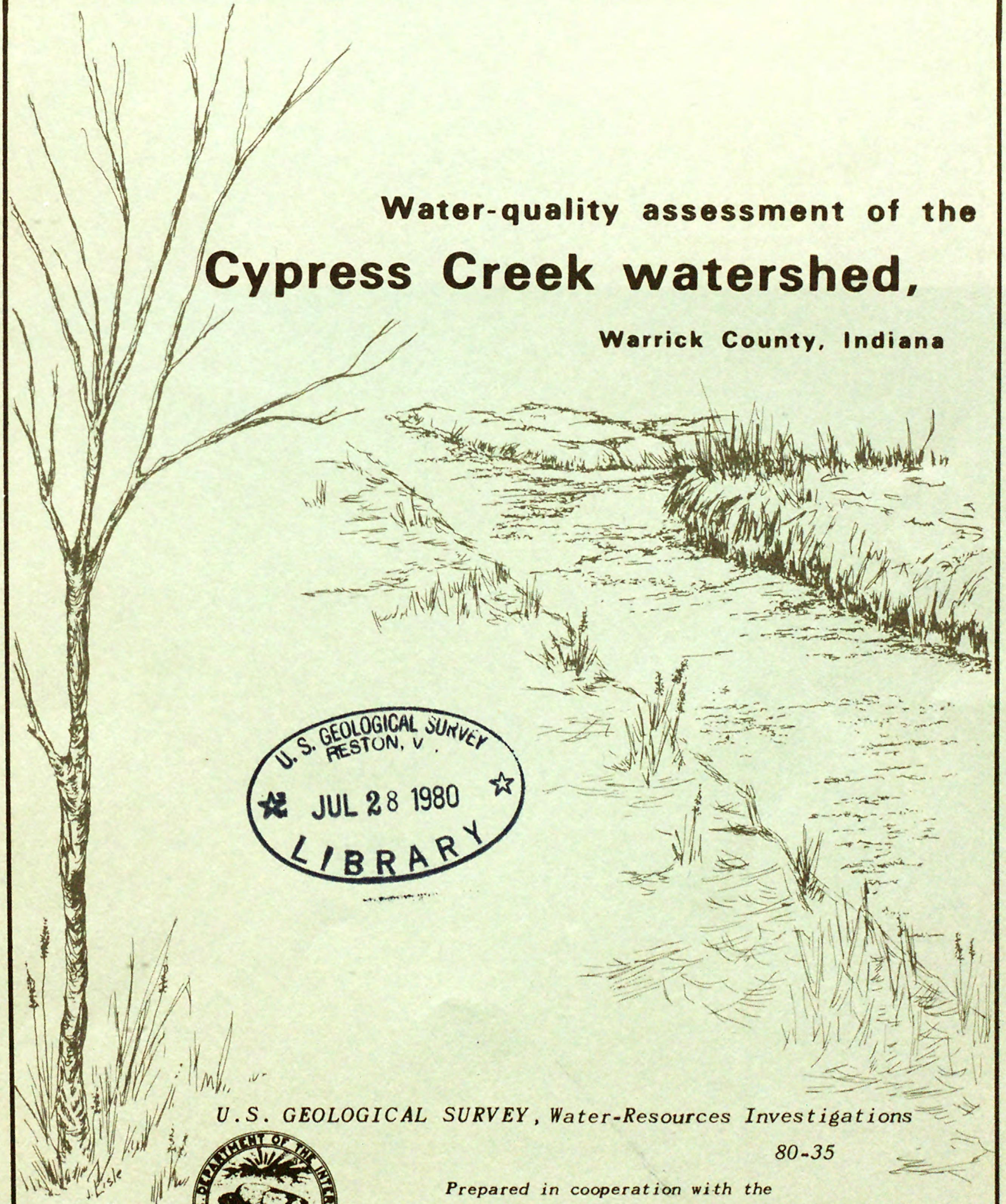
Water-quality assessment of the

Cypress Creek watershed,

Warrick County, Indiana



U.S. GEOLOGICAL SURVEY, Water-Resources Investigations 80-35

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U.S. Department of Agriculture, Soil Conservation Service

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Past and present surface coal mining is the factor having the greatest impact on water quality in the watershed. The general water type of Cypress Creek and most of its tributaries is calcium and magnesium sulfate. The water type at background site 21 on Summer Pecka ditch is calcium sulfate. Specific conductance ranged from 470 to 4,370 micromhos per centimeter at 25 degrees Celsius, and pH ranged from 1.2 to 8.8. Specific conductance, hardness, and concentrations of major ions and dissolved solids were highest in tributaries affected by mining. The pH was lowest in the same tributaries. Concentrations of iron, manganese, and sulfate in water samples and chlordane, DDT, and PCB's (polychlorinated biphenyls) in streambed samples exceeded water-quality limits set by the U.S. Environmental Protection Agency. The Boonville sewage-treatment plant, immediately upstream from site 2 on Cypress Creek, is probably responsible for that site having the highest concentrations of nitrogen and phosphorus in water and streambed samples and the highest PCB concentration in streambed samples in the watershed.

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METRIC CONVERSION FACTORS

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

Multiply inch-pound-system unit	By	To obtain metric unit
inch (in)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square foot (ft^2)	0.0929	square meter (m^2)
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)
acre	0.4047	hectare (ha)
acre-foot	1,233	cubic meter (m^3)

WATER-QUALITY ASSESSMENT OF THE CYPRESS CREEK WATERSHED, WARRICK COUNTY, INDIANA

By Linda L. Bobo and Charles A. Peters

ABSTRACT

The U.S. Soil Conservation Service needs chemical, biological, microbiological, and hydrological data to prepare an environmental evaluation of the water quality in the Cypress Creek watershed before alternatives can be devised to (1) improve surface-water quality, (2) minimize flooding, (3) reduce sedimentation, and (4) provide adequate outlets for drainage in the watershed. The U.S. Geological Survey obtained these data for the Soil Conservation Service in a water-quality survey of the watershed from March to August 1979. Alternatives to the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress) may also be devised to improve water-quality conditions.

Past and present surface coal mining is the factor having the greatest impact on water quality in the watershed. The upper reaches of Cypress Creek receive acid-mine drainage from a coal-mine waste slurry during periods of intense rainfall. All the remaining tributaries, except Summer Pecka ditch, drain mined or reclaimed lands.

The general water type of Cypress Creek and most of its tributaries is calcium and magnesium sulfate. In contrast, the water type at background site 21 on Summer Pecka ditch is calcium sulfate.

Specific conductance ranged from 470 to 4,370 micromhos per centimeter at 25 degrees Celsius, and pH ranged from 1.2 to 8.8. Specific conductance, hardness, and concentrations of major ions and dissolved solids were highest in tributaries affected by mining. The pH was lowest in the same tributaries.

Concentrations of iron, manganese, and sulfate in water samples and chlordane, DDT, and PCB's (polychlorinated biphenyls) in streambed samples exceeded water-quality limits set by the U.S. Environmental Protection Agency.

The Boonville sewage-treatment plant, immediately upstream from site 2 on Cypress Creek, is probably responsible for that site having the highest concentrations of nitrogen and phosphorus in water and streambed samples and the highest PCB concentration in streambed samples in the watershed.

Suspended-sediment concentration in Cypress Creek ranged from 91 to 776 micrograms per kilogram and increased with streamflow, which ranged from 4.26 to 2,300 cubic feet per second. A sieve analysis indicated that the particles being transported downstream in Cypress Creek during low flow on August 14, 1979, were 96 percent silt-and-clay size and 4 percent sand size.

INTRODUCTION

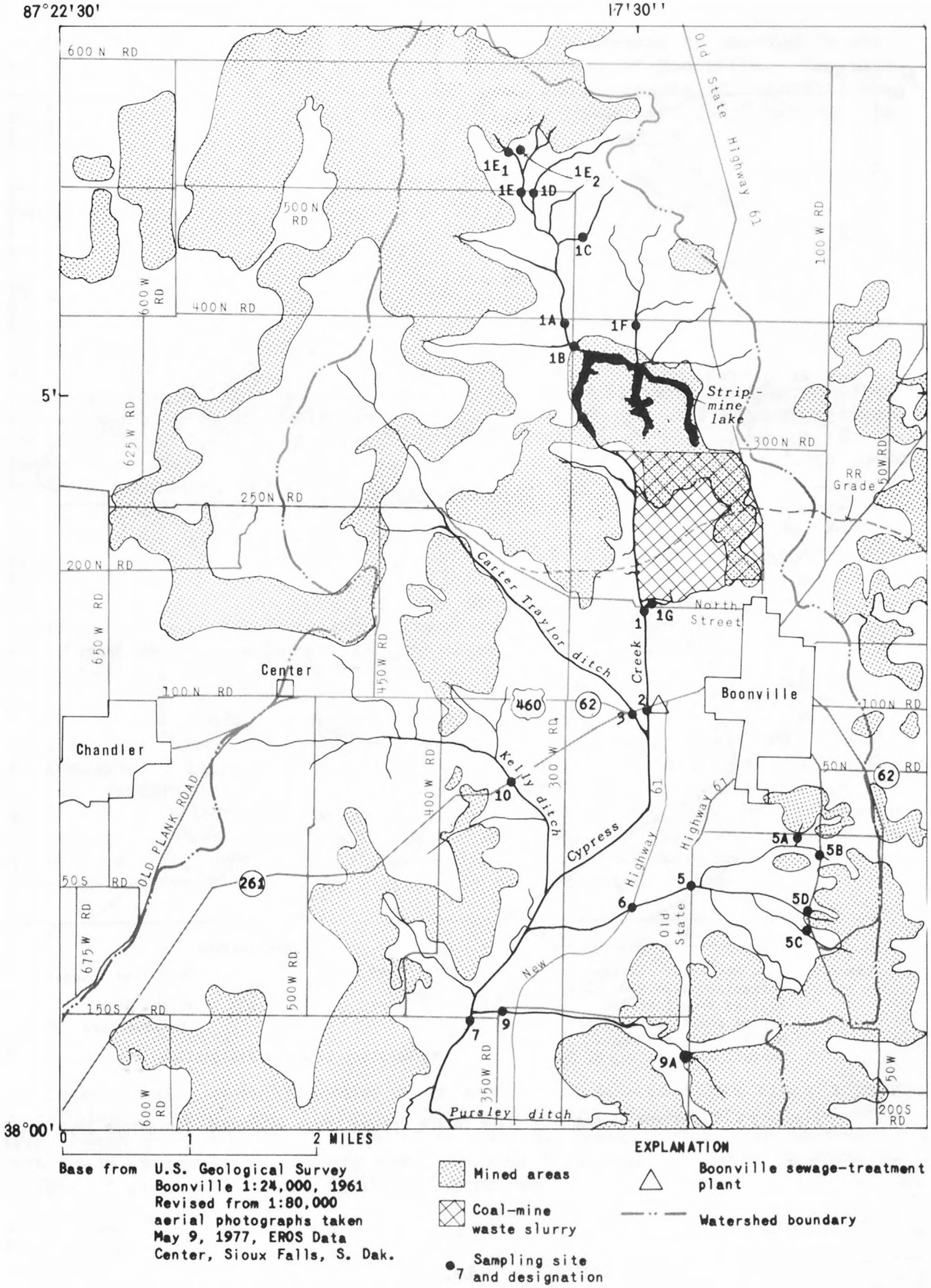
The main stem of Cypress Creek begins north of Boonville, Ind., and flows approximately 10 mi south into the Ohio River. The creek drains approximately 90 mi^2 (square miles) of nearly flat farmland and reclaimed strip-mine land in Warrick County in southwestern Indiana. Drainage areas (DA) for selected sites in the watershed are listed in the table that follows:

Cypress Creek		Tributaries of Cypress Creek	
Site	DA (mi^2)	Site	DA (mi^2)
1	8.8	5	2.1
2	9.7	9	.7
11	32.4	12	1.3
19	44.0	21	1.4

The far northern segment of Cypress Creek (north of Boonville) drains through old reclaimed surface coal-mine lands into a large surface coal-mine lake and then flows from the lake through reclaimed and unreclaimed surface coal-mine lands (fig. 1). The unreclaimed land contains a coal-mine waste slurry. The slurry area, northeast of site 1 (Cypress Creek), contains several low-pH tributaries (fig. 1) that drain into Cypress Creek during intense rainfall. However, during low flow, sediment dams restrict flow from these tributaries into Cypress Creek. Also, these tributaries have a significantly lower pH during low flow. Further downstream, the Boonville sewage-treatment plant is located north of sampling site 2 near State Highway 62 (fig. 1). The remaining downstream sites on Cypress Creek drain through primarily agricultural areas.

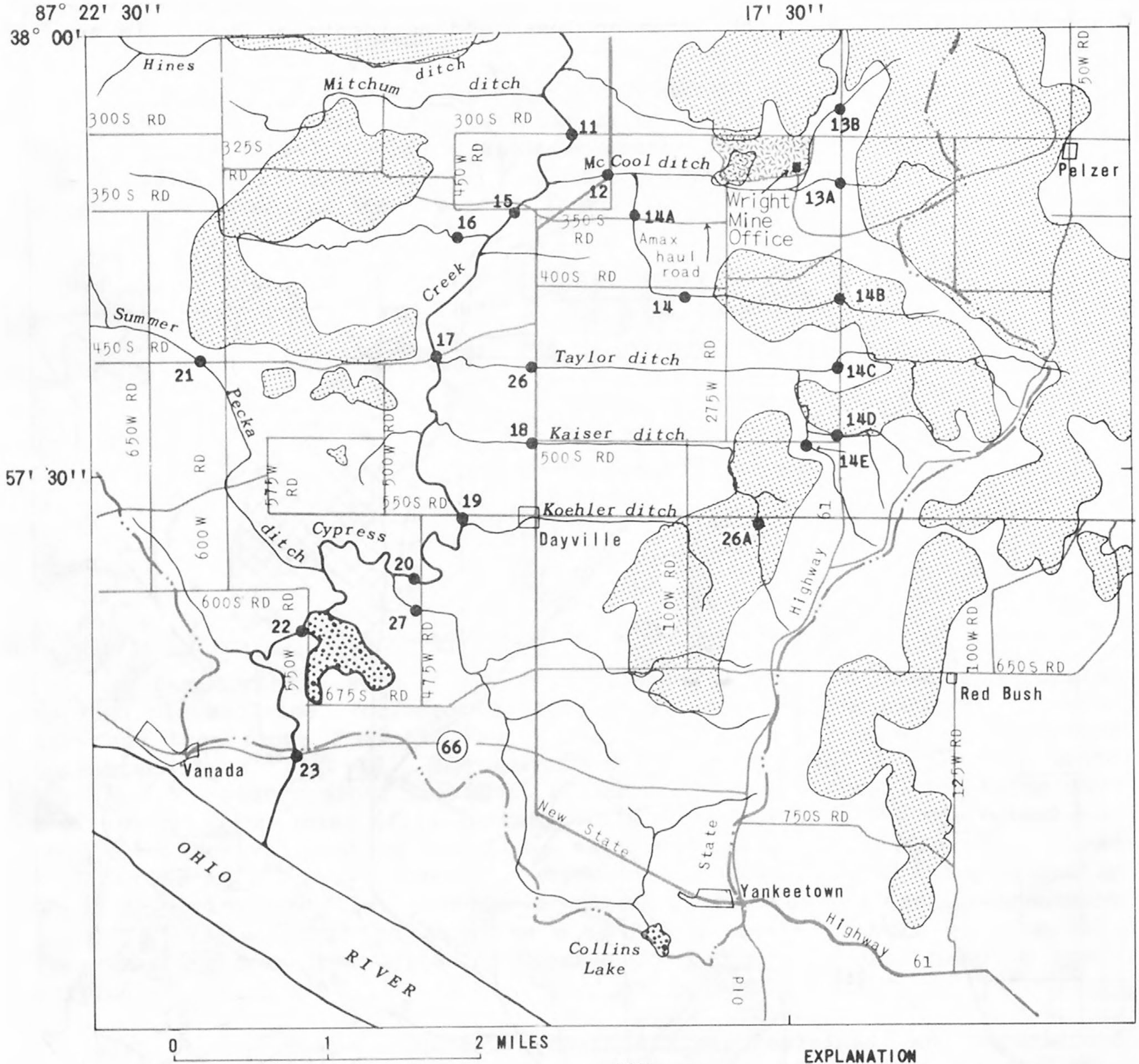
Most Cypress Creek tributaries drain active, reclaimed, and unreclaimed surface coal-mine lands (figs. 1 and 2). Summer Pecka ditch is the only tributary not flowing through surface coal-mine lands. However, Amax coal-mining operations are almost adjacent to the tributary several miles northwest of site 21.

Even though land use along Cypress Creek is approximately 65 percent cropland, 10 percent pasture, 10 percent woodland, and 15 percent surface coal-mine land, the creek will most likely be affected by surface coal mining because of its tributary drainage (fig. 1). Local crops consist mostly of corn, soybeans, and wheat. The area contains only a small amount of wood growth along the channel and little good timberland. Trees and grass are now stabilized in various parts of surface coal-mine land. In the future, coal may be mined in both new areas and in previously mined areas.



Base from U.S. Geological Survey Boonville 1:24,000, 1961 Revised from 1:80,000 aerial photographs taken May 9, 1977, EROS Data Center, Sioux Falls, S. Dak.

Figure 1.-- Locations of sampling sites in the Cypress Creek watershed, Boonville area.



Base from U.S. Geological Survey
Yankeetown 1:24,000, 1964
Revised from 1:80,000
aerial photographs taken
May 9, 1977, EROS Data
Center, Sioux Falls, S. Dak.

EXPLANATION

- ░ Mined areas
- ⁘ Lakes
- ●9 Sampling site and designation
- —··— Watershed boundary
- ▨ Wright Mine headquarters

Figure 2.-- Locations of sampling sites in the Cypress Creek watershed, Yankeetown area.

Of the 4,000 inhabitants in the 42,280-acre watershed in Warrick County, 300 are farmers and 2,600 are residents of the town of Boonville. The size of about half the farms is 80 acres or less, and residents of Boonville are heavily employed by the mines (primarily by Peabody and Amax) and by the Alcoa plant.

Soils are mostly on or in formations of siltstone, shale or sandstone that have a silty loess cap (Shively, 1979, p. 1). Loess thickness ranges from 2.5 ft in the north part of the watershed to 20 ft in the south part. The main source of loess is the lowlands along the Wabash and Ohio Rivers to the west and south (Shively, 1979, p. 1). Soils in the north range from well to poorly drained and have slow percolation rates; soils in the south are generally poorly drained. Generally, bottom lands are flooded, terraces are wet, and uplands are eroding.

The watershed is in an unglaciated area in the Pleistocene Atherton Formation underlain by Pennsylvanian bedrock of the Dugger and Petersburg Formations of the Carbondale Group, which consists of shale, sandstone, limestone, clay, and the Danville coal member of the Dugger and Springfield coal member of the Petersburg (Gray, Wayne, and Wier, 1970).

The broad, nearly flat tract of the watershed is in the Wabash Lowland physiographic unit (Schneider, 1966, p. 48), whose average elevation is 500 ft above National Vertical Geodetic Datum (NGVD) of 1929 (formerly called "mean sea level"). The shallow channel of Cypress Creek cuts into lacustrine deposits. Unreclaimed land consists of coarse shale, sandstone, limestone, and clay, whereas reclaimed land consists of fine particles of the same materials.

During the study, mean monthly temperature ranged from 19°F (January 1979) to 76°F (July 1979) at the Spurgeon weather station (National Oceanic and Atmospheric Administration, 1979). Mean annual rainfall is 45 in. (inches), and parts of the watershed are flooded two to three times a year by intense rains. Rainfall is usually heaviest in April and lightest in October and November. Mean annual runoff is 12 in. (Hoggatt, 1962, p. 9). Maximum and minimum air temperatures and precipitation at the Spurgeon weather station from January 1979 through August 1979 are presented in figure 3.

Problems

Intense rains cause flooding on an average of two to three times a year to cropland, roads, and bridges. During flooding, backwaters of the Ohio River reach as far north as site 19 on Cypress Creek. High suspended-sediment loads, moderate and severe sheet erosion from adjacent lands, and general lack of aquatic life are additional problems.

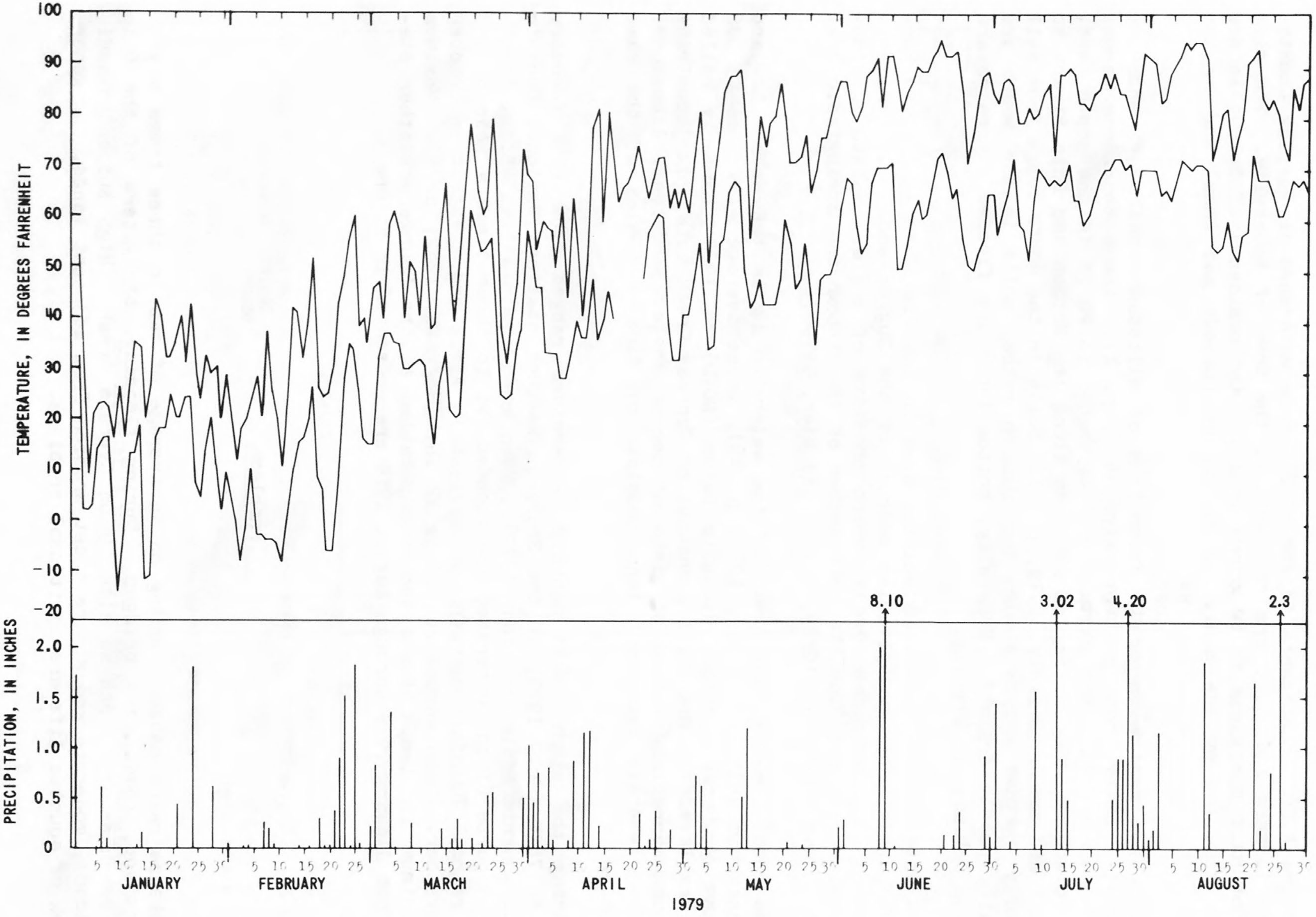


Figure 3.-- Precipitation and maximum and minimum air temperatures at the Spurgeon, Ind., weather station (data from National Oceanic and Atmospheric Administration, 1979).

The County Drainage Board cleared Cypress Creek channels of trees and woody growth and now clear new growth annually (Robert Rasely, Soil Conservation Service, written commun., March 1979). In the March 1979 reconnaissance, no growth of any kind was observed along the channels of the creek, but high suspended-sediment loads and severe erosion of streambanks and adjacent fields were observed in Cypress Creek during intense rains at this time. General lack of fishlife was also noted in the August 1979 sampling after several severe rainstorms and floods. In contrast, several carp and other aquatic animals were noted at sites 11 and 19 in the June 1979 sampling.

Purpose and Scope

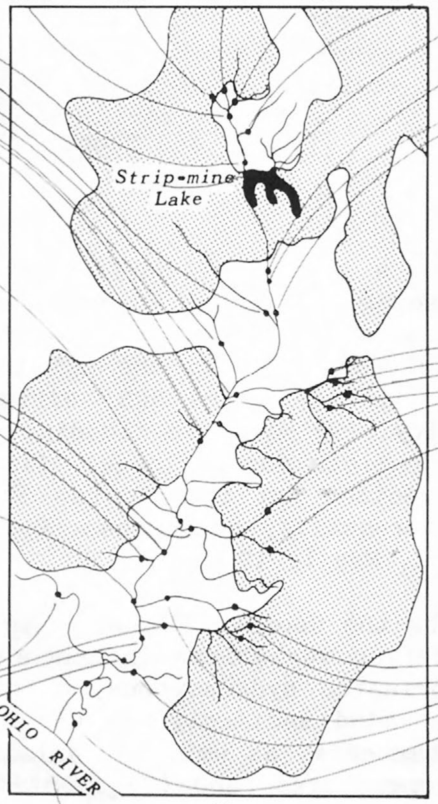
This study is one in a series of surface-water-quality assessments of watersheds by the U.S. Geological Survey in cooperation with the Soil Conservation Service (SCS). Data collected by the Geological Survey for the Cypress Creek watershed will be used by the SCS to prepare an environmental evaluation of the water quality before SCS devises alternatives to (1) improve surface-water quality, (2) minimize flooding, (3) reduce sedimentation, and (4) provide adequate outlets for drainage. Alternatives to the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress) may also be devised to improve water-quality conditions (Robert Rasely, Soil Conservation Service, oral commun., May 1, 1980).

Data were collected by the Geological Survey in March, April, June, July, and August 1979 to (1) define variations in concentrations of selected heavy metals, major ions, chlorinated hydrocarbons, nutrients (compounds of nitrogen and phosphorus), suspended sediment, organic carbon, and fecal coliform and fecal streptococcal bacteria, as well as variations in counts and identification of periphyton communities, and (2) identify possible sources of water-quality problems.

Eh, pH, specific conductance, dissolved-oxygen concentration, and water temperature were measured in a basinwide reconnaissance (table 1 and fig. 4) on March 19-21, 1979. These data (fig. 4) provided information for selecting sites for further study to assess the general water quality. Followup water-quality surveys were done at sites 1, 2, 11, and 19 (Cypress Creek) on April 10-12, June 11-13, July 25-26, August 13-14, 1979, and at sites 5, 9, 12, and 21 (tributaries) on June 11-13, 1979, to obtain data for different seasons and streamflow conditions.

Subsequent field trips involved field measurements of Eh, pH, specific conductance, and instantaneous and estimated stream discharge; collection of water samples for laboratory determination of concentrations of selected heavy metals, nutrients (nitrogen and phosphorus compounds), major ions, organic carbon (dissolved, suspended, and total), bacteria (fecal coliform and fecal streptococcus), and suspended sediments; and collection of streambed samples for the determination of concentrations of chlorinated hydrocarbons, nitrogen, phosphorus, aluminum, iron, manganese, and total organic and inorganic carbon.

10	3	1B	1A	1E	1E$_1$	1E$_2$	1D	1C	1F	1G	1	2
3/20/79	3/20/79	3/19/79	3/19/79	3/19/79	3/19/79	3/19/79	3/19/79	3/19/79	3/19/79	3/19/79	3/19/79	3/20/79
1120	1045	1555	1420	1455	1500	1505	1445	1435	1600	1600	1640	1055
12.5	12.5	13.5	13.5	13.5	13.5	12.5	13.0	12.5	13.6	—	11.5	11.6
7.4	7.2	8.0	8.2	8.1	8.2	7.6	7.8	7.5	7.2	1.7	5.1	6.4
1300	1100	2000	2000	3000	3050	1800	1200	190	315	—	1300	1200
+210	+310	+380	+350	+370	+410	+340	+390	+380	+270	—	+430	+290
10.6	10.8	10.8	10.1	10.6	13.8	10.2	11.0	11.2	9.6	—	10.6	10.5



6	9	7	11
3/20/79	3/20/79	3/20/79	3/20/79
1540	1230	1210	1550
14.5	13.5	12.5	13.0
8.2	7.7	7.0	7.1
1900	2200	1300	1400
+360	+210	+210	+200
10.6	10.8	8.9	9.2

5A	5B	5D	5C
3/21/79	3/21/79	3/21/79	3/21/79
1315	1300	1235	1220
16.5	14.9	15.3	13.5
6.5	7.9	7.0	7.4
2100	1600	1350	1200
+270	+245	+345	+330
9.6	10.4	9.1	10.2

12	15	16	17
3/20/79	3/20/79	3/20/79	3/21/79
1245	1315	1345	1500
14.0	12.5	14.0	7.2
8.1	7.3	7.8	15.3
2550	1500	860	1200
+308	+190	+310	+310
12.6	9.2	11.4	9.5

13B	13A	14C	14D
3/21/79	3/20/79	3/21/79	3/21/79
1330	1600	1410	1425
17.6	18.5	18.0	20.0
8.0	7.9	8.2	8.1
3500	2135	1450	1400
+285	+345	+370	+360
14.8	13.6	12.6	12.6

21	18	19	20
3/20/79	3/20/79	3/20/79	3/20/79
1440	1540	1500	1640
13.0	14.5	13.3	13.5
7.8	8.2	7.3	7.4
400	1900	1500	1500
+330	+360	+250	+365
10.8	15.0	9.2	9.3

22
3/20/79
1655
13.2
7.3
1500
+400
8.6

23	27	26	14E
3/20/79	3/20/79	3/20/79	3/21/79
1710	1605	1520	1430
10.5	13.5	14.0	22.0
7.2	7.9	8.3	7.9
1100	710	1850	1600
+380	+370	+300	+390
9.1	11.4	12.8	12.7

EXPLANATION

1D	Sampling site designation
3/19/79	Date (month/day/year)
1445	Military time of day, or 2:45 p.m.
13.0	Water temperature, in degrees Celsius
7.8	pH
1200	Specific conductance, in microhmos per centimeter at 25° Celsius
+390	Eh, in millivolts
11.0	Dissolved oxygen, in milligrams per liter
▨	Mined areas: active, reclaimed and unreclaimed

Figure 4.--Locations of sites and data collected in reconnaissance in the Cypress Creek watershed, March 19-21, 1979.

On July 25, 1979, a core sample was taken at a depth of 2 ft into the streambed at site 11. In addition, streambed surface samples were collected at sites 1, 2, 11, and 19. Chlorinated hydrocarbon concentrations of the core and the streambed surface samples were determined by the Geological Survey laboratory. Also, on July 25, 1979, field measurements were made at all sites (tables 2 and 3).

During an 8-week period in the summer, jumbo multiplate samplers were placed at selected sites in the stream for colonizing benthic invertebrates communities. At the same time, mylar strips were placed at selected sites in the stream for colonizing periphyton. The samplers and strips were placed at sites 1, 2, 11, and 19 (Cypress Creek) on June 13, 1979, and were collected on August 14, 1979. In addition, an Eckman[1] grab was used in attempting to collect samples of resident benthic invertebrate communities from the stream bottom at sites 1 and 19 on July 25 and August 14, 1979.

METHODOLOGY

Methods used in collecting data were those approved by the Geological Survey, through various technical memorandums and training manuals.

In the reconnaissance (fig. 4) and in subsequent field trips, pH, specific conductance, Eh (redox potential), air and water temperatures, and dissolved-oxygen concentrations were measured in the stream with a Hydrolab (multiparameter instrument). A platinum electrode and a reference electrode attached to the Hydrolab were used to measure Eh. Average values based on measurements in depth- and width-integrated cross sections are reported in figure 4 and tables 2 and 3. Low flow in June and August 1979 was measured with a pygmy meter attached to a wading rod, and high flow in April 1979 was measured with an AA flowmeter suspended from a bridge rig. Streamflow was estimated on July 25 and 26, 1979.

In low-flow conditions, the authors waded into the streams and collected samples; in high-flow conditions, they used the bridge rig and accessories to collect all stream samples from the bridge. Methods for bridge-rig sampling and stream-gaging techniques are outlined by Carter and Davidian (1968, p. 6-7) and Brown and others, (1970, p. 9-12).

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[1] The use of brand names is for identification only and does not imply endorsement by the U.S. Geological Survey.

Raw water samples were taken in depth- and width-integrated cross sections of the stream with a D.H.-48 sampler containing a 0.2-in. nozzle. A churn sample splitter was used for maximum cross-section mixing of the water sample (Ralph Pickering, written commun., December 13, 1976). Samples were filtered with the Sartorius stainless steel tank and filter system equipped with a 0.45-mm nitrocellulose filter (Ralph Pickering, written commun., April 5, 1978). The water used in all filtering processes was taken from the churn sample splitter. Water samples collected for dissolved, suspended, and total organic carbon were filtered by a Millipore silver filter organic-carbon kit (Ralph Pickering, written commun., December 28, 1976, and Goerlitz and Brown, 1972, p. 4-6). All these water samples were chilled for shipment to the Geological Survey laboratory for determination of selected inorganic and organic constituents.

The D.H.-48 suspended-sediment sampler was used for collection of width- and depth-integrated suspended sediment samples (Ralph J. Pickering, written commun., January 17, 1977; Guy and Norman, 1970; and Guy, 1970). Streambed samples for determining concentrations of chlorinated hydrocarbons, selected organic-carbon constituents, nutrients, aluminum, iron, and manganese were collected by methods suggested by Ralph J. Pickering (written commun., June 19, 1975). Samples for chlorinated hydrocarbon determination were placed in sterilized glass jars, and the remaining samples were placed in nontransparent plastic containers. A core sample 2.0 ft into the streambed was taken at site 11 by a piston-type, bed-material hand sampler (US BMH-53 corer) to determine chlorinated hydrocarbon concentrations. All these samples were chilled for shipment to the laboratory. Methods used for determination of fluvial sediments and inorganic substances in water were those outlined by Skougstad and others (1979).

Water samples for determination of fecal streptococci and fecal coliform were collected in sterilized glass bottles, were chilled immediately, and were plated within 3 hours after collection. Bacterial colonies were then counted by the Geological Survey after full incubation (24 hours at 44°C for fecal coliform and 48 hours at 35°C for fecal streptococci). Methods of collection and analysis of bacterial samples that were used are outlined by Greeson and others (1977, p. 53 and 59).

Mylar strips and jumbo multiplates were placed in the stream for the colonization and determination of periphyton populations and benthic invertebrates, respectively (Greeson and others, 1977, p. 127 and 159). Additionally, dredging of the streambed for collection of samples of resident benthic invertebrate communities was attempted with an Eckman grab as outlined in Greeson and others (1977, p. 148).

RESULTS

Field Measurements

Water temperatures generally paralleled concurrent air temperatures and seasonal variations and ranged from 10.5° to 29.2°C. The lowest temperature was at site 10 on April 10, 1979, and the highest was at sites 3 and 12 on June 12, 1979.

Specific conductance ranged from 470 to 4,370 umho/cm (micromhos per centimeter) at 25°C. The highest value was measured at site 13A on June 12, 1979. Generally, tributaries affected by past or present surface coal-mining operations had higher specific conductance values than Cypress Creek. The lowest specific conductance was measured at site 19 on Cypress Creek on July 26, 1979, probably owing to dilution after the intense rain on the evening of July 25, 1979 (figs. 5 and 6). However, the increase in specific conductance at sites 1 and 2 during high flow in July 1979 (fig. 6) was probably due to the flushout of tributaries and overland flow draining the coal-mine waste slurry just north of site 1 (fig. 1). Tributaries that drain the slurry flow into Cypress Creek only during or immediately after intense rainfall.

The pH ranged from 1.2 to 8.8. However, all but three values are within the range from 6.5 to 8.5, typical for natural streams (Hem, 1970, p. 93). The lowest pH was measured at site 1-G, on a tributary draining the coal-mine waste slurry. The highest pH was measured in June 1979 at site 15. Values of pH were lower in tributaries affected by past or present surface coal-mining operations than in Cypress Creek and were higher in August 1979 than in April 1979 at most sites. Values of pH in Cypress Creek were generally lower during periods of high flow when the creek receives drainage from low-pH tributaries, such as the one at site 1-G. The pH at sites on the tributaries did not correlate with streamflow.

Dissolved-oxygen concentration, generally near theoretical saturation at most sites, ranged from 45 (site 1, June 12, 1979) to 212 (site 18, June 13, 1979) percent of saturation (tables 2 and 3). The concentration was less than saturation at most sites in July 1979. The concentrations at sites 5 and 21 were consistently less than saturation. Flow at site 5 is from an area of reclaimed surface coal mines. Site 21 is near a pig feedlot that may contribute some organic loading. There was no correlation between dissolved-oxygen concentration and the ratio, FC/FS (fecal coliform/fecal streptococcus). Also, dissolved-oxygen concentrations were not significantly higher for high flow than for low flow.

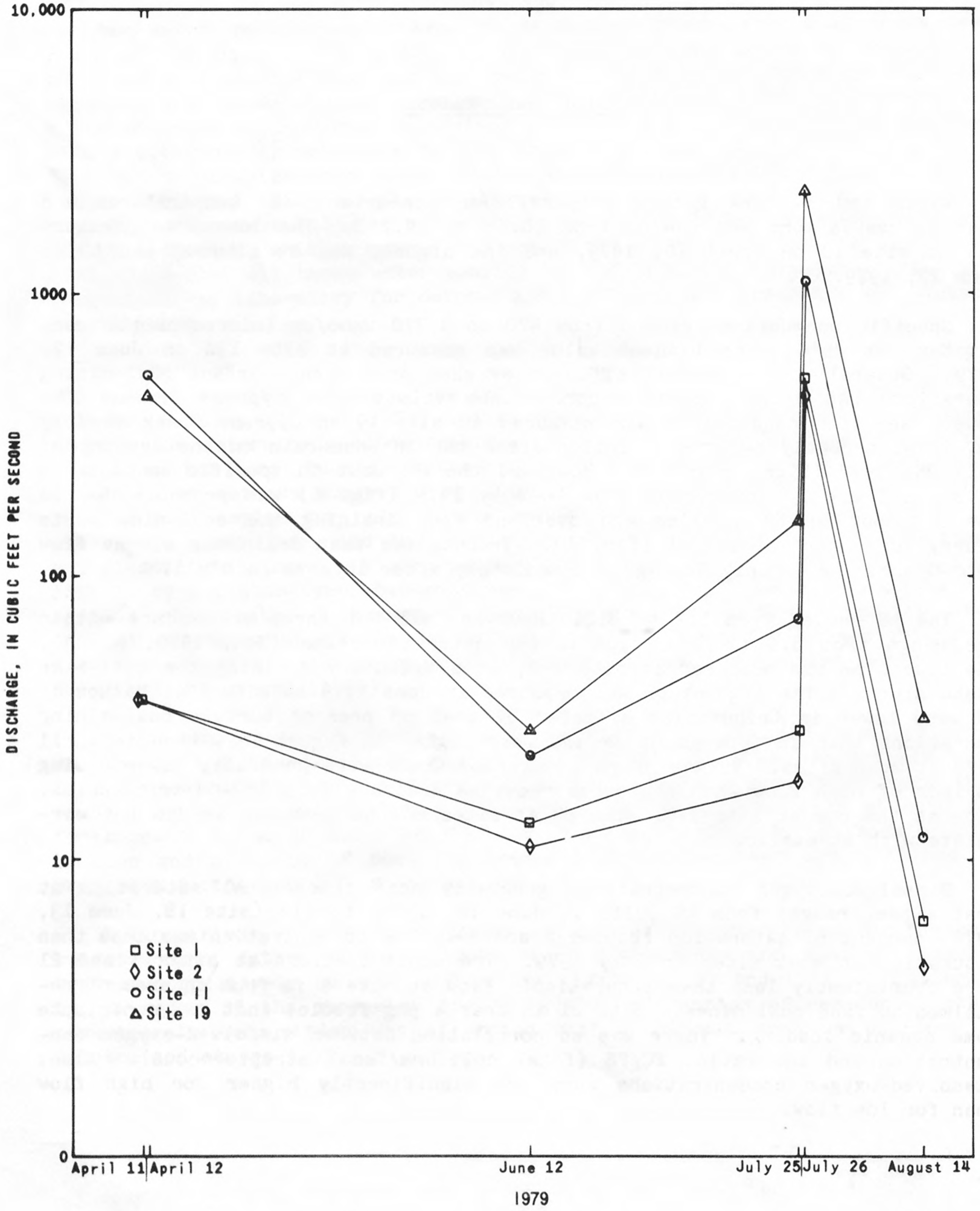

Figure 5.-- Fluctuations of stream discharge at selected sampling sites in the Cypress Creek watershed.

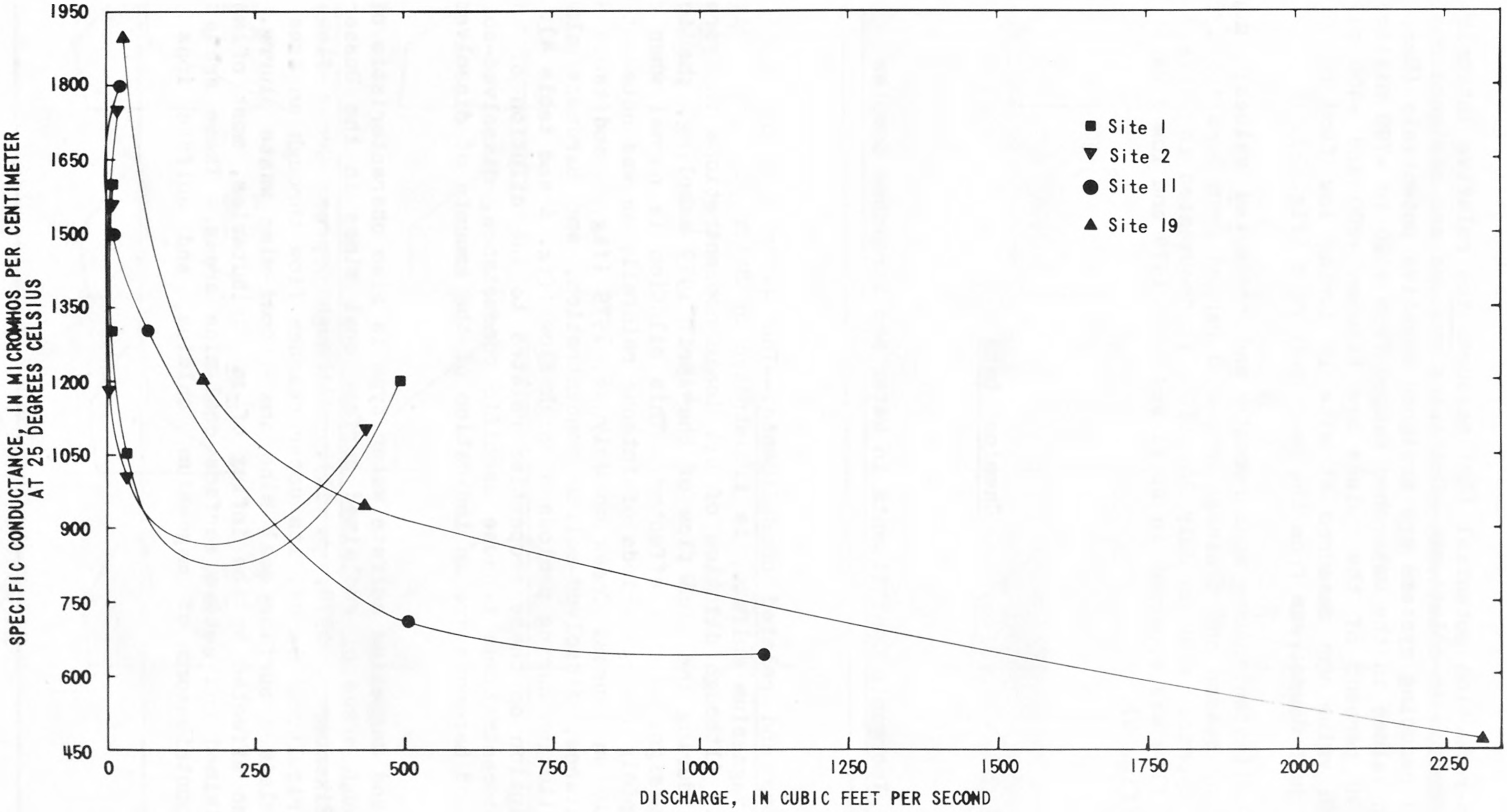

Figure 6.-- Relation of specific conductance to stream discharge in the Cypress Creek watershed.

Oxidation-reduction potential (Eh) measures the relative intensity of oxidation or reduction in solutions. Oxidizing systems are assigned positive potentials, and reducing systems are assigned negative potentials (Hem, 1970, p. 229). The Eh values in the watershed ranged from +120 to +790 millivolts. Approximately 90 percent of the values are between +200 and +400 millivolts. The lowest Eh value was measured at site 14 during low flow on August 13, 1979, a site just downstream from the Amax haul road (fig. 2).

Discharge (instantaneous measurements and estimated values), during the study varied by season and drainage area and ranged from 4.26 to 2,300 ft^3/s. The flood on Cypress Creek on July 26, 1979, is documented in table 2 and figure 5. High flow was apparent in April and July 1979 and low flow in June and August 1979 (fig. 5).

Chemical Data

Inorganic Constituents in Water and Streambed Samples

Major ions and related constituents.--The water type of Cypress Creek, calcium and magnesium sulfate, is illustrated by Stiff patterns (Stiff, 1951) in figure 7. Although dilution of all ionic concentrations in Cypress Creek was observed during the high flow of the April 1979 sampling, the ionic balance was not significantly affected. This dilution is normal when discharge increases rapidly during periods of intense rainfall, as was noted at sites 1, 2, 11, and 19 on Cypress Creek on July 26, 1979 (fig. 5 and table 4). Specific conductance, dissolved-solids concentration, and hardness also showed effects of dilution during periods of high flow (fig. 6 and table 4). The effects of dilution on these properties relates to the dilution of the cation and anion concentrations because specific conductance, dissolved-solids concentration, and hardness are an indication of the amounts of dissolved ions in water.

Calcium and magnesium sulfate water type is also characteristic of streams flowing through areas of reclaimed surface coal mines in the Busseron Creek watershed (Eikenberry, 1978, p. 11). Although Cypress Creek flows through primarily agricultural lands, its upper reaches flow through an area that includes a reclaimed surface coal mine and a coal-mine waste slurry. Cypress Creek is also affected by the influx of its tributaries, most of which flow through reclaimed and active surface coal-mine areas. These areas could be additional contributors of magnesium, calcium, and sulfate ions into the stream.

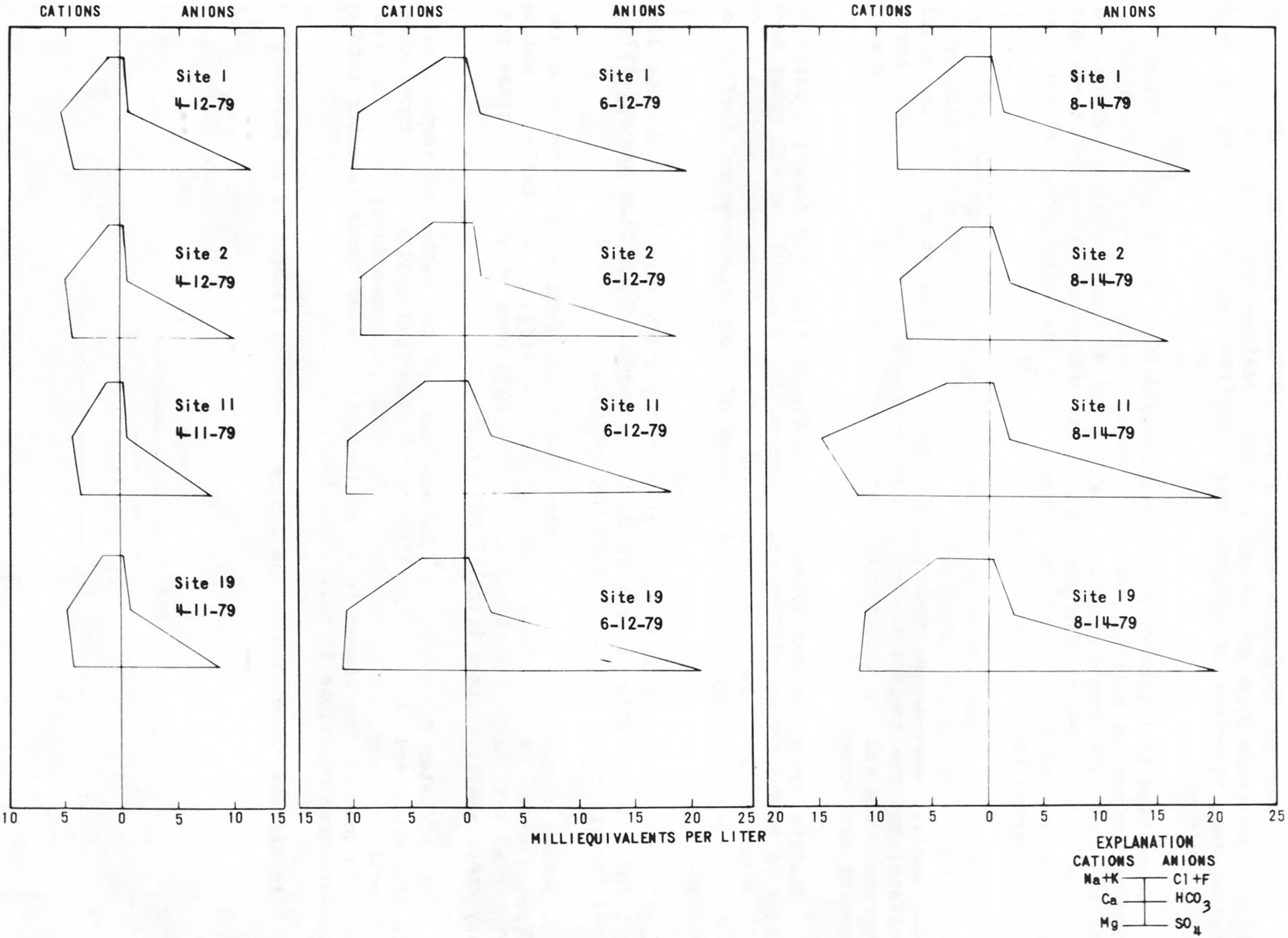

Figure 7.-- Stiff patterns representing analyses of water samples from Cypress Creek.

Water type at tributary sites 9 and 12 was magnesium sulfate. These sites, downstream from active and reclaimed surface coal-mine areas, had the highest concentrations of calcium, magnesium, and sulfate ions in the watershed (table 4).

Water type at tributary site 5 was the same as that of Cypress Creek, calcium and magnesium sulfate, but ionic concentrations were greater at site 5 for the June 1979 sampling period (figs. 7 and 8) than in Cypress Creek. Site 5 is on a tributary to Cypress Creek, just below the influx of three other tributaries that flow through reclaimed surface coal-mine lands; however, site 5 is on agricultural land (fig. 1).

Site 21, on Summer Pecka ditch, was chosen as the background site because the ditch flows through primarily agricultural land unaffected by past or present surface coal-mining operations. The water type at site 21 was calcium sulfate, and the concentrations of ions were low in comparison with those of Cypress Creek and its tributaries that flow from areas of reclaimed and active surface coal mines.

Sulfate concentrations exceeded the 250-mg/L limit for domestic water supplies (U.S. Environmental Protection Agency, 1976, p. 394) at all sites during all sampling runs except for background site 21. These high sulfate concentrations are probably due to influences of past and present surface coal mining.

Concentrations of chloride throughout the study were less than the limits set for domestic water supply (U.S. Environmental Protection Agency, 1976, p. 394) for all sites during all sampling periods.

Sodium concentrations increased downstream from site 1 to site 19 in Cypress Creek in all three sampling periods (fig. 7 and table 4) and were higher at tributary sites 9 and 12 in June 1979 than at any other sites and at any other sampling times (figs. 7 and 8).

Use of water for irrigation is dependent on the ratios of various cations in the water and the osmotic effects of dissolved solids (U.S. Environmental Protection Agency, 1976, p. 399). The SAR (sodium-adsorption ratio) can be used to predict the degree to which irrigation water tends to enter into cation-exchange reactions in soil (Hem, 1970, p. 228).

An SAR was calculated by the Geological Survey laboratory as follows:

$$\mathrm{SAR} = \frac{(\mathrm{Na}^{+})}{\sqrt{\dfrac{(\mathrm{Ca}^{+2}) + (\mathrm{Mg}^{+2})}{2}}}$$

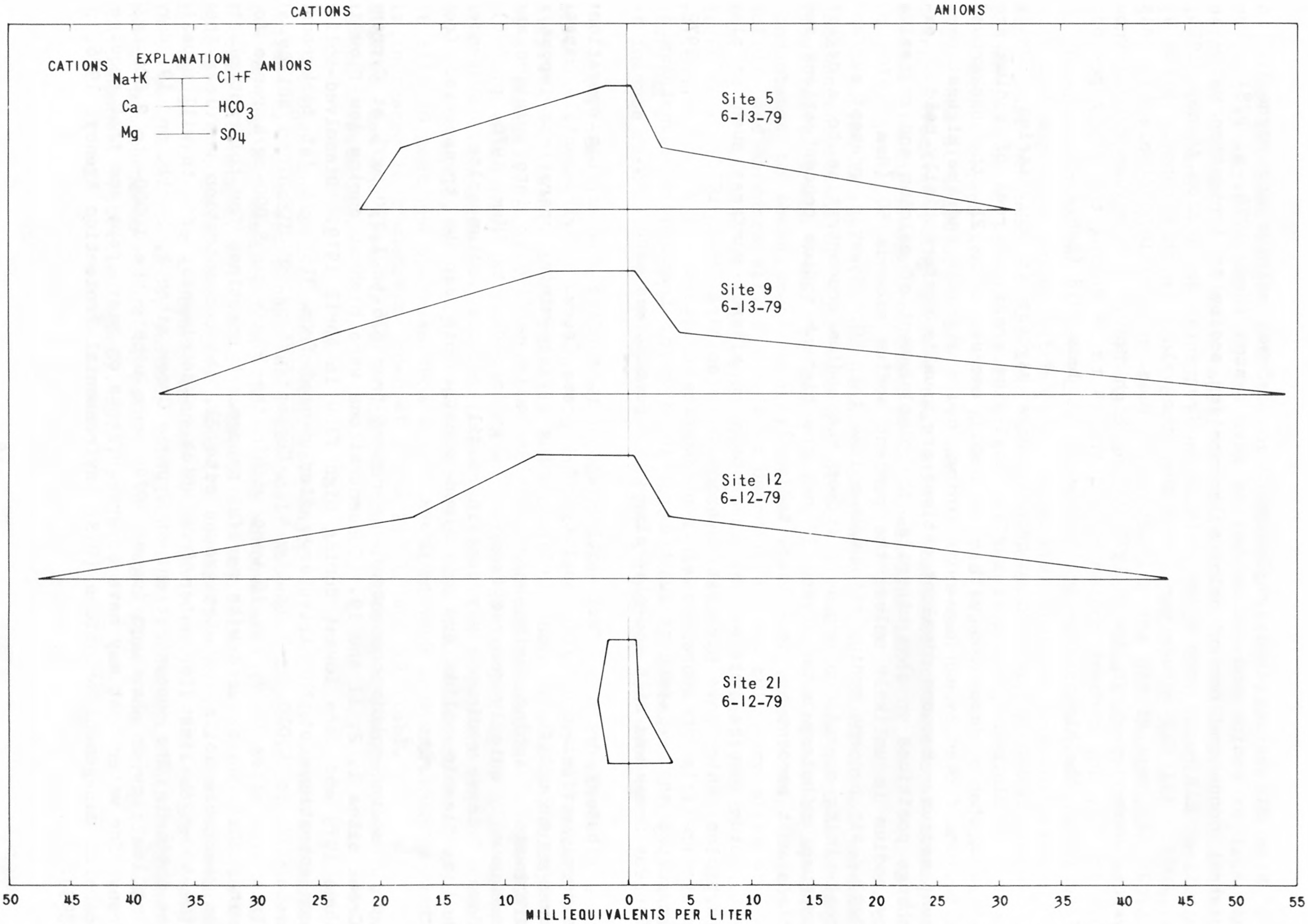

Figure 8.-- Stiff patterns representing analyses of water samples from tributaries of Cypress Creek.

High SAR values imply replacement of adsorbed calcium and magnesium in the soil by sodium and damage to the soil system (Hem, 1970, p. 228). For general crops and forages, the tolerance for sodium in irrigation water is within an SAR range from 8 to 18 (U.S. Environmental Protection Agency, 1976, p. 400). All SAR values were less than the values in this range. Sites 9, 11, 12, 19, and 21 had the highest SAR values in June 1979 (table 4). SAR values were lowest in April 1979 during high flow. SAR values ranged from 0.4 to 1.4, and percent sodium ranged from 4 to 28 during the study period. Site 21 had the highest percent sodium, 28 in June 1978 (table 4).

Even though sodium concentrations were highest in tributaries flowing through reclaimed and active surface coal-mine areas, sources of sodium are still probably deposited within the soil because site 21, the background site, unaffected by surface coal-mining, had a high SAR and the highest percent sodium. Because divalent cations are usually preferentially held in exchange positions on clay minerals, the displacement of calcium and magnesium by sodium is unlikely unless the percent sodium exceeds 50 (Hem, 1970, p. 229). All percent sodium values were less than 50. However, present surface coal-mining operations probably affect the sodium concentration to a degree because tributary sites 9 and 12 had the highest sodium concentrations and the lowest percent-sodium values (table 4).

Sodium can be retained by adsorption on mineral surfaces such as clay particles, which have high cation-exchange capacities (Hem, 1970, p. 145). A sieve analysis of suspended sediment samples collected on August 14, 1979, indicated that 96 percent of the particles being transported downstream in Cypress Creek was silt and clay size and 4 percent was sand size.

Tributary drainage from active and past surface coal-mining operations directly affect the water quality of Cypress Creek. Environmental changes such as an uplift of land surface during surface-mining operations impose a freshwater leaching regime where soluble salts readily go into solution and are usually quickly removed from coarse grain sediments (Hem, 1970, p. 146). Some of these sediments may contain readily soluble sodium salts. Suspended and settleable solids and dissolved constituents can be transported from these tributaries into Cypress Creek.

Dissolved-solids concentrations ranged from 626 to 1,790 mg/L at Cypress Creek sites 1, 2, 11 and 19. Concentrations were highest during low flow in June 1979 and were lowest during high flow in April 1979. Dissolved-solids concentrations at the tributary sites ranged from 316 mg/L (at background site 21) to 4,040 mg/L (table 4). Concentrations of dissolved solids at tributary sites 5, 9, and 12 were within the 2,000- to 5,000-mg/L range for water that can be used with careful management practices for tolerant plants on permeable soils. At background site 21, the concentration was less than the 500-mg/L limit for water from which no detrimental effects will usually be noticed. The concentrations at Cypress Creek sites 1, 2, 11, and 19, during low flow in June and August 1979, were within the 1,000- to 2,000-mg/L range for water that may have adverse effects on many crops and that requires careful management practices (U.S. Environmental Protection Agency, 1976, p. 399).

Total hardness ranged from 390 to 1,100 mg/L at Cypress Creek sites 1, 2, 11, and 19 and from 180 to 3,300 mg/L at tributary sites 5, 9, 12, and 21. Dilution effects on hardness, specific conductance, and dissolved-solids concentration were apparent during high flow in April 1979 (table 4 and fig. 9). All hardness values were greater than 300 mg/L, an indication of very hard water according to the classification set by the U.S. Environmental Protection Agency (1976, p. 147), except for the background site 21 (180 mg/L).

Hardness of water is predominantly attributable to the presence of calcium and magnesium ions, although other metals, such as iron and manganese, also cause hardness (U.S. Environmental Protection Agency, 1976, p. 147). Concentrations of all these metals, as well as hardness of water, are high at all sites, except at background site 21. The high values of hardness and major ions at tributary sites 5, 9, and 12 can probably be attributed to discharges from operating surface coal mines, abandoned surface coal mines, or streams flowing through reclaimed surface coal-mine land.

Dilution of specific conductance corresponded to dilutions of hardness and concentrations of major ions and dissolved solids during periods of high flow (tables 2 and 4 and fig. 9). Because of this relationship of specific conductance to these constituents, concentrations of major ions, dissolved solids, and hardness will also likely decrease at the tributary sites during periods of intense rainfall and high streamflow, when specific conductance decreases (table 3). The tributary sites were sampled only in June 1979, a period of low flow, but field measurements were made at the sites for each sampling period. Specific conductance values seem to decrease during periods of intense rainfall and increased streamflow throughout the watershed.

Alkalinity is the sum of components in water that tend to elevate the pH of water above a value of about 4.5 and is a measure of water-buffering capacity. Constituents that increase alkalinity include carbonates, bicarbonates, phosphates, and hydroxides (U.S. Environmental Protection Agency, 1976, p. 11). Alkalinity concentrations ranged from 39 to 340 mg/L. The lowest alkalinity concentration was at site 1 on April 11, 1979, and may have been due to the inflow of low-pH tributaries from the coal-mine waste slurry (as at site 1G that are upstream from site 1). Alkalinity concentration generally increases in downstream order at sites 2, 11, and 19 (table 4), which indicates that the creek is buffering out the effects of drainage received from low-pH tributaries.

Nitrogen and Phosphorus Compounds.--Major nutrients in water and soils include nitrogen and phosphorus compounds. Nitrogen compounds can enter water through (1) municipal and industrial wastewaters, (2) septic tanks, (3) feedlot discharges, (4) farm-site fertilizer and animal wastes, (5) lawn fertilizer, (6) atmospheric fallout, and (7) losses from natural sources such as mineralization of soil organic matter (U.S. Environmental Protection Agency, 1976, p. 201-202). Crop, forest, idle, and urban lands can contribute phosphorus compounds in runoff of rainfall or return flow from irrigation (U.S. Environmental Protection Agency, 1976, p. 353).

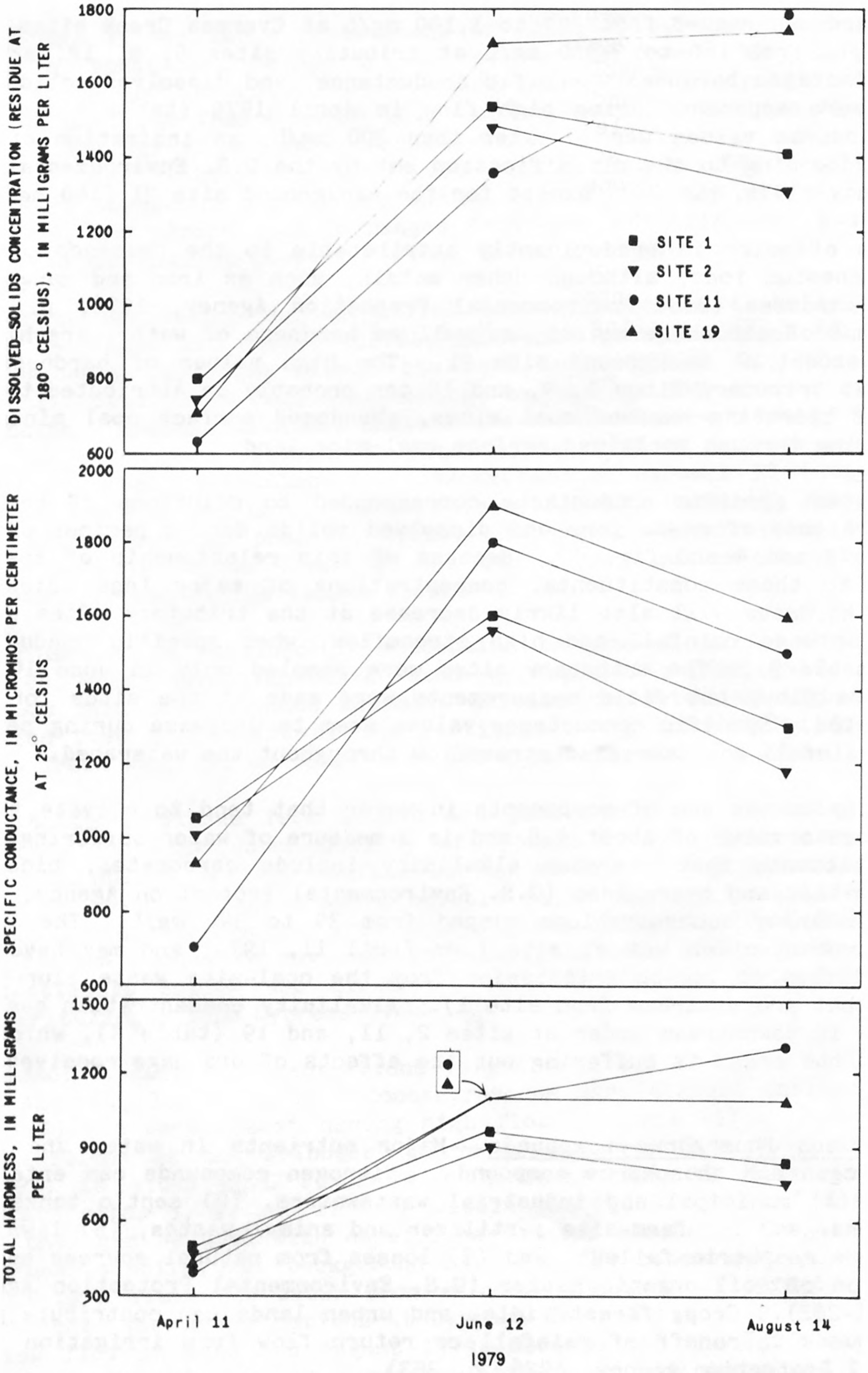

Figure 9.-- Distribution of dissolved-solids concentrations, specific conductance, and hardness at selected sites in Cypress Creek watershed.

Concentrations of nitrogen compounds dissolved in streams ranged (1) from 0.08 to 1.2 mg/L for nitrogen ammonia, dissolved as NH_4; (2) from 0.14 to 0.77 mg/L for nitrogen, dissolved organic as N; (3) from 0.93 to 3.6 mg/L for nitrogen, dissolved as N; and (4) from 0.13 to 1.8 mg/L for nitrite plus nitrate, dissolved as N (table 5). Concentrations of the nitrogen compounds (reported as nitrogen) varied seasonally (fig. 10). Generally, high concentrations were detected in June 1979 and low concentrations in April and August 1979.

The concentration limit of nitrate in domestic water supplies is 10 mg/L as nitrogen (US. Environmental Protection Agency, 1976, p. 203). Nitrate concentrations at all sampling sites were below this limit.

Ammonia concentrations greater than 0.10 mg/L (as nitrogen) in surface water often indicates sewage or industrial contamination (National Academy of Sciences and the National Academy of Engineering, 1972, p. 55). Ammonia concentrations greater than 0.10 mg/L (nitrogen, ammonia, dissolved as NH_4) were detected at all sites sampled, except for background site 21 on June 12, 1979, and site 1 on August 14, 1979 (table 5). These concentrations are probably high because of (1) past and present surface coal-mining operations and (2) the Boonville sewage-treatment plant upstream from site 2.

Concentrations of phosphorus ranged (1) from 0.00 to 0.20 mg/L for phosphorus (dissolved as phosphorus); (2) from 0.00 to 0.42 mg/L for phosphate, ortho, dissolved (PO_4) as phosphorus; and (3) from 0.00 to 0.14 mg/L for phosphorus, dissolved orthophosphate as phosphorus (table 5).

The elemental form of phosphorus is toxic and can bioaccumulate, whereas phosphate is a major nutrient required for plant nutrition and is essential to life (U.S. Environmental Protection Agency, 1976, p. 352). Concentrations of phosphorus or phosphate that exceed or equal 0.10 mg/L (as phosphorus) can cause plant nuisances in flowing water (U.S. Environmental Protection Agency, 1976, p. 356). In June 1979, water samples from sites 2 and 9 (table 5) had concentrations of phosphorus or phosphate that exceeded or equaled 0.10 mg/L (as phosphorus). Plant nuisances were observed at site 9 but not at site 2; however, site 2 may be affected by the Boonville sewage-treatment plant, which could be a contributing source of phosphorus.

Nitrogen and phosphorus in streambed material have a variety of sources. Runoff from fields where nitrogen and phosphorus-based fertilizers have been used is among the largest contributors, estimated to be 24 lb/acre/yr (pounds per acre per year), as nitrogen in surface water (Feth, 1966, p. 41). Accumulations of refractory remains of algae in bottoms of rivers and lakes should tend to build up reservoirs of organic nitrogen and phosphorus (McCarty and others, 1968, p. 135). Crop residues and animal wastes also contribute nitrogen and phosphorus, as do sewage-treatment plants (Brady, 1974, p. 424).

Concentration of nitrogen in streambed samples ranged from 4,600 mg/kg to 23,000 mg/kg as nitrogen (table 5). The high and low concentrations were detected on August 14, 1979, at sites 1 and 19, respectively.

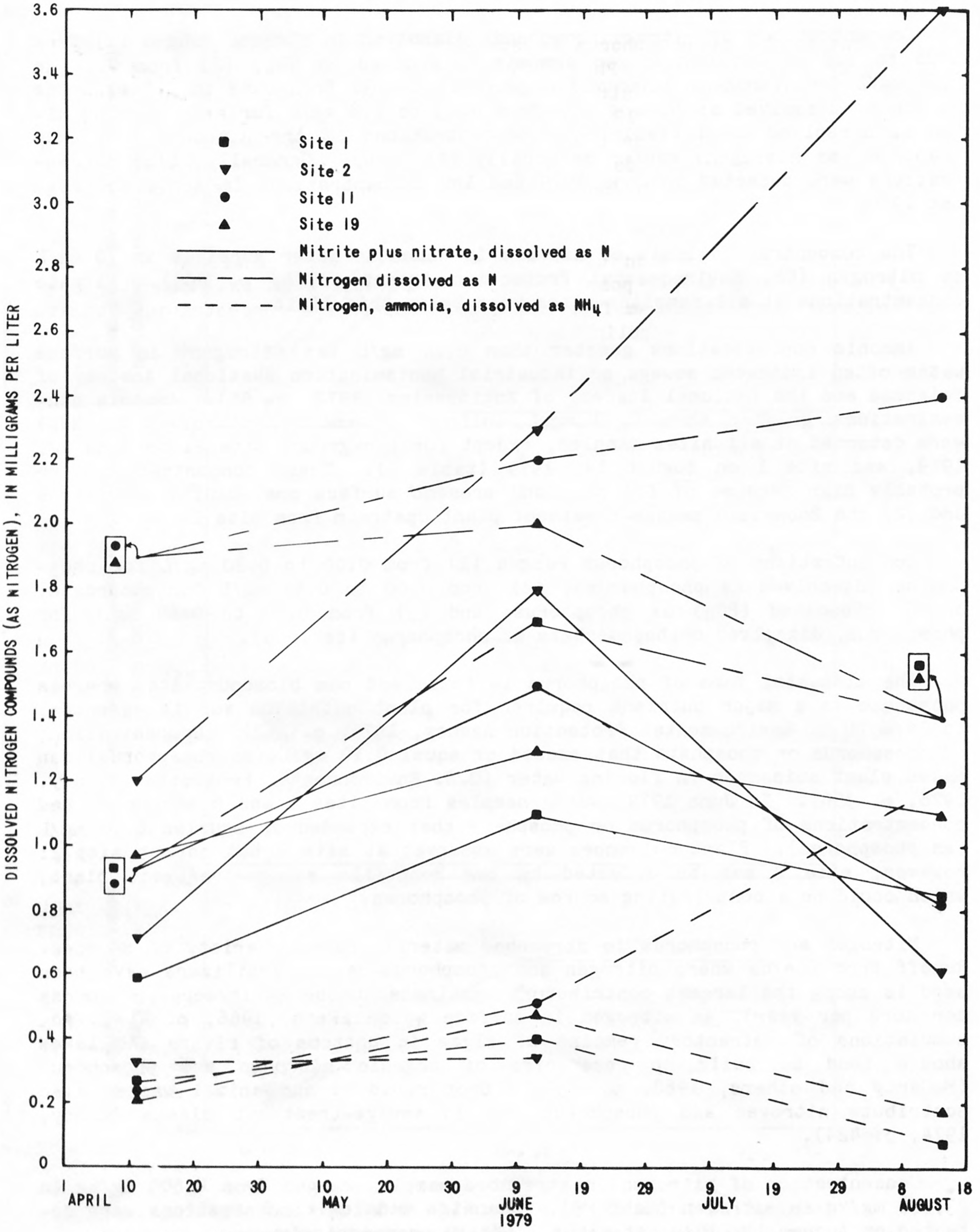

Figure 10.-- Seasonal distribution of concentrations of dissolved nitrogen compounds (reported as nitrogen) at selected sites in the Cypress Creek watershed.

Concentrations of phosphorus in streambed samples ranged from 0 mg/kg to 1,900 mg/kg as phosphorus. Phosphorus was not detected in streambed samples collected in April 1979 at sites 1, 2, and 19. The highest concentration was detected at site 2 on June 12, 1979. The low concentrations of phosphorus in April 1979 may have been due to (1) dilution during high flow at this time or (2) no fertilizing of fields by April 1979. The highest concentrations of phosphorus were detected in June 1979, possibly owing to low flow and fertilization of crops.

Phosphorus concentration of streambed samples was highest at site 2 in both June and August 1979, possibly owing to effects from the Boonville sewage-treatment plant upstream from the site. Phosphorus concentration at site 1 was the lowest of all samplings.

The amounts of phosphorus in soils largely determine the concentrations in local surface water, unless local pollution from animal or human sources is a factor (Thomas, 1970, p. 16). Nitrogen and phosphorus concentrations of both water and streambed samples were highest at site 2, which was occasionally affected by sewage.

The tributaries had much lower nitrogen and phosphorus concentrations and lower flow and less runoff from adjacent fields than Cypress Creek. At all sites, nitrogen concentrations of streambed samples were much higher than phosphorus concentrations.

Aluminum.--Common sources of aluminum in water are minerals, clays, and mine drainage (Hem, 1970, p. 109, 113). Because the aluminum is so abundant in the earth's outer crust, most natural waters have ample opportunity to dissolve it; however, the complexity of aluminum chemistry probably accounts for low aluminum concentrations in near neutral pH water (Hem, 1970, p. 109). The pH at the sampling sites ranged from 6.4 to 7.4, and most aluminum concentrations were in the suspended rather than dissolved phase (table 4).

Concentrations of total aluminum ranged from 0.12 to 0.85 mg/L in Cypress Creek and from 0.15 to 2.0 mg/L in the tributaries (table 4). Highest total aluminum concentrations were detected at tributary site 9 on June 12, 1979, and at Cypress Creek site 1 on June 12 and August 14, 1979 (table 4). Both sites are directly affected by either present or past surface coal-mining operations.

Concentrations of aluminum in streambed samples ranged from 3,600 to 11,000 μg/kg in Cypress Creek and from 4,600 to 11,000 μg/kg in the tributaries (table 6). Highest aluminum concentrations in streambed samples were at tributary site 5 on June 13, 1979, and Cypress Creek site 11 on April 12, 1979, and August 14, 1979 (table 6).

Iron.--Iron is generally present as ferrous ion in the dissolved phase and as ferric ion in the suspended phase. Concentrations of suspended iron were greater than dissolved iron at all sites (fig. 11 and table 4), which is normal in surface water where pH ranges from 6.4 to 7.4 and Eh exceeds 0.20 volt (Hem, 1970, p. 120).

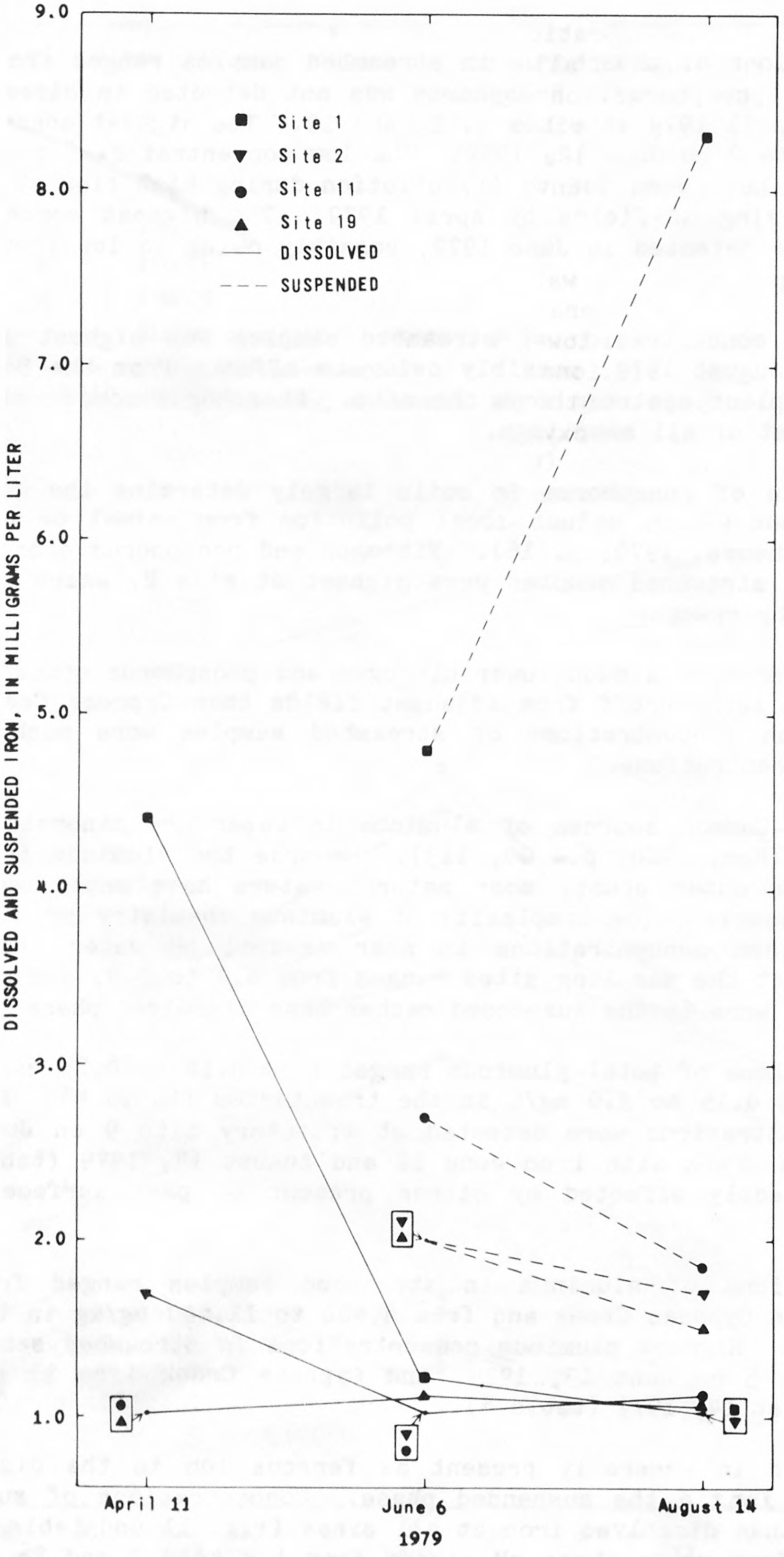

Figure 11.--Trends of dissolved- and suspended-iron concentrations at selected sites in the Cypress Creek watershed.

Dissolved iron concentrations at sites 1 and 2 on April 11, 1979, and total iron concentrations at all sites exceeded the 0.3 mg/L limit set by the U.S. Environmental Protection Agency (1976, p. 152) for domestic water supply. Dissolved iron at site 1 on April 11 and total iron at sites 1, 11, 19, 9, and 21 in June 1979 and at site 1 on August 14, 1979, exceeded the 1.0-mg/L limit set by the U.S. Environmental Protection Agency (1976, p. 152) for fresh-water aquatic life.

Sources of iron in the watershed are probably the soil and past and present surface coal-mining operations. Drainage from the coal-mine waste slurry upstream from site 1 and low-pH tributaries, such as at site 1-G (pH, 1.2), probably contribute additional quantities of iron into Cypress Creek. For low-pH conditions such as these, iron is mostly in the dissolved phase. In the presence of dissolved oxygen, dissolved iron is precipitated as a yellow or red hydroxide or oxide (U.S. Environmental Protection Agency, 1976, p. 153). Red deposits were observed on the surface of the streambed upstream from site 1 and at site 1 near the edge of water from which the low-pH tributary (at site 1G) occasionally drains into Cypress Creek and at tributary sites 5 and 5 A-D. The pH was near neutral at all these sites (tables 2 and 3). When iron flock is suspended in water, as during high streamflow with corresponding increased sediment loads and stream discharge, the flock can be detrimental to fish and other aquatic life (U.S. Environmental Protection Agency, 1976, p. 153).

Iron in soil is a vital micronutrient and an essential trace element required by both plants and animals (Brady, 1974, p. 22). Concentrations of iron in streambed samples ranged from 15,000 to 48,000 ug/kg (table 6 and fig. 12). Iron concentration in soil commonly ranges from 5,000 to 50,000 ug/kg, and the iron concentration of a representative surface soil is commonly 25,000 ug/kg (Brady, 1974, p. 23). Major natural sources of iron in soil are oxides, sulfides, and silicates of iron (Brady, 1974, p. 489).

Manganese.--Manganese and iron are closely related in chemical behavior (Hem, 1970, p. 130). Both are constituents of acid-mine drainage from coal mines. However, manganese persists in river water for greater distances downstream than iron. As an acid stream neutralizes, manganese takes longer to precipitate out of solution than iron (Hem, 1970, p. 130). Generally, manganese was present in greater concentrations in the dissolved rather than the suspended phase--the opposite that of iron. Distribution of dissolved- and suspended-iron and manganese concentrations in water are presented in figures 11 and 13, respectively.

Dissolved-manganese concentrations exceeded the 50-ug/L limit set by the U.S. Environmental Protection Agency (1976, p. 178) for domestic water supplies at all sites in the watershed except for background site 21 (table 4). Dissolved-, suspended-, and total- manganese concentrations ranged from 0.07 to 3.0 mg/L, from 0 to 1.1 mg/L, and from 0.13 to 4.1 mg/L, respectively.

Manganese concentration ranging from slightly less than 1 mg/L to a few milligrams per liter in irrigation water applied to soils having pH values lower than 6.0 may be toxic to plants; however, concentrations of manganese

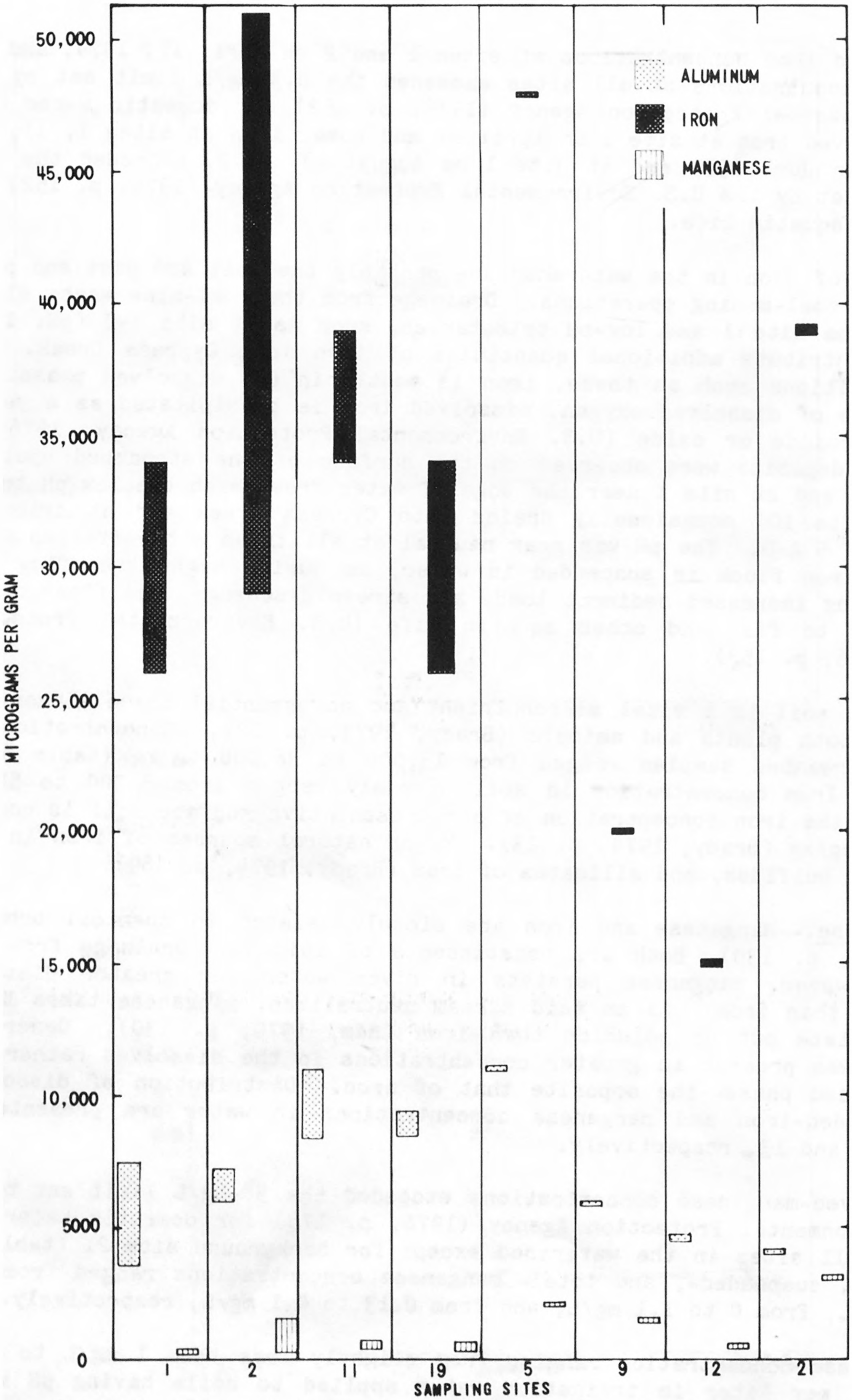

Figure 12.-- Ranges of aluminum, iron, and manganese concentrations in streambed samples at selected sites in the Cypress Creek watershed.

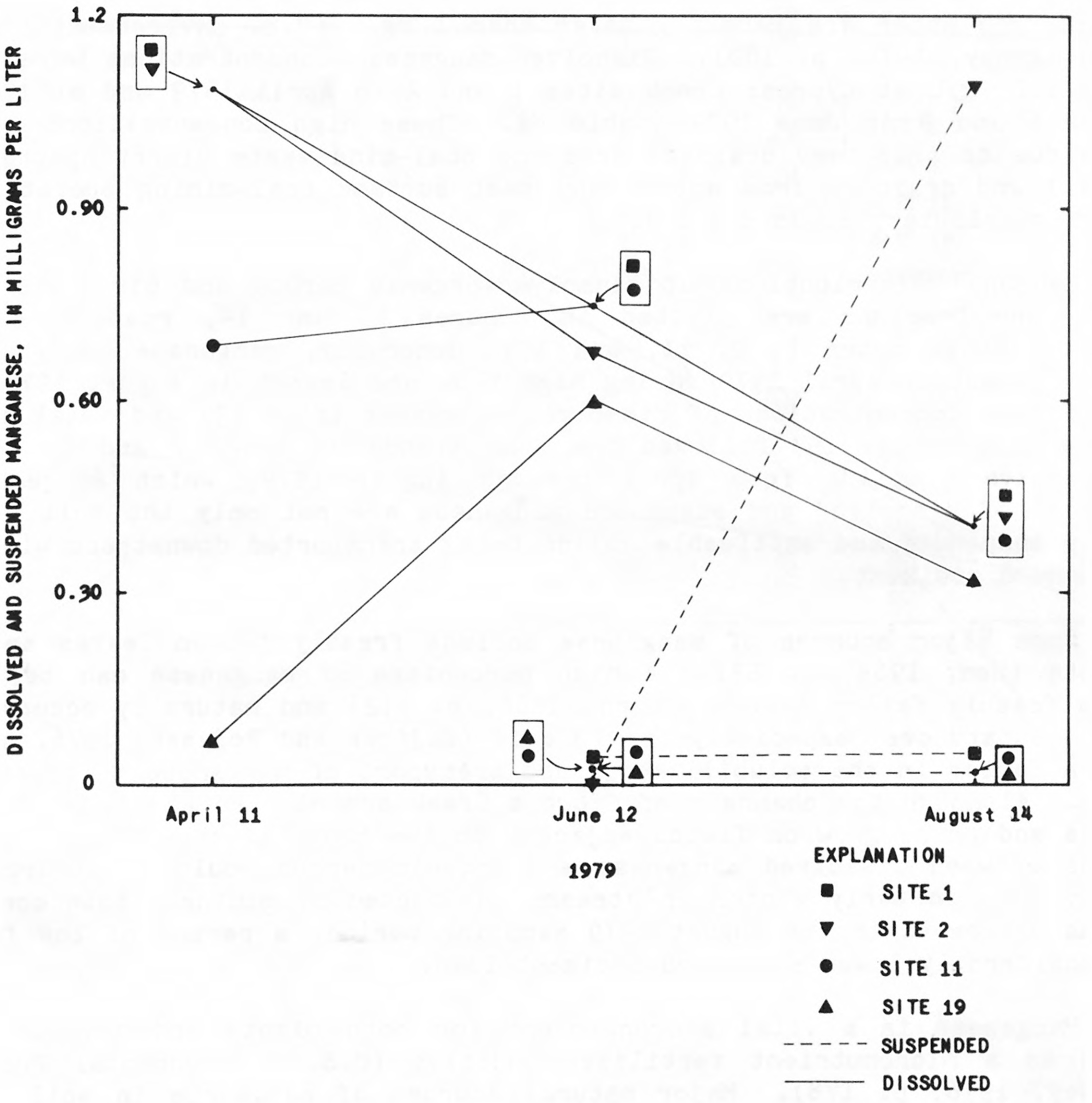

Figure 13.-- Trends of dissolved- and suspended-manganese concentrations at selected sites in the Cypress Creek watershed.

in surface water are rarely greater than 1 mg/L (U.S. Environmental Protection Agency, 1976, p. 180). Dissolved-manganese concentrations were greater than 1.0 mg/L at Cypress Creek sites 1 and 2 in April 1979 and at tributary sites 5 and 9 in June 1979 (table 4). These high concentrations may have been due to tributary drainage from the coal-mine waste slurry upstream from site 1 and drainage from active and past surface coal-mining operations affecting tributary sites 5 and 9.

Seasonal distributions of dissolved-organic carbon and dissolved-manganese concentrations are plotted in figures 13 and 14, respectively, for Cypress Creek sites 1, 2, 11, and 19. Generally, manganese concentrations were highest in April 1979 during high flow and lowest in August 1979 during low flow. Concentrations of dissolved manganese (fig. 13) and total suspended sediment (fig. 15) followed the same trends at sites 1 and 2 with each successive sampling from April through August 1979, which suggests that sources of dissolved and suspended manganese are not only the soil but possibly suspended and settleable solids being transported downstream with or on suspended sediment.

Some major sources of manganese include freshly fallen leaves and other plants (Hem, 1964, p. B3). A high percentage of manganese can be leached from freshly fallen leaves (Oborn, 1964, p. C12) and naturally occurring organic substances, especially fulvic acid (Zajicek and Pojasek, 1976, p. 306), are a factor in the solubilization and transport of manganese in aquatic systems. Although the channels of Cypress Creek are cleared annually of growth, trees and crops grow on fields adjacent to the banks of the creek. Relationships between dissolved manganese and organic carbon would be apparent from early fall to early winter in streams unaffected by mining. Both concentrations decreased in the August 1979 sampling period, a period of low flow and a considerably lower suspended-sediment load.

Manganese is a vital micronutrient for both plants and animals and is used as a micronutrient fertilizer additive (U.S. Environmental Protection Agency, 1976, p. 178). Major natural sources of manganese in soil are oxides, silicates, and carbonates (Brady, 1974, p. 489).

The normal range of manganese concentration in soils is from 200 to 10,000 ug/g. A normal manganese concentration in a representative surface soil is 2,500 ug/kg (Brady, 1974, p. 23). Concentrations of manganese in streambed samples ranged from 260 to 3,100 ug/kg (fig. 12 and table 6). Manganese concentrations in streambed samples for the Cypress Creek sampling sites were highest in April 1979 during high flow; however, the highest manganese concentrations in streambed samples were at tributary sites 5, 9, and 21 in June 1979. Sources of manganese at sites 5 and 9 are probably past and present surface coal-mining operations, farming operations, and soil. Sources of manganese for background site 21 are probably farming operations and soil.

Ranges of concentrations of aluminum, iron, and manganese in streambed materials for all sites sampled are plotted in figure 12.

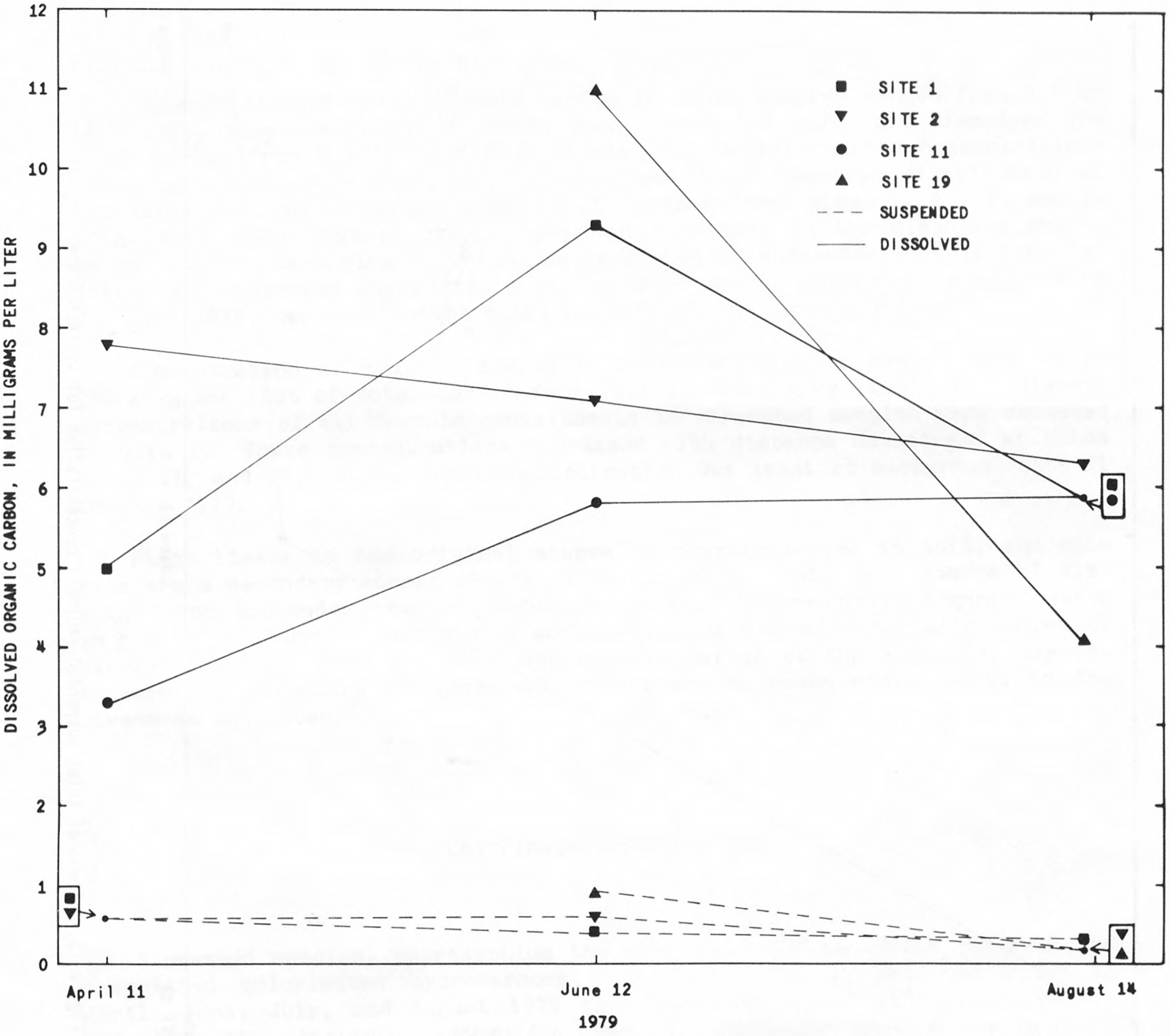

Figure 14.-- Seasonal distribution of dissolved- and suspended-organic carbon concentrations at selected sites in the Cypress Creek watershed.

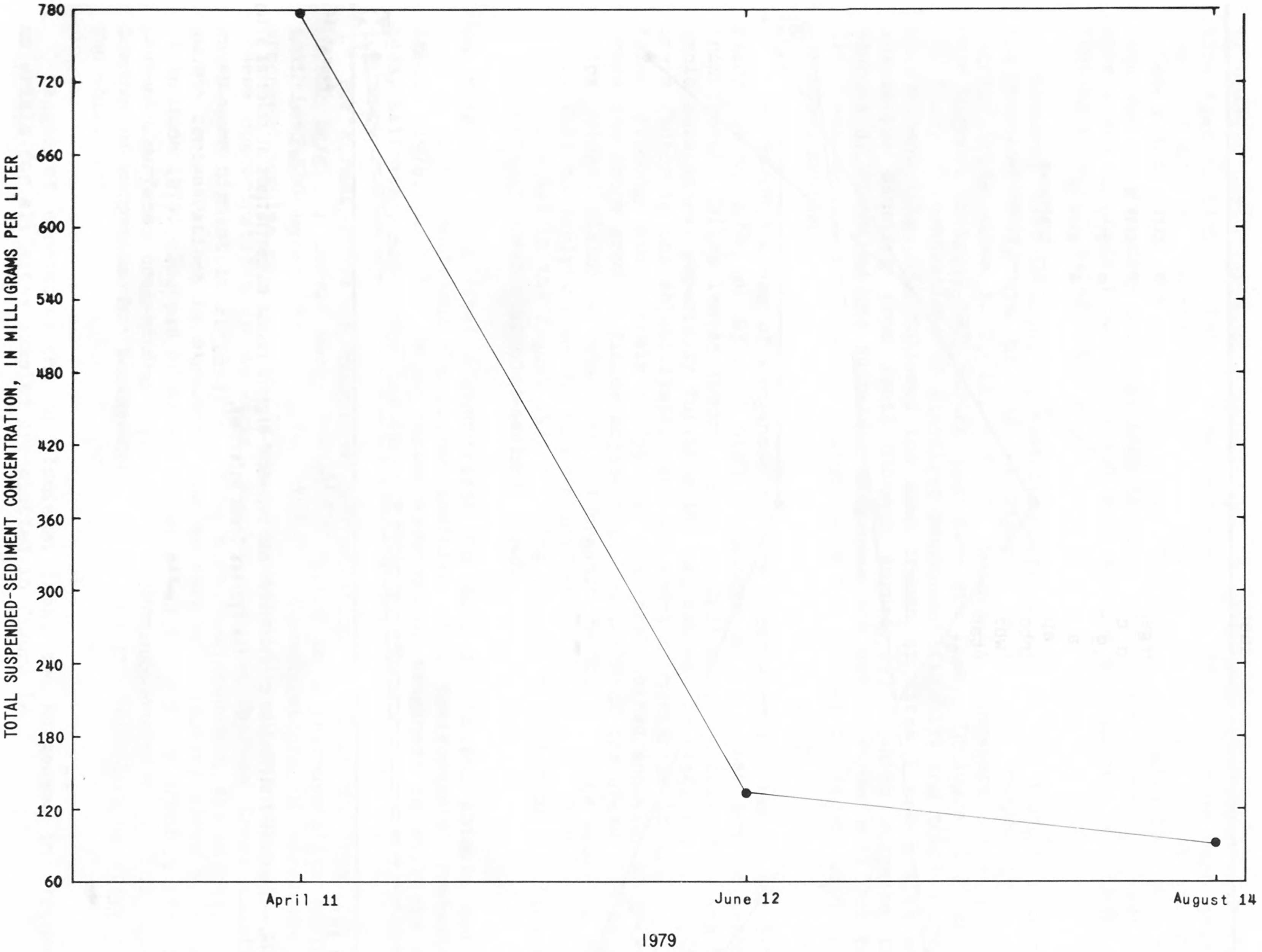

Figure 15.-- Trend of total suspended-sediment concentration for Cypress Creek.

Organic Constituents in Water and Streambed Samples

Concentration of total organic carbon in water samples ranged from 3.6 to 11.9 mg/L, suspended organic carbon from 0.2 to 2.4 mg/L, and dissolved organic carbon from 3.3 to 11.9 mg/L (table 7). Organic carbon concentrations were highest in June 1979, a period of low flow. Seasonal distribution of dissolved organic carbon was apparent at Cypress Creek sites 1, 2, 11, and 19 (fig. 14). Most organic carbon concentrations were in the dissolved phase, except at tributary site 9, which had nearly equal concentrations in the dissolved and suspended phase (table 7). A water sample collected at site 19 on June 12, 1979, had the highest total organic carbon concentration.

Concentration of organic carbon in streambed samples ranged from 13 to 280 g/kg and that of total carbon from 20.1 to 280.3 g/kg (table 7). Highest concentrations of all organic constituents in streambed samples were detected at site 1. These concentrations decreased with distance downstream at sites 1, 2, 11, and 19. Total carbon concentration was least at background site 21 in June 1979.

Plant tissue is the original source of organic matter in soil, and animals are a secondary source (Brady, 1974, p. 137). Soil is a source of dissolved and suspended organic carbon in water. Consequently, organic matter in soil is a source of phosphorus and sulfur and virtually the sole source of nitrogen (Brady, 1974, p. 14). The organic matter of the soil also may influence the chemistry of manganese and other inorganic constituents in the streambed and water.

Chlorinated Hydrocarbons

Streambed samples, representing the most recently deposited sediment and associated chlorinated hydrocarbons, were collected at selected sites in April, June, July, and August 1979 for determination of aldrin, chlordane, DDD, DDE, DDT, dieldrin, endosulfan, endrin, heptachlor epoxide, heptachlor, lindane, mirex, or polychlorinated naphthalene (PCN), perthane, toxaphene and PCB's or polychlorinated biphenyls (table 8). Additionally, a core sample was collected on July 25, 1979, at site 11 at a depth of 2 ft into the stream bottom for determination of chlorinated hydrocarbon concentration. This sample represented long-term accumulations of chlorinated hydrocarbons. Chlordane, DDD, DDE , and PCB's were detected in the core sample (table 8). Most concentrations of PCB exceeded the 20-μg/kg water-quality alert limit (U.S. Environmental Protection Agency, 1976, p. 364), and concentrations of most constituents in the core sample were lower than the concentrations in the more recent sediment deposits.

Runoff from fields and lawns transports suspended and settleable solids and associated chlorinated hydrocarbons to Cypress Creek and its tributaries, where they are deposited. These deposits continue to move with the water flow and bring chlorinated hydrocarbon-bearing sediments into contact with chlorinated hydrocarbon-free sediments. This mixing provides strong adsorption sites for the chlorinated hydrocarbons and reduces their effective concentrations (Caro and Taylor, 1970, p. 6).

Chlorinated-hydrocarbon concentrations of streambed samples were determined because of (1) their potential harm to plant, animal, and human life; (2) their transport capabilities by adhering to suspended and settleable solids; and (3) their persistence in the natural environment for as long as 20 yr (Guenzi, 1974, p. 342; and Weimer and others, 1978, p. 2).

Insecticides.--Insecticides detected in streambed samples included chlordane, DDD, DDE, DDT, dieldrin, and heptachlor epoxide (table 8). Chlordane, an insecticide used for control of ants, termites, grasshoppers, and insects inhabiting soils, was detected at sites 1, 2, 5, 9, 11, 12, 19, and 21 of various samplings (table 8). Concentrations of chlordane at sites 2 and 19 for all samplings exceeded the 20-μg/kg water-quality alert limit set by the U.S. Environmental Protection Agency (1976, p. 240). All four tributary sites sampled contained detectable amounts of chlordane, and chlordane concentration at two of these sites (5 and 12) in June 1979 exceeded the water-quality alert limit set by the U.S. Environmental Protection Agency, 1976, p. 364). The tributary sites were all near farms and homes, where chlordane was probably used on adjacent cornfields and lawns.

Before 1972, DDT was used extensively for crop protection and disease control and was frequently detected in soils (Guenzi, 1974, p. 484). DDT is reduced to DDD and DDE residuals when incorporated into the soil (Guenzi, 1974, p. 137). Even though DDT was banned in 1972 (Hampel and Hawley, 1976, p. 76), DDT and it's reduced counterparts, DDD and DDE, were detected at sites 1, 2, 5, 11, 12, 19 and 21 on most sampling runs in 1979 (table 8). DDT concentrations at site 1 on July 25 exceeded the 20 μg/kg water-quality alert limit set by the U.S. Environmental Protection Agency (1976, p. 254).

At most sites in Cypress Creek where DDT was detected, DDD and (or) DDE were also detected; at most sites DDT concentrations were higher than DDD and DDE concentrations. DDD and DDE are byproducts in the reduction of DDT and, where detected, may indicate the use of an old supply of DDT on adjacent croplands.

Dieldrin, besides being the decomposition product of aldrin, is also an insecticide used extensively on cornfields. Dieldrin was detected at sites 1, 2, 5, 11, 12, 19, and 21 in various samplings (table 8). Dieldrin concentrations did not exceed the U.S. Environmental Protection Agency water-quality alert limits for any sampling period. Because aldrin was not detected, the presence of dieldrin was probably from applications of dieldrin on adjacent fields and not from the reduction of aldrin to dieldrin.

Heptachlor is a commercial component of chlordane, and heptachlor epoxide is the weathered product of heptachlor. Heptachlor is also an insecticide used to control soil mites, springtails, grasshoppers, and other soil inhabiting insects (Guenzi, 1974, p. 361). The detection of heptachlor epoxide at sites 1, 2, 11 and 19 in June and July 1979 (table 8) could be either from chlordane or heptachlor applications to adjacent fields.

Polychlorinated biphenyls (PCB's).--Because PCB's are chemically similar to certain chlorinated insecticides (Carey and Gowen, 1975) and are potentially harmful to plant, animal, and human life, PCB concentrations of streambed samples were determined. PCB's were detected at all sites on Cypress Creek (sites 1, 2, 11, and 19) and at two of four tributary sites (sites 5 and 9). PCB concentrations exceeded the 20 ug/kg water-quality alert limit set by the U.S. Environmental Protection Agency (1976, p. 364) at all four sampling sites in Cypress Creek in each sampling period; however, PCB concentrations were less than this limit at tributary sites 5 and 9 in June 1979 (table 8). PCB concentrations were highest at site 2 on State Highway 62 just downstream from the Boonville sewage-treatment plant (fig. 1).

Even though domestic PCB production was stopped in August 1977 and sale of products containing PCB's ceased 2 months later (Durfee, 1975), PCB's will continue to be found in the hydrologic environment because of (1) their 20- to 30-yr persistence after introduction into the environment; (2) the long life of manufactured products containing PCB's, and (3) imported items containing PCB's still being sold in the United States (Weimer and others, 1978). Because PCB's were also used widely before 1971, the exact source of PCB's in Cypress Creek and its two tributaries would be difficult to identify. However, PCB's can enter the hydrologic environment from (1) runoff of sewage sludges disposed of on land, (2) industrial and municipal waste discharge, (3) accidental spills, (4) improper waste-disposal practices, and (5) formerly as ingredients of insecticides or as carriers for insecticides (Dennis, 1975).

The upper reaches of Cypress Creek, upstream from site 1, flow adjacent to a coal-mine waste slurry, where equipment containing PCB's could have been used and which could have been an early PCB source for Cypress Creek. However, the high PCB concentrations continually detected at site 2 possibly indicate an additional PCB source at this site. The much lower PCB concentrations at downstream sites 11 and 19 than at site 2 indicate that the PCB sources are probably being transported from an upstream location rather than entering the stream at the site. High suspended-sediment concentrations observed during the high flow of the April 1979 sampling period would transport attached PCB's through the hydrologic system (table 9). PCB particles would be deposited later as flow conditions returned to normal.

Because several carp and fishermen were noted at various locations (including site 11) along Cypress Creek in June 1979, PCB's in Cypress Creek could affect both fish and man. PCB's are potentially harmful to human beings and could easily be incorporated into the biological food chain by fish. PCB's seek out and accumulate in fatty tissue in fish and animals, and fish are slow in eliminating PCB's from their system (Weimer and others, 1978, p. 3).

PCB concentrations of streambed samples collected at tributary sites 5, 9, 12, and 21 in June 1979 were 12, 10, and 0 μg/kg, respectively. The tributary sites were sampled only one time for PCB's. During high flow, the tributaries could also transport PCB's into Cypress Creek by PCB adherence to suspended and settleable solids.

Suspended Sediment

Suspended-sediment concentration ranged from 13 to 362 mg/L at Cypress Creek sites in April and June 1979 and from 15 to 78 mg/L at the tributary sites in June 1979 (table 9). Total suspended-sediment concentration for Cypress Creek ranged from 91 mg/L (August 14, 1979) to 776 mg/L (April 11 and 12, 1979).

Suspended-sediment samples collected for Cypress Creek on August 14, 1979, were composited for determination of total concentration. A sieve analysis of the composited sample was done to determine particle size of the suspended material. The analysis (table 10) indicated that the particles being transported downstream in Cypress Creek during low flow on August 14, 1979, were 96 percent silt and clay size and 4 percent sand size. According to Kennedy (1965, p. D26), the exchange capacity of stream sediments acts as a stabilizing influence on the chemical quality of streams and may be an important factor in the fluvial transport of cations.

Core samples collected at various depths in Cypress Creek and analyzed by the U.S. Soil Conservation Service indicated that the streambed was chiefly silt and clay but contained some medium-sized sand particles. The plastic-like clay was a consistent combination of grey, red, and brown colors (Robert Rasely, U.S. Soil Conservation Service, oral commun., June 1979) that were also characteristic of the surface streambed material throughout Cypress Creek. Highest suspended-sediment concentrations were detected during periods of high flow (figs. 15, 16, and 17) in April 1979. A thunderstorm early on April 12, 1979, before the sampling of downstream sites 11 and 19, caused a significant increase in the suspended-sediment concentration. However, concentrations at upstream sites 1 and 2 were higher in April 1979 than in June 1979 because of high flow in April 1979 at these sites, owing to intermittent rains before sampling (figs. 3 and 5). Relation of suspended-sediment concentration and streamflow for Cypress Creek is presented in figure 17.

Erosion of adjacent fields and of banks and the silt streambed material observed during sampling probably accounts for the high suspended sediment concentrations detected during periods of intense rainfall and high streamflow (Colby, 1956 p. 83).

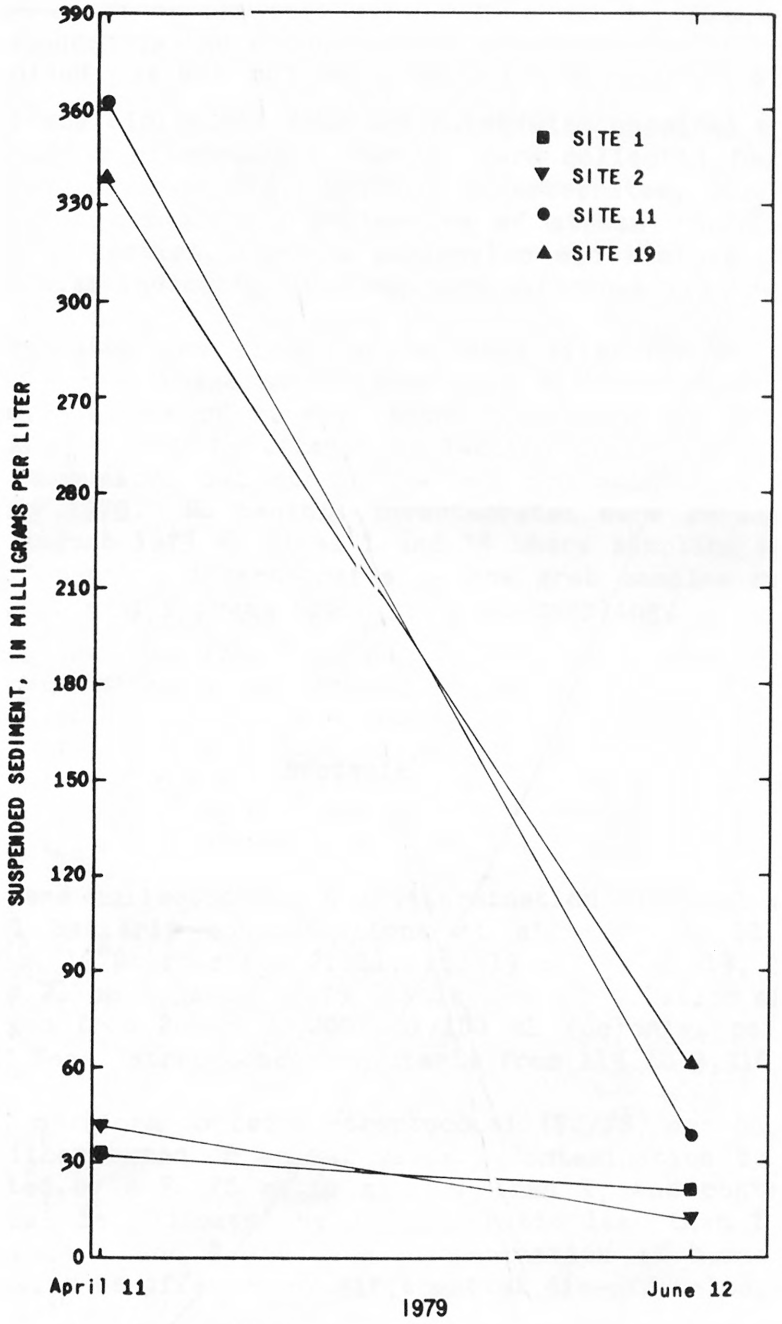

Figure 16.-- Trends of suspended-sediment concentration at selected sites in the Cypress Creek watershed.

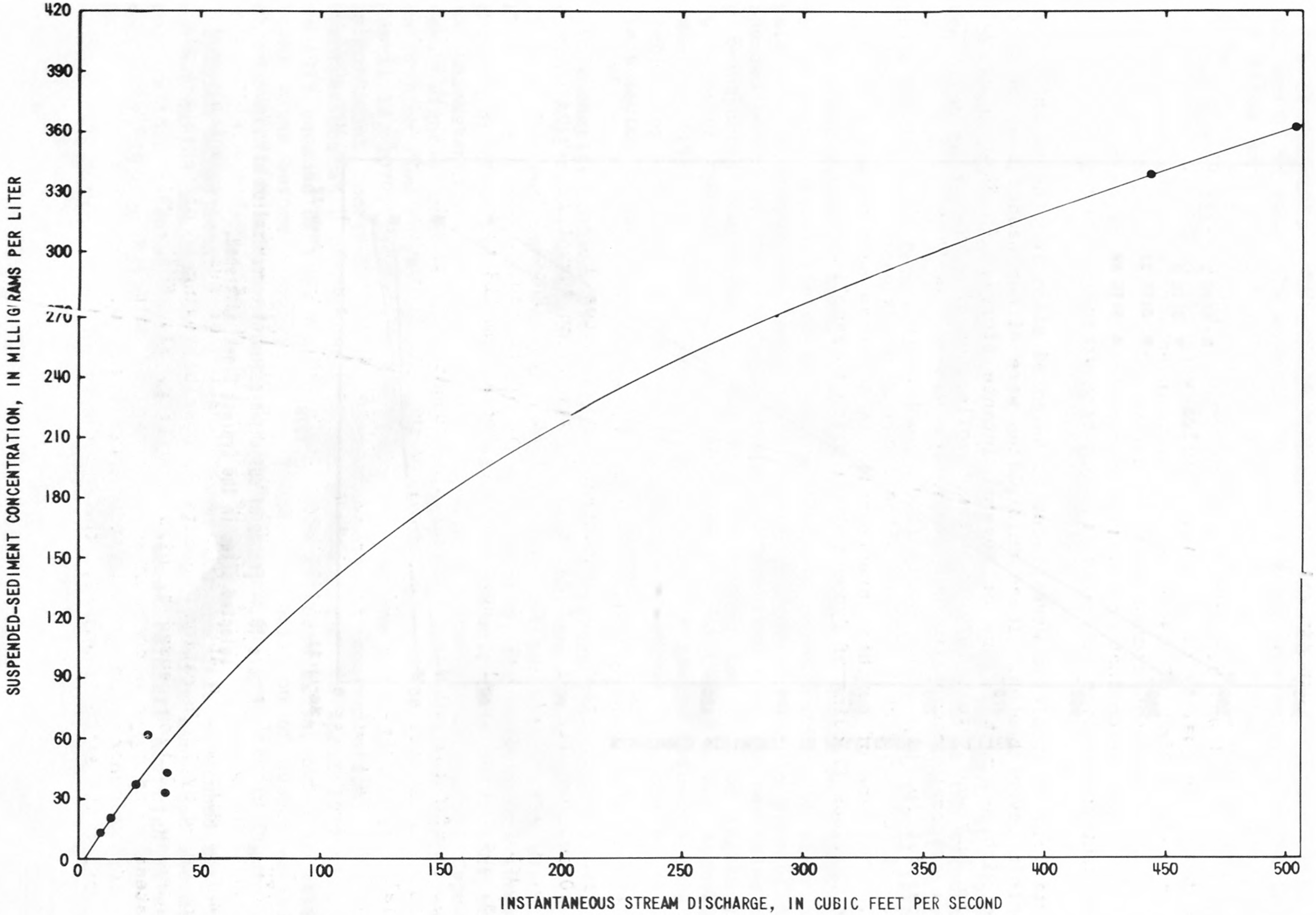

Figure 17.-- Relation of stream discharge and suspended-sediment concentration in the Cypress Creek watershed.

Microbiological and Biological Data

Microbiological and biological data collected with chemical data can help define the water quality of streams. Samples were collected for identification and enumeration of bacteria, benthic invertebrates, and periphyton. Bacteria are transient communities reflective of stream conditions only at the time of sample collection, whereas periphyton and benthic invertebrates are resident communities indicative of long-term water-quality trends.

Artificial multiplates were placed at selected sites for the colonization of benthic invertebrates. These multiplates were either washed away or were buried with sediment in one of several intense storms. An Ekman grab was used in July and August 1979 to attempt collection of a representative benthic invertebrate community, but streamflow was too swift and dredging was unsuccessful in July 1979. No benthic invertebrates were detected at lower flow conditions in August 1979 at sites 1 and 19 where sampling was attempted again. The lack of benthic invertebrates in the grab samples may have been due to previous flooding of Cypress Creek prior to sampling.

Bacteria

Water samples were collected for the determination of fecal coliform and fecal streptococcal bacteria concentrations at sites 1, 2, 11, and 19 on April 10 and June 11, 1979; at sites 2, 11, and 19 on August 13, 1979; and at sites 5, 9, 12, and 21 on June 11, 1979 (table 11). Population of fecal coliform bacteria ranged from 20 to 27,200 col/100 mL (colonies per 100 milliliters) and that of fecal streptococcal bacteria from 113 to 3,310 col/100 mL.

Ratios of fecal coliform to fecal streptococci (FC/FS) can be used to define bacteria as either human or animal waste. Contamination by human fecal material is indicated by a FC/FS ratio greater than 4, and contamination by animal fecal material is indicated by a FC/FS ratio less than 1 (Geldreich, 1966). Ratios between 1 and 4 indicate a combination of human and animal waste. Ratios may also be affected by differential die-off rates.

FC/FS ratios for site 2 in June and August 1979 indicated human waste contamination, probably owing to the Boonville sewage-treatment plant upstream from site 2. In April 1979, a combination of human and animal waste was indicated by FC/FS ratios for site 2, possibly owing to differential die-off rates or dilution caused by high flow (fig. 5). FC/FS ratios at site 1 consistently indicated a combination of human and animal waste, probably because of residences and animal life immediately upstream from the site. FC/FS ratios at sites 11 and 19, the two farthest downstream Cypress Creek sites, varied widely in the study. At high flow in April 1979, ratios at both sites indicated a combination of human and animal waste. At low flow in June 1979, ratios at both sites indicated human waste, and at low flow in August 1979 ratios at both sites indicated animal waste.

Of the four tributary sites sampled in June 1979, FC/FS ratios indicated animal waste at sites 5, 12, and 21 and a combination of human and animal waste at site 9. Home septic systems along the tributary may have caused the high ratio at site 9. A pig feedlot immediately downstream from tributary site 21 probably accounts for the low ratio that indicates animal waste contamination at that site.

Periphyton

Periphyton are resident communities of microscopic aquatic plants and animals that grow in a fixed, submerged substrate of a stream and are a long-term water-quality indicator of stream conditions. Mylar strips for the colonization of periphyton were placed along Cypress Creek at sites 1, 2, 11, and 19 on June 13, 1979, and were collected on August 14, 1979. Unfortunately, the strips at sites 11 and 19 were lost in one of the floodings during the colonization period. Only Chrysophyta (yellow-brown algae diatoms) organisms were detected at sites 1 and 2 (table 12). Dominant organisms at sites 1 and 2 were Nitzschia, and Navicula and Nitzschia, respectively. These widely distributed organisms inhabit all types of water; however, certain species of Navicula and Nitzschia are characteristic of streams affected by sewage. Site 2, downstream from the Boonville sewage-treatment plant, is occasionally affected by human waste, as indicated by the FC/FS ratio (table 11). Information on the species of Navicula and Nitzschia is sparse because only a qualitative analysis of the samples was done to identify the algal part of the periphyton.

Diversity seems to be low at both sites 1 and 2; however, the intense rainfall and corresponding high flow and flooding, increased suspended-sediment loads, and increased discharge (fig. 17) probably account for the low variety of organisms at each site. Biomass was 4.21 g/m^2 (grams per square meter) at site 1 and 2.19 g/m^2 at site 2 (table 12). A lower biomass was detected at site 2, which had correspondingly higher suspended-sediment loads and stream discharge during high flow and floods than site 1 (figs. 5, 16, and 17).

WATER-QUALITY PROBLEMS

Coal-Mine Drainage

In its north reaches, Cypress Creek is directly affected by a coal-mine waste slurry that feeds tributaries, such as the one at site 1G (pH = 1.2), which drain into the creek during intense rainfall. At high flow, drainage from these low-pH tributaries seems to lower alkalinity concentrations (table 4) and pH values (table 2) in the upper reaches of the creek at sites 1 and 2 and to raise specific conductance (fig. 6), dissolved-solids concentration, and hardness, possibly owing to a flushing of materials from these tributaries (table 4 and fig. 9). However, during high-flow, concentrations of all these properties at downstream-sites 11 and 19 show dilution effects. Drainage area and streamflow are significantly greater at sites 11 and 19 than at upstream sites 1 and 2, and these factors may account for the dilution effects.

Most of the tributaries drain active or reclaimed surface coal-mine lands that affect Cypress Creek. Concentrations of major ions and related constituents in the June 1979 sampling period (tables 2 and 4) were maximum for all the samplings in the study and were the highest in these tributaries. Direct and indirect effects from present and past surface coal-mining operations probably account for the higher major ion concentrations detected in Cypress Creek and tributary sites 5, 9, and 12, than at background site 21.

The general water type of the watershed was calcium and magnesium sulfate, which was characteristic of streams affected by past or present surface coal-mining operations in the Busseron Creek watershed (Eikenberry, 1978). As illustrated by Stiff (1951) patterns in figure 7 and 8, water samples collected at background site 21 (unaffected by past or present surface coal-mining operations) contained the lowest concentrations of the major ions as compared to Cypress Creek (fig. 7) and the other tributary sites (fig. 8). The water type at site 21 was calcium sulfate.

Sewage

Site 2 on Cypress Creek is near Highway 62, just south of the Boonville sewage-treatment plant (fig. 1). This site had the highest FC/FS ratio and fecal coliform population in the watershed. The FC/FS ratios at the site in June and August 1979 indicated human-waste contamination (table 11). High flow in April 1979 seemed to cause either a dilution effect or a differential die-off of fecal coliform. *Navicula* and *Nitzschia* were the dominant periphyton genera at site 2. Certain species of these genera are characteristic of sewage-affected water.

Ammonia concentrations exceeded 0.10 mg/L (as nitrogen) for all samplings. These concentrations commonly indicate sewage or industrial contamination (National Academy of Sciences and the National Academy of Engineering, 1972, p. 55). Generally, nutrient concentrations of both water and streambed samples were highest at site 2 (table 5), which indicates effects of sewage on the creek at this site.

Chlorinated Hydrocarbons

Concentrations of chlordane and DDT detected in streambed samples at some sites exceeded the 20-ug/kg water-quality alert limit set by the U.S. Environmental Protection Agency (1976, p. 240 and 254). Concentration of PCB's at all Cypress Creek sampling sites for all sampling periods (table 8) exceeded the 20-ug/kg water-quality alert limit set by the U.S. Environmental Protection Agency (1976, p. 364). The highest PCB concentrations were at site 2 for all sampling periods.

Analysis of a core sample taken 2 ft into the streambed at site 11 on July 25, 1979, detected chlordane, DDD, DDE, and PCB's. The PCB concentration exceeded the water-quality alert limit of 20 ug/kg. Because the concentrations of these constituents in the core sample is indicative of accumulations of chlorinated hydrocarbons over a period of time, further use of these chlorinated hydrocarbons could cause problems.

Suspended Sediment

Erosion of fields and embankments adjacent to Cypress Creek and of the silt streambed material of the creek probably accounts for high suspended-sediment concentrations of the creek during periods of high flow (fig. 17). Inadequate drainage and restriction of flow in the lower reaches of Cypress Creek cause backwaters from the Ohio River to as far north as site 19 in Cypress Creek, as well as flooding and increased erosion of adjacent banks and high suspended-sediment loads at these times.

The erosion of fields adjacent to Cypress Creek and of its banks can introduce chlorinated hydrocarbons into the creek, and increased suspended-sediment concentrations can act as a transport mechanism for these hydrocarbons. Other soil constituents (nitrogen, phosphorus, aluminum, iron, and manganese) may also be transported with or on material suspended in water during high flow and periods of high suspended-sediment loads. A sieve analysis of suspended-sediment samples collected on August 14, 1979, indicated that particles being transported downstream in Cypress Creek were 96 percent silt and clay size and 4 percent sand size. According to Kennedy (1965, p. D26), the exchange capacity of stream sediments acts as a stabilizing influence on the chemical quality of streams and may be an important factor in the fluvial transport of cations.

SUMMARY

A water-quality survey of the Cypress Creek watershed, Warrick County, was made by the Geological Survey from March to August 1979 to provide the U.S. Soil Conservation Service with water-quality data needed for preparing an environmental evaluation of the watershed before alternatives can be devised to (1) improve water quality, (2) minimize flooding, (3) reduce sedimentation, and (4) provide adequate outlets for drainage. Alternatives to the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress) may also be devised to improve water-quality conditions (Robert Rasely, Soil Conservation Service, oral commun., May 1, 1980).

Water type for Cypress Creek was calcium and magnesium sulfate; that for tributary sites 9 and 12 was magnesium sulfate; that for tributary site 5 was calcium and magnesium sulfate; and that for background tributary site 21 was calcium sulfate. Sources of these ions are probably the soil and past and present surface coal-mining operations.

Highest concentrations of the major ions and dissolved solids and values of hardness and of specific conductance were detected at the tributary sites affected by either past or present surface coal-mining operations. The lowest pH in the watershed, 1.2, was detected at tributary site 1G. The pH values in Cypress Creek were lower during periods of high flow (March, April and July 1979) than during low flow (June and August 1979) when low-pH tributaries drained from the coal-mine waste slurry into Cypress Creek. This drainage correspondingly lowered the alkalinity of the creek. Increases of specific conductance, dissolved-solids concentration, and hardness were also detected at upstream sites 1 and 2 during high flow; however, most of these properties decreased downstream because flow increases downstream as the drainage area increases. Concentrations of most constituents in Cypress Creek are still much greater than concentrations at background site 21.

Ammonia concentrations at all sampling sites, except background site 21, exceeded 0.10 mg/L (as nitrogen). These concentrations in surface water generally indicate sewage or industrial contamination. Concentrations of phosphorus and phosphate in water at sites 2 and 9 in June 1979 exceeded 0.10 mg/L (as phosphorus). Concentrations greater than 0.10 mg/L may cause plant nuisances in flowing water.

Concentrations of chlordane and DDT in streambed samples from selected sites exceeded water-quality alert limits set by the U.S. Environmental Protection Agency, and PCB concentrations exceeded the limit for PCB's at Cypress Creek sites 1, 2, 11, and 19 for all sampling periods. The highest PCB concentration was at site 2. Chlorinated-hydrocarbon concentrations were lower at the tributary sites than at Cypress Creek sites. Chlordane, DDD, DDE, and PCB's were detected in a core sample collected at a depth of 2 ft into the streambed at site 11 on July 25, 1979. The PCB concentration exceeded the Environmental Protection Agency water-quality alert limit.

Concentrations of ammonia as nitrogen, nitrogen as nitrogen , nitrite plus nitrate as nitrogen, and organic carbon varied seasonally. Dissolved and total iron, manganese, and sulfate concentrations in water at selected sites in the watershed exceeded limits set by the Environmental Protection Agency for domestic water supplies. Manganese did not follow any seasonal trends but did follow the same trend as suspended-sediment concentrations at sites 1 and 2, where both decreased in subsequent samplings from April to August 1979. Organic-carbon concentrations varied seasonally in Cypress Creek, and highest organic-carbon concentrations of both water and streambed samples were detected at site 1.

In Cypress Creek, suspended-sediment concentration increased and specific conductance, hardness, and concentrations of major ions and dissolved solids decreased as streamflow increased. Alkalinity concentrations and pH were lower in Cypress Creek during periods of high flow in March, April, and July 1979 than during low flow in June and August 1979. A decrease in specific conductance values was detected at most tributary sites during the high flow of March, April, and July 1979.

Highest total suspended-sediment concentration was detected in April 1979, a period of high flow, and the lowest in August 1979, a period of low flow. A sieve analysis of the samples collected on August 14, 1979, indicated that particles being transported in Cypress Creek were 96 percent silt and clay size and 4 percent sand size.

Ratios of FC/FS indicated human waste at site 2 on June 11 and August 13, 1979, and at sites 11 and 19 on June 11, 1979. All sites are downstream from the Boonville sewage-treatment plant. Sites affected by both human and other animal waste were 1, 2, 11, and 19 in April 1979 and 1 and 9 in June 1979.

Chrysophytan organisms were detected on mylar strips placed at sites 1 and 2 for colonization of periphyton. Dominant organisms at sites 1 and 2 were Nitzschia, and Navicula and Nitzschia, respectively. Low populations and lower biomass at sites 1 and 2 were probably due to scouring of the mylar strips by increased suspended-sediment loads during the high flow and flooding.

Generally, water quality of the Cypress Creek watershed is affected by (1) past and present surface coal-mining operations; (2) sewage, possibly from the Boonville sewage-treatment plant and home septic-tank systems; (3) erosion; (4) high suspended-sediment loads during high flow; (5) high PCB and chlordane concentrations in the streambed; and (6) floods and backwaters from the Ohio River during periods of intense rainfall and high streamflow.

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Tables 1-12

Table 1.--Locations of sampling sites plotted in figures 1 and 2, Cypress Creek watershed

[Trib, tributary; Rd., road; RR, railroad track; N., north; W., west, S., South, NE., northeast]

Site	Location
1A	Cypress Creek at 400 N. Rd. north of Boonville.
1B	Cypress Creek at 300 W. Rd. before lake.
1C	Trib north of 300 W. Rd. and 400 N. Rd. intersection.
1D	Trib at 500 N. Rd.
1E	Trib at 500 N. Rd.
$1E_1$	Trib to 1E, east side.
$1E_2$	Trib to 1E, west side.
1F	Trib at 400 N. Rd., east of 400 N. Rd. and 300 W. Rd. intersection.
1G	Acid trib, NE. of site 1.
1	Cypress Creek at North St., north of Boonville.
2	Cypress Creek at State Highway 62, south of sewage-treatment plant.
3	Carter-Traylor ditch at State Highway 62.
5	Trib at old State Highway 61, south of Boonville.
5A	Trib to Arm A, northern sector.
5B	Trib to Arm A, at city lake outlet.
5C	Trib to Arm B, southern sector.
5D	Trib to Arm B, northern sector.
6	Trib at new State Highway 61, west of site 5.
7	Cypress Creek at 150 S. Rd.
9	Trib at 350 W. Rd.
10	Kelly ditch at State Highway 261.
11	Cypress Creek at 300 S. Rd near RR.
12	McCool ditch at Friendship Church on 350 W. Rd.
13A	Trib arm to McCool ditch east of Wright mine at old State Highway 61.
13B	Trib arm to McCool ditch on old State Highway 61 north of 300 S. Rd.
14	Trib arm to McCool ditch at 350 S. Rd.
14C	Trib arm to Taylor ditch at 350 S. Rd.
14D	Trib arm to Taylor ditch at old State Highway 61, north of 500 S. Rd.
14E	Trib arm to Taylor ditch at 500 S. Rd.
15	Cypress Creek.
16	Trib to Cypress Creek at 450 W. Rd.
17	Cypress Creek at 450 S. Rd.
18	Kaiser ditch at new State Highway 61 and 500 S. Rd.
19	Cypress Creek at 550 S. Rd. west of Dayville.
20	Cypress Creek.
21	Summer Pecka ditch at 450 S. Rd.
22	Cypress Creek at 550 W. Rd.
23	Cypress Creek at State Highway 66.
26	Taylor ditch at new State Highway 61.
26A	Trib arm to Koehler ditch at 550 S. Rd.
27	Cypress Creek trib at 475 W. Rd.

Table 2.--Field measurements at sites along Cypress Creek in April, June, July, and August 1979

[Measurements by U.S. Geological Survey; °C, degree Celsius; μmho/cm, micromho per centimeter; ft³/s, cubic foot per second]

Site	1	2	7	11	15	17	19
				April 1979			
Sampling date (1979)	April 11	April 11	April 10	April 12	April 10	April 10	April 12
Time (eastern standard)	1105	[1]1440	1550	1000	1630	1725	1805
Water temperature (°C)	11.1	14.0	11.0	13.5	10.7	10.6	18.4
Air temperature (°C)	--------	--------	9.5	--------	9.6	9.6	--------
pH	6.6	7.2	6.9	7.1	7.1	7.2	7.4
Eh, oxidation-reduction potential (millivolts)	+305	+250	+260	+320	+255	+380	+410
Specific conductance (μmho/cm at 25°C)	1,050	1,000	1,150	705	1,300	1,300	940
Dissolved oxygen (mg/L)	11.4	15.6	11.0	9.6	11.3	11.2	9.5
Dissolved oxygen (percent saturation)	105	153	101	93	103	102	102
Instantaneous stream discharge (ft³/s)	36.2	36.7	--------	505	--------	--------	443
Weather	Overcast, intermittent rain, and warm						
				June 1979			
Sampling date (1979)	June 12	June 12	June 13	June 12	June 13	June 13	June 12
Time (eastern standard)	1855	1610	1415	1513	1425	1510	1045
Water temperature (°C)	25.2	25.8	27.4	27.1	27.0	27.1	24.0
Air temperature (°C)	24.5	26.0	29.0	31.1	29.0	31.0	28.0
pH	7.1	7.0	7.7	7.0	8.8	7.8	6.4
Specific conductance (μmho/cm at 25°C)	1,600	1,560	2,000	1,800	2,120	2,110	1,900
Dissolved oxygen (mg/L)	3.8	9.7	7.6	8.1	7.8	9.6	9.0

Table 2.--Field measurements at sites along Cypress Creek in April, June, July, and August 1979--Continued

Site	1	2	7	11	15	17	19
June 1979--Continued							
Dissolved oxygen (percent saturation)	45	118	95	100	96	118	106
Instantaneous stream discharge (ft^3/s)	13.2	11.1	--------	23.2	--------	--------	28.1
Weather	Hot, humid, and sunny						
July 25, 1979							
Time (eastern standard)	0950	1040	1316	1110	1350	1410	1155
Water temperature (°C)	25.0	24.8	24.5	24.0	24.5	24.6	24.0
Air temperature (°C)	--------	--------	--------	--------	--------	--------	--------
pH	6.4	6.8	7.0	6.7	6.9	7.0	6.8
Eh, oxidation-reduction potential (millivolts)	+310	+263	+240	+265	+240	+245	+245
Specific conductance (μmho/cm at 25°C)	2,100	1,750	1,500	1,300	1,400	1,400	1,200
Dissolved oxygen (mg/L)	6.4	6.1	5.1	4.8	5.6	5.7	5.4
Dissolved oxygen (percent saturation)	75	72	59	55	65	66	62
Estimated stream discharge (ft^3/s)	[2]29	[2]19	[2]48	[2]70	[2]106	[2]64	[2]160
Weather	Intermittent light showers and overcast						

Table 2.--Field measurements at sites along Cypress Creek in April, June, July, and August 1979--Continued

Site	1	2	7	11	15	17	19
			July 26, 1979				
Time (eastern standard)	1157	1200	---	1210	---	---	1215
pH	7.0	6.6	---	7.2	---	---	7.1
Eh, oxidation-reduction potential (millivolts)	+350	+280	---	+310	---	---	+285
Specific conductance (µmho/cm at 25°C)	1,200	1,100	---	650	---	---	470
Estimated stream discharge (ft^3/s)	[2]493	[2]440	---	[2]1,100	---	---	[2]2,300
Weather	Heavy rain[3]						
			August 13, 14, 1979				
Sampling date (1979)	Aug. 14	Aug. 14	Aug. 13	Aug. 14	Aug. 13	Aug. 13	Aug. 14
Time (eastern standard)	1600	1410	1550	1205	1615	1626	0950
Water temperature (°C)	25.0	25.8	27.5	24.4	27.2	27.0	22.5
pH	7.4	7.6	8.0	8.0	8.0	7.8	7.5
Eh, oxidation-reduction potential (millivolts)	+210	+340	+340	+392	+335	+345	+480
Specific conductance (µmho/cm at 25°C)	1,300	1,180	2,100	1,500	2,200	2,120	1,600
Dissolved oxygen (mg/L)	7.9	7.7	12.4	9.4	11.2	9.8	7.6
Dissolved oxygen (percent saturation)	93	92	153	109	137	120	85
Instantaneous stream discharge (ft^3/s)	6.07	4.26	--------	11.97	--------	--------	13.13
Weather	Warm and partly cloudy						

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[1] For example, 1440 is 2:40 p.m.

[2] Estimated discharge.

[3] Flooding.

Table 3.--Field measurements at tributary sites draining into Cypress Creek in April, June, July, and August 1979

[Measurements by U.S. Geological Survey; °C, degree Celsius; umho/cm, micromho per centimeter; ft^3/s, foot per second]

Site	1G	3	10	5	6	9
Sampling date (1979)	April 11	April 10	April 10	April 10	April 10	April 10
Time (eastern standard)	1105	[1]1800	1600	1455	1607	1540
Water temperature (°C)	14.7	10.8	10.5	12.5	12.7	12.4
Air temperature (°C)	--------	9.9	10.5	11.0	10.0	11.0
pH	1.2	7.7	7.3	7.2	7.2	8.0
Eh, oxidation-reduction potential (millivolts)	+670	+275	+260	+300	+240	+400
Specific conductance (umho/cm at 25°C)	1,700	1,300	1,250	2,000	2,090	3,200
Dissolved oxygen (mg/L)	10.4	11.6	11.6	13.6	13.0	14.0
Dissolved oxygen (percent saturation)	98	105	105	128	124	132
Weather	Overcast, intermittent rain, and warm					

Site	13A	13B	12	26	18	21
Sampling date (1979)	April 10	April 10	April 10	April 10	April 10	April 10
Time (eastern standard)	1510	1520	1620	1640	1705	1715
Water temperature (°C)	11.5	12.1	10.7	11.4	11.1	10.6
Air temperature (°C)	10.5	9.5	11.5	10.0	9.2	9.3
pH	7.5	7.6	7.9	8.0	7.7	7.8
Eh, oxidation-reduction potential (millivolts)	+410	+420	+350	+345	+380	+182
Specific conductance (umho/cm at 25°C)	3,500	2,810	2,000	1,800	1,300	690
Dissolved oxygen (mg/L)	14.6	15.2	14.2	14.0	13.2	12.3
Dissolved oxygen (percent saturation)	138	142	131	130	119	113
Weather	Overcast, intermittent rain, and warm					

Table 3.--Field measurements at tributary sites draining into Cypress Creek in April, June, July, and August 1979--Continued

Site	3	5	5A	5B	5C	6	9
Sampling date (1979)	June 12	June 13	June 13	June 13	June 13	June 13	June 13
Time (eastern standard)	--------	0955	1330	1335	1350	1410	1050
Water temperature (°C)	29.2	21.2	19.0	26.0	21.3	25.6	22.7
Air temperature (°C)	-------	29.0	32.5	32.0	29.0	30.5	29.5
pH	7.7	8.0	6.7	7.7	7.7	8.4	7.9
Eh, oxidation-reduction potential (millivolts)	-------	+222	+224	+275	+252	+225	+217
Specific conductance (µmho/cm at 25°C)	1,650	2,520	2,360	1,880	2,270	2,440	3,850
Dissolved oxygen (mg/L)	11.6	9.7	6.7	6.7	5.5	14.0	6.4
Dissolved oxygen (percent saturation)	147	123	67	80	60	165	73
Instantaneous stream discharge (ft³/s)	-------	1.09	-------	-------	-------	-------	1.20
Weather	Hot, humid, and sunny						

Site	10	12	13A	13B	14	18	21	26
Sampling date (1979)	June 12	June 12	June 12	June 12	June 13	June 13	June 12	June 13
Time (eastern standard)	--------	1430	1325		1515	1445	1130	1440
Water temperature (°C)	26.5	29.2	26.9		28.5	27.8	25.5	27.6
Air temperature (°C)	--------	30.5	--------	No Flow	29.0	29.5	29.0	29.5
pH	8.0	8.2	8.1		8.0	8.1	7.9	8.1
Eh, oxidation-reduction potential (millivolts)	-------	+290	+266		+260	+242	+302	+240
Specific conductance (µmho/cm at 25°C)	2,295	3,540	4,370		2,710	2,430	500	2,000
Dissolved oxygen (mg/L)	15.6	12.8	10.1		14.7	17.1	6.8	9.1
Dissolved oxygen (percent saturation)	188	163	124		184	212	80	112
Instantaneous stream discharge (ft³/s)	-------	1.47	-------		-------	-------	.17	--------
Weather	Hot, humid, and sunny							

Table 3.--Field measurements at tributary sites draining into Cypress Creek in April, June, July, and August 1979--Continued

Site	3	5	6	9	10
	July 25, 1979				
Time (eastern standard)	1300	1450	1307	1313	1255
Water temperature (°C)	25.5	23.8	22.5	24.0	23.4
pH	7.4	7.4	7.4	7.9	7.5
Eh, oxidation-reduction potential (millivolts)	+365	+268	+380	+790	+370
Specific conductance (umho/cm at 25°C)	1,300	1,900	1,600	2,850	1,555
Dissolved oxygen (mg/L)	7.3	7.8	7.2	7.0	7.2
Dissolved oxygen (percent saturation)	86	90	81	80	83
Weather	Overcast, hot, humid, and occasional light rain				

Site	12	14	18	21	26
	July 25, 1979				
Time (eastern standard)	1330	1338	1435	1420	1425
Water temperature (°C)	24.5	24.0	22.0	25.8	25.5
pH	7.6	7.3	7.4	8.2	7.8
Eh, oxidation-reduction potential (millivolts)	+320	+330	+270	+310	+340
Specific conductance (umho/cm at 25°C)	1,600	1,100	1,100	900	1,900
Dissolved oxygen (mg/L)	7.4	6.7	7.7	9.4	9.6
Dissolved oxygen (percent saturation)	86	77	86	112	114
Weather	Overcast, hot, humid, and occasional light rain				

Table 3.--Field measurements at tributary sites draining into Cypress Creek in April, June, July, and August 1979--Continued

Site	3	5	6	9	10
August 13, 1979					
Time (eastern standard)	1735	1525	1540	1558	1740
Water temperature (°C)	28.5	25.5	25.5	24.4	25.5
pH	8.0	7.9	8.2	8.1	8.2
Eh, oxidation-reduction potential (millivolts)	+350	+380	+380	+260	+300
Specific conductance (μmho/cm at 25°C)	1,950	2,000	2,420	3,900	2,300
Dissolved oxygen (mg/L)	8.0	8.0	12.2	8.5	15.8
Dissolved oxygen (percent saturation)	120	94	144	99	97
Weather	Warm and partly cloudy				

Site	12	14	18	21	26
August 13, 1979					
Time (eastern standard)	1605	1610	1650	1635	1645
Water temperature (°C)	29.0	25.8	28.5	28.8	28.9
pH	8.0	7.5	8.0	8.1	8.4
Eh, oxidation-reduction potential (millivolts)	+260	+120	+355	+340	+350
Specific conductance (μmho/cm at 25°C)	3,180	3,400	3,200	742	2,200
Dissolved oxygen (mg/L)	14.4	11.0	11.8	7.6	12.5
Dissolved oxygen (percent saturation)	182	131	149	96	158
Weather	Warm and partly cloudy				

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[1] For example, 1800 is 6:00 p.m.

Table 4.--Chemical analyses of water samples from the Cypress Creek watershed

[Analyses by U.S. Geological Survey; °C, degree Celsius]

	Date of sampling (1979)	April 11		April 12		June 12			
	Site	1	2	11	19	1	2	11	19
	Eastern standard time	1105	[1]1440	1000	1805	1830	1630	1410	1045
Milligrams per liter	Alkalinity, total (as $CaCO_3$)	39	51	62	78	120	120	190	180
	Aluminum (Al)	0.20	.20	.20	.20	.40	.20	.20	.20
	Aluminum (Al), suspended	-------	-------	-------	-------	.45	.06	.58	.34
	Aluminum (Al), total	-------	-------	-------	-------	.85	.26	.78	.54
	Calcium (Ca)	110	100	84	95	190	180	210	210
	Chloride (Cl)	5.0	5.7	6.1	6.3	6.4	11.0	9.5	9.9
	Fluoride (F)	0.2	.2	.2	.2	.3	.4	.3	.4
	Hardness, noncarbonate	460	410	320	370	850	780	870	880
	Hardness, total (as $CaCO_3$)	500	460	390	440	970	900	1,100	1,100
	Iron (Fe)	3.4	.67	.01	.03	.21	.01	.01	.11
	Iron (Fe), suspended	-------	-------	-------	-------	3.8	.99	1.7	.99
	Iron (Fe), total	-------	-------	-------	-------	4.0	1.0	1.7	1.1
	Magnesium (Mg)	55	52	43	50	120	110	130	130
	Manganese (Mn)	1.1	1.1	.68	.07	.73	.68	.72	.61
	Manganese (Mn), suspended	-------	-------	-------	-------	.04	.0	.03	.03
	Manganese (Mn), total	-------	-------	-------	-------	.77	.67	.75	.64
	Potassium (K)	3.4	3.3	3.2	3.3	4.2	4.3	4.3	4.2
	Dissolved solids (residue on evaporation at 180°C)	802	759	626	709	1,540	1,470	1,360	1,790
	Silica (SiO_2)	6.7	7.1	5.6	21.0	5.9	6.7	6.4	6.3
	Sodium (Na)	25	25	26	35	62	59	77	88
	Sulfate (SO_4)	530	500	370	410	960	910	860	1,000
	Sodium-adsorption ratio (SAR)	0.5	.5	.6	.7	.9	.9	1.0	1.2
	Percent sodium	10	10	13	15	12	12	14	15

Table 4.--Chemical analyses of water samples
from the Cypress Creek watershed--Continued

	Date of sampling (1979)	June 13		June 12		August 14			
	Site	5	9	12	21	1	2	11	19
	Eastern standard time	0955	1050	1430	1130	1600	1410	1205	0750
Milligrams per liter	Alkalinity, total (as $CaCO_3$)	180	340	280	70	110	130	160	170
	Aluminum (Al)	0.20	.20	.30	.20	.08	.04	.20	.03
	Aluminum (Al), suspended	0.0	.70	0	1.8	.69	.08	.09	.16
	Aluminum (Al), total	0.18	.90	.15	2.0	.77	.12	.29	.19
	Calcium (Ca)	370	470	350	47	170	160	290	220
	Chloride (Cl)	5.7	6.1	9.9	20.0	5	16	11	11
	Fluoride (Fl)	0.5	.3	.2	.3	.3	.4	.4	.4
	Hardness, noncarbonate	1,800	2,700	3,000	110	730	620	1,100	960
	Hardness, total (as $CaCO_3$)	2,000	3,100	3,300	180	840	750	1,300	1,100
	Iron (Fe)	0.03	.04	.04	0	.02	.03	.08	.05
	Iron (Fe), suspended	0.51	2.6	.3	4.1	7.3	.68	.82	.50
	Iron (Fe), total	0.54	2.60	.34	4.1	7.3	.71	.90	.55
	Magnesium (Mg)	260	460	580	16	100	86	140	140
	Manganese (Mn)	1.9	3.0	.1	.04	.41	.41	.40	.32
	Manganese (Mn), suspended	0.20	1.1	.03	.29	.05	0	.02	.02
	Manganese (Mn), total	2.1	4.1	.13	.33	.46	.41	.42	.34
	Potassium (K)	3.7	5.1	5.0	1.7	4.4	4.9	5.1	4.8
	Dissolved solids (residue on evaporation at 180°C)	2,520	4,040	3,470	316	1,410	1,300	1,780	1,750
	Silica (SiO_2)	10.0	10.0	7.0	5.3	5.7	8.7	7.0	7.8
	Sodium (Na)	36	130	180	33	50	53	80	100
	Sulfate (SO_4)	1,500	2,600	2,100	150	850	740	1,000	1,000
	Sodium-adsorption ratio (SAR)	0.4	1.0	1.4	1.1	.8	.8	1.0	1.3
	Percent sodium	4	8	11	28	11	13	12	16

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[1] For example, 1440 is 2:40 p.m.

Table 5.--Concentrations of nitrogen and phosphorus in water and streambed samples from the Cypress Creek watershed

[Analyses by U.S. Geological Survey; mg/L, milligram per liter; mg/kg, milligram per kilogram]

Date of sampling (1979)	April 11		April 12		June 12			
Site	1	2	11	19	1	2	11	19
Eastern standard time	1105	[1]1440	1000	1805	1830	1630	1410	1045
Water samples								
Nitrogen, ammonia, dissolved as NH_4 (mg/L)	0.26	.32	.24	.21	.40	.35	.52	.48
Nitrogen, dissolved organic as N (mg/L)	0.14	.28	.77	.74	.26	.27	.30	.31
Nitrogen, dissolved as N (mg/L)	0.93	1.2	1.9	1.9	1.7	2.3	2.2	2.0
Nitrogen, dissolved Kjeldahl as N (mg/L)	0.34	.53	.96	.90	.57	.27	.40	.37
Nitrogen, ammonia, dissolved as N (mg/L)	0.20	.25	.19	.16	.31	.27	.40	.37
Nitrite plus nitrate, dissolved as N (mg/L)	0.59	.71	.93	.97	1.1	1.8	1.5	1.3
Phosphorus, dissolved orthophosphate as P (mg/L)	0.00	.00	.00	.00	.00	.06	.00	.00
Phosphate, ortho, dissolved (PO_4) as P (mg/L)	0.00	.00	.00	.00	.00	.18	.00	.00
Phosphorus, dissolved as P (mg/L)	0.00	.00	.01	.02	.00	.10	.02	.01

Date of sampling (1979)	April 11		April 12		June 12			
Site	1	2	11	19	1	2	11	19
Eastern standard time	1105	[1]1440	1000	1805	1830	1630	1410	1045
Streambed samples								
Nitrogen, total as nitrogen (mg/kg)	17,000	18,000	8,600	5,700	16,000	20,000	9,000	6,200
Phosphorus, total as phosphorus (mg/kg)	0	0	1	0	380	1,900	1,700	940

Table 5.--Concentrations of nitrogen and phosphorus in water and streambed samples from the Cypress Creek watershed--Continued

Date of sampling (1979)	June 13		June 12		August 14			
Site	5	9	12	21	1	2	11	19
Eastern standard time	0955	1050	1430	1130	1600	1410	1205	0905
Water samples								
Nitrogen, ammonia, dissolved as NH_4 (mg/L)	0.15	.27	.10	.03	.08	----	1.2	.17
Nitrogen, dissolved organic as N (mg/L)	0.24	.26	.62	.22	.48	----	.67	.15
Nitrogen, dissolved as N (mg/L)	0.49	.66	.85	.89	1.4	3.6	2.4	1.4
Nitrogen, dissolved Kjeldahl as N (mg/L)	0.36	.47	.70	.24	.54	3.0	1.6	.28
Nitrogen, ammonia, dissolved as N (mg/L)	0.12	.21	.08	.02	.06	----	.93	.13
Nitrite plus nitrate, dissolved as N (mg/L)	0.13	.19	.15	.65	.85	.62	.83	1.1
Phosphorus, dissolved orthophosphate as P (mg/L)	0.00	.08	.00	.00	.00	.14	.02	.00
Phosphate, ortho, dissolved (PO_4) as P (mg/L)	0.00	.25	.00	.00	.00	.42	.06	.00
Phosphorus, dissolved as P (mg/L)	0.01	.11	.05	.01	.00	.20	.02	.02

Date of sampling (1979)	June 13		June 12		August 14			
Site	5	9	12	21	1	2	11	19
Eastern standard time	0955	1050	1430	1130	1600	1410	1205	0905
Streambed samples								
Nitrogen, total as nitrogen (mg/kg)	5,200	7,000	5,200	3,200	23,000	20,000	5,000	4,600
Phosphorus, total as phosphorus (mg/kg)	4,500	740	360	760	370	1,400	720	880

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[1] For example, 1440 is 2:40 p.m.

Table 6.--Concentrations of aluminum, iron, and manganese in streambed samples from the Cypress Creek watershed

[Analyses by U.S. Geological Survey; μg/kg, microgram per kilogram]

Date of sampling (1979)	April 11		April 12	
Site	1	2	11	19
Eastern standard time	1105	[1]1440	1000	1805
Aluminum (μg/kg)	7,500	6,000	11,000	9,000
Iron (μg/kg)	34,000	29,000	35,000	26,000
Manganese (μg/kg)	360	1,100	680	460

Date of sampling (1979)	June 12			
Site	1	2	11	19
Eastern standard time	1830	1630	1410	1045
Aluminum (μg/kg)	3,600	7,100	8,400	8,500
Iron (μg/kg)	32,000	46,000	39,000	28,000
Manganese (μg/kg)	260	370	420	290

Date of sampling (1979)	June 13		June 12	
Site	5	9	12	21
Eastern standard time	0955	1050	1430	1130
Aluminum (μg/kg)	11,000	5,900	4,600	5,100
Iron (μg/kg)	48,000	20,000	15,000	39,000
Manganese (μg/kg)	2,100	1,500	450	3,100

Date of sampling (1979)	August 14			
Site	1	2	11	19
Eastern standard time	1600	1410	1205	0950
Aluminum (μg/kg)	4,800	7,200	11,000	9,400
Iron (μg/kg)	26,000	51,000	34,000	34,000
Manganese (μg/kg)	320	540	400	600

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[1] For example, 1440 is 2:40 p. m.

Table 7.--Concentrations of organic carbon in streambed and water samples from the Cypress Creek watershed

[Analyses by U.S. Geological Survey; mg/L, milligram per liter; g/kg, gram per kilogram]

Date of sampling (1979)	April 11		April 12		June 12			
Site	1	2	11	19	1	2	11	19
Eastern standard time	1105	[1]1440	1000	1805	1830	1630	1410	1045
Water samples								
Carbon, dissolved organic (mg/L)	5.0	7.8	3.3	---	9.3	7.1	5.8	11.0
Carbon, suspended organic (mg/L)	0.6	.6	2.4	---	0.4	.6	---	.9
Carbon, total organic (mg/L)	5.6	8.4	5.7	---	9.7	7.7	---	11.9
Streambed samples								
Carbon (g/kg)	---	---	---	---	0.3	.1	2.6	.4
Carbon, organic (g/kg)	---	---	---	---	280	105	38	29
Carbon, total (g/kg)	---	---	---	---	280.3	105.1	40.6	29.4

Date of sampling (1979)	June 13		June 12		August 14			
Site	5	9	12	21	1	2	11	19
Eastern standard time	0955	1050	1430	1130	1600	1410	1205	0950
Water samples								
Carbon, dissolved organic (mg/L)	3.2	3.9	5.9	5.1	5.9	6.3	5.9	4.1
Carbon, suspended organic (mg/L)	0.4	3.7	.5	1.8	0.3	.2	---	.2
Carbon, total organic (mg/L)	3.6	7.6	6.4	6.9	6.2	6.5	---	4.3
Streambed samples								
Carbon (g/kg)	1.1	5.5	4.5	1.7	0.3	1.0	.8	2.1
Carbon, organic (g/kg)	24	27	16	13	142	96	21	18
Carbon, total (g/kg)	25.1	32.5	20.5	14.7	142.3	97	21.8	20.1

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[1] For example, 1440 is 2:40 p.m.

Table 8.--Concentrations of chlorinated hydrocarbons in surface and core streambed samples from the Cypress Creek watershed

[Analyses by U.S. Geological Survey; PCB, polychlorinated biphenyl, PCN, polychlorinated naphthalene; ND, not detected; all units ug/kg, microgram per kilogram]

Date of sampling (1979)	April 11		April 12		June 12		June 13		June 12		July 25				
	Streambed samples														Core[2] sample
Site[1]	1	2	11	19	1	19	5	9	12	21	1	2	11	19	11
Aldrin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlordane	4	[3]30	ND	[3]130	ND	[3]91	[3]68	12	[3]110	7.0	ND	[3]96	[3]29	[3]54	6
DDD	ND	.6	ND	ND	ND	ND	2.2	ND	5.5	ND	4.5	ND	ND	ND	3.1
DDE	ND	.4	1.6	ND	ND	ND	ND	ND	ND	1.0	1.6	11	5.1	2.6	.5
DDT	2.7	1.3	5.4	ND	1.4	ND	ND	ND	ND	3.9	[3]28	14	4.5	.8	ND
Dieldrin	ND	ND	17	5.1	1.2	3.6	6.0	ND	9.3	4.2	1.5	12	5.3	17	ND
Endosulfan	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	ND	ND	1.9	ND	1.1	ND	ND	ND	ND	ND	.5	5	1.5	2.2	ND
Heptachlor	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lindane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mirex	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB	[3]32	[3]92	[3]62	[3]34	[3]100	[3]34	12	10	ND	ND	[3]62	[3]330	[3]39	[3]45	[3]42
PCN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Perthane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toxaphene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

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[1] Site numbers are plotted in figure 2.

[2] Core sample, 2-ft depth, taken in stream bottom on upstream side of bridge at site 11, left edge of water.

[3] Exceeds water-quality alert limit of 20 ug/kg for chlordane, DDT, and PCB's set by the U.S. Environmental Protection Agency (1976, p. 240, 254, and 364).

Table 9.--Concentrations of suspended sediment in the Cypress Creek watershed

[Data obtained by U.S. Geological Survey; mg/L, milligram per liter]

Site	Sampling date (1979)	Eastern standard time	Concentration (mg/L)	Total concentration, Cypress Creek (mg/L)
1	4-11	1105	33	
2	4-11	[1]1440	42	
11	4-12	1000	362	
19	4-12	1805	339	776
1	6-12	1830	21	
2	6-12	1630	13	
11	6-12	1513	38	
19	6-12	1045	61	133
5	6-13	0955	15	
9	6-13	1050	21	
12	6-12	1530	28	
21	6-12	1130	78	---
1	8-14	1600	---	
2	8-14	1410	---	
11	8-14	1205	---	
19	8-14	0950	---	91

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[1] For example, 1440 is 2:40 p.m.

Table 10.--Sieve analysis of a composite of the suspended-sediment samples from Cypress Creek, August 14, 1979

[Analysis by U.S. Geological Survey]

Sediment fraction size	Weight in grams	Percent finer than	Percent
Silt and clay	0.1408	--	96.0
0.062 mm sand	.0017	99	1.2
0.125 mm sand	.0034	96	2.3

Total weight of sediment: 0.1459 gram.
Weight of water sediment mixture: 1,598.0 grams.
Mean concentration of suspended sediment in Cypress Creek: 91.0 milligrams per liter.

Table 11.--Bacterial data for streams in the Cypress Creek watershed

[Counts and ratios determined by U.S. Geological Survey; mL, milliliter]

Site	Sampling date (1979)	Colonies per 100 mL Fecal coliform	Colonies per 100 mL Fecal streptococcus	Fecal coliform / Fecal streptococcus
1	4-10	300	253	1.19
2	4-10	1,435	980	1.46
11	4-10	6,127	1,750	3.50
19	4-10	797	207	3.85
1	6-11	228	133	1.71
2	6-11	5,500	510	10.78
11	6-11	5,800	257	22.57
19	6-11	2,782	153	18.18
5	6-11	900	1,825	.49
9	6-11	6,233	3,310	1.88
12	6-11	105	113	.93
21	6-11	940	1,440	.65
2	8-13	27,200	190	143.20
11	8-13	30	1,580	.02
19	8-13	20	1,123	.02

Table 12.--Periphyton data for Cypress Creek, colonization period, June 13 through August 13, 1979

[Analyses by U.S. Geological Survey;
X, sample contains organism;
D, dominant organism; g/m^2, gram per square meter;
ND, not detected]

Organism	Site 1	Site 2
Chrysophyta (yellow-brown algae and diatoms and pennates)		
Bacillariophyceae	X	X
Naviculaceae	ND	X
Navicula	ND	D
Nitzschiaceae	X	X
Nitzschia	D	D
Pennales	X	X
Biomass, ASH (g/m^2)	8.89	9.01
Biomass, DRY (g/m^2)	13.10	11.20
Biomass, ACTUAL (g/m^2)	4.21	2.19

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