Quality of Surface Water...

QUALITY OF SURFACE WATER BEFORE IMPLEMENTATION OF A FLOOD–CONTROL PROJECT IN CHASKA, MINNESOTA

U. S. GEOLOGICAL SURVEY
WATER–RESOURCES INVESTIGATIONS 81–83

PREPARED IN COOPERATION WITH THE
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March 3, 1849

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Samples were collected for 1 year from East Creek, Chaska Creek, and Courthouse Lake in Chaska, Minnesota, to determine the water quality before implementation of a flood-control project proposed by the U.S. Army Corps of Engineers. The creeks had similar water-quality characteristics. Data indicate that ground water may be the primary source of dissolved solids, sulfate, chloride, and chromium in the creeks. The pesticides alachlor, atrazine, simazine, and 2,4-D were found in water samples from both creeks but were well below the lethal concentrations for fish. Courthouse Lake, a 57-foot-deep stream-trout lake, had a mean summer trophic-state index of 35. Phytoplankton populations varied seasonally, and blue-green algae were predominant only in late summer. The algal-pollution index was highest in late summer, but did not provide evidence of high organic pollution. The apparently successful recovery of Courthouse Lake from past inundations by Minnesota River floodwaters having total phosphorus concentrations as high as 0.66 milligram per liter suggests that the lake, in time, will also recover from the added runoff expected as a result of implementing the flood-control project. The runoff could temporarily raise the total phosphorus concentration in the lake from 0.03 to 0.12 milligram per liter and raise the spring trophic-state index from 49 to 69.

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QUALITY OF SURFACE WATER BEFORE IMPLEMENTATION OF A FLOOD-CONTROL PROJECT IN CHASKA, MINNESOTA

By L. H. Tornes

Quality of East and Chaska Creeks, and Courthouse Lake, and evaluation of probable changes in lake quality following construction

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UNITED STATES DEPARTMENT OF INTERIOR

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GEOLOGICAL SURVEY

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St. Paul, Minnesota 55101

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Multiply inch-pound units	By	To obtain SI (metric) units
inch (in)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
acre	0.4047	hectare (ha)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
square mile (mi^2)	2.590	square kilometer (km^2)
acre-foot (acre-ft)	1233	cubic meter (m^3)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

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

QUALITY OF SURFACE WATER BEFORE IMPLEMENTATION OF A FLOOD-CONTROL PROJECT IN CHASKA, MINNESOTA

By L. H. Tornes

ABSTRACT

Samples were collected for 1 year from East Creek, Chaska Creek, and Courthouse Lake in Chaska, Minnesota, to determine the water quality before a flood-control project proposed by the U.S. Army Corps of Engineers is implemented.

The two creeks had similar water-quality characteristics. Data indicate that ground water may be the primary source of dissolved solids, sulfate, chloride, and chromium in the creeks. The pesticides alachlor, atrazine, simazine, and 2,4-D were found in water samples from both creeks but were well below the lethal concentrations for fish.

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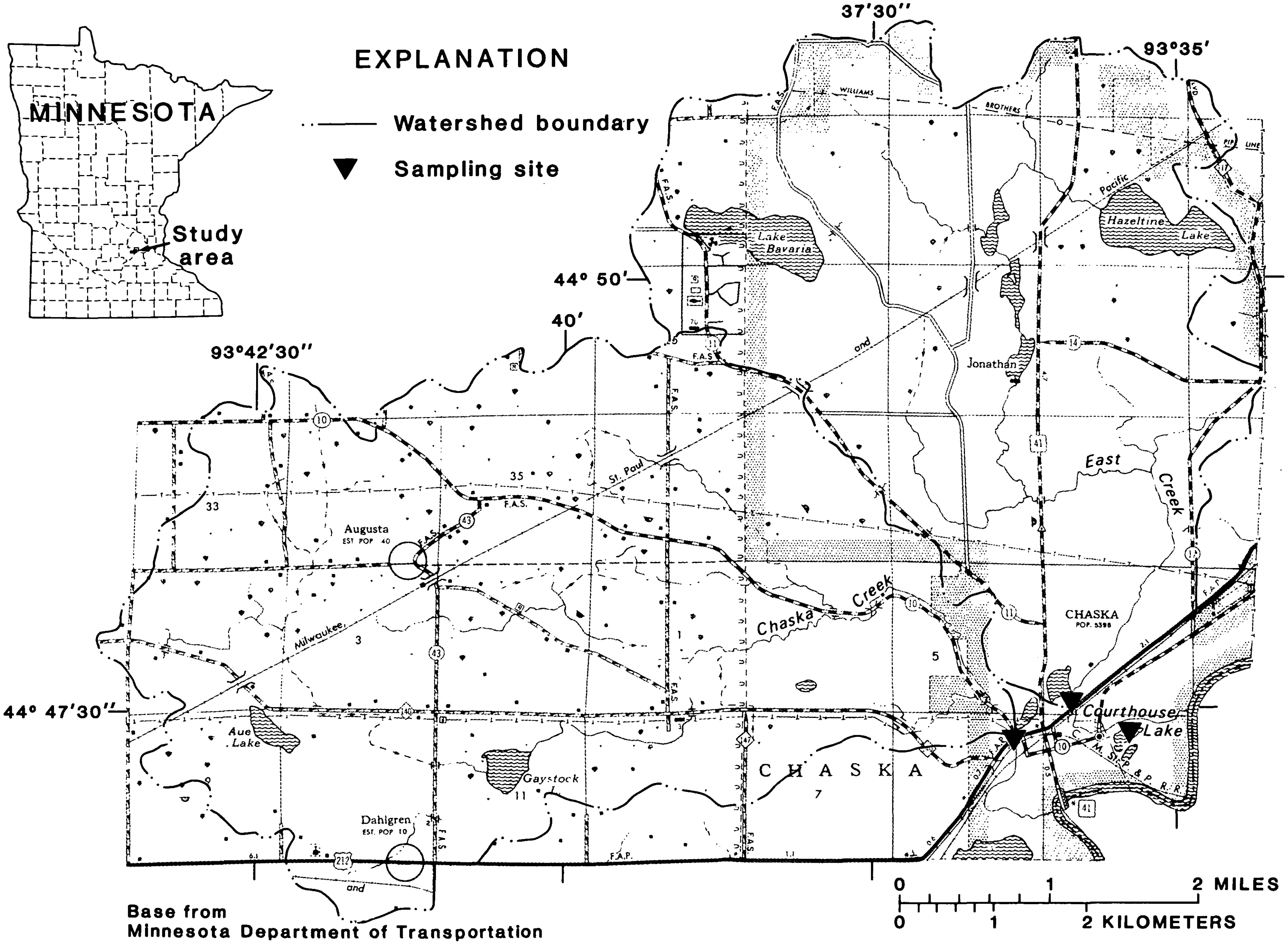
The successful recovery of Courthouse Lake from past inundations by Minnesota River floodwaters having total phosphorus concentrations as high as 0.66 milligram per liter suggests that the lake, in time, will also recover from the added runoff expected as a result of implementing the flood-control project. The runoff could temporarily raise the total phosphorus concentration in the lake from 0.03 to 0.12 milligram per liter and raise the spring trophic-state index from 49 to 69.

INTRODUCTION

Chaska, in Carver County, Minn., southwest of the Twin Cities metropolitan area (fig. 1), is subject to periodic flooding from the Minnesota River. The U.S. Army Corps of Engineers, before implementing a project to reduce damage from floods, asked the U.S. Geological Survey to determine the water quality of East Creek, Chaska Creek, and Courthouse Lake in Chaska, which will be affected by implementing the proposed project. Data were collected from August 1979 through August 1980. This report describes the quality of the waters and the potential water-quality impacts of redesigning a levee that surrounds the city.

Hydrologic Setting

East and Chaska Creeks drain 11.7 and 14.8 square miles, respectively, along the northern bluff of the Minnesota River valley. The watersheds slope about 100 feet per mile and are underlain by till, outwash, and alluvium consisting of clay, silt, sand, and gravel. Courthouse Lake is in the Minnesota River flood plain and was formed when an abandoned clay-mining pit filled with water. It has been stocked with rainbow, brown, brook, and lake trout, splake, and coho salmon since 1967 and is the only designated



Base from
Minnesota Department of Transportation
General Highway Map of Carver County, 1977

Figure 1.--Location and setting of study area

stream-trout lake in the seven-county metropolitan area (Minnesota Department of Natural Resources, written commun., 1980). The lake has a surface area of 11 acres and a maximum depth of 57 feet.

The mean annual precipitation in the Chaska area is 29 inches, which produces a mean annual runoff between 4.5 and 5 inches (Anderson and others, 1974).

Sampling Program

East and Chaska Creeks were sampled 12 times, as shown in table 1. Field measurements of discharge, air and water temperatures, specific conductance, dissolved oxygen, and pH were obtained with each sample. A sample for 5-day biochemical oxygen demand (BOD) was generally obtained with the standard samples that were analyzed for dissolved and suspended organic carbon, chloride, total and dissolved phosphorus, dissolved and suspended solids, dissolved sulfate, turbidity, dissolved ammonia, dissolved organic nitrogen, dissolved nitrite plus nitrate nitrogen, and total ammonia plus organic nitrogen.

Table 1.--Sampling schedule for East and Chaska Creeks and Courthouse Lake

[C, chlorophyll _a_; B, BOD; S, standard sample; SB, standard sample near lake bottom; SS standard sample near lake surface; M, metals plus oil and grease; P, pesticides; PP, phytoplankton]

Sampling Date	East Creek	Chaska Creek	Courthouse Lake
8-30-79	S,B	S,B	SS,SB,C,PP
9-27-79	S,B	S,B	—
10-30-79	S,B	S,B	—
1-14-80	S	S	—
3-25-80	S,M	S,M	SS,PP
4-30-80	S,B	S,B	SS,C,PP
5-30-80	S,B	S,B	—
6-12-80	S,P	S,P	—
6-24-80	S,B	S,B	SS,PP
7-17-80	S,M	S,M	—
7-23-80	B	B	—
8-22-80	S,B	S,B	SS,SB,C,PP

The first sample of the creeks on August 30, 1979, was analyzed for total instead of dissolved concentrations of ammonia, organic nitrogen, and nitrite plus nitrate nitrogen. Samples collected from each creek site on March 25 and July 17, 1980, were analyzed for oil and grease and total concentrations of arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, and zinc. Pesticide samples collected at each creek site on June 12, 1980, were analyzed for total concentrations of 4 chlorinated phenoxy-acid herbicides, 11 triazine herbicides, and 22 organochlorine and organophosphorus insecticides plus polychlorinated biphenyls (PCB) and polychlorinated naphthalenes (PCN).

Courthouse Lake was sampled five times. The constituents determined were the same as for the creeks except that turbidity and suspended solids were not determined and dissolved sulfate was determined only twice. Only total concentrations for the nitrogen-species part of the analysis were determined in the first sample. Pesticides, metals, and oil and grease were not determined for Courthouse Lake samples.

Each sample was analyzed for phytoplankton concentrations and taxonomic identification of the dominant phytoplankton genera. Measurement of Secchi-disk transparency and samples for chlorophyll a concentration were obtained each time, except in March 1980 when the lake was ice covered and primary productivity should have been near the annual minimum.

The August 1979 and August 1980 samplings of Courthouse Lake included samples taken near the bottom to determine whether constituent concentrations varied with depth. The constituents sampled were the same as those sampled at the surface, except that chlorophyll and phytoplankton were not analyzed and suspended and dissolved organic carbon concentrations were determined only on the final bottom sample. The August 1980 samples of Courthouse Lake were analyzed for concentrations of major cations and anions, dissolved silica, dissolved fluoride, and total alkalinity in addition to the other constituents.

Methods

Streamflow measurements were obtained by standard U.S. Geological Survey methods (Carter and Davidian, 1968). Field specific conductance, pH, dissolved oxygen, and water temperature were determined in situ using meters according to methods of the American Public Health Association and others (1976) and Brown and others (1970). Meters were calibrated before and after each sampling. Stream samples were depth-integrated at multiple points in the cross section and composited. Lake samples collected near the water surface were obtained near the center of the lake with a point sampler near the depth having the maximum dissolved-oxygen concentration and were generally composited from multiple depths above this zone. Samples were obtained near the lake bottom from a point sampler within 7 feet of the bottom at the deepest part of the lake. Vertical profiles were obtained near the center of the lake above the point of maximum depth.

Samples were filtered and (or) preserved at the site before shipment to the U.S. Geological Survey central laboratory in Doraville, Ga. for analysis. Five-day BOD's were determined by the azide modification of the iodometric titration method (American Public Health Association and others, 1976). The procedures used for preservation and analysis of water samples are specified for biological constituents by Greeson and others (1977), inorganic constituents by Skougstad and others (1979), and organic constituents by Goerlitz and Brown (1972).

WATER QUALITY OF EAST CREEK

Physical Characteristics and Major Inorganic Constituents

The flow of East Creek was measured a total of 12 times, coincidental with the sampling. The measured discharge of East Creek ranged from 0.22 ft^3/s on July 17, 1980, to 6.6 ft^3/s on August 30, 1979.

Figure 2 shows that East Creek discharges were generally low in winter, but were lowest near the end of summer 1980. Peak discharges were notable in March 1980 from snowmelt and in August 1979 and June 1980 from rainfall. Water temperatures followed normal seasonal variations. The lowest temperature of 1.0°C was measured on January 14, 1980, and the highest, 29.5°C, was measured on July 17, 1980.

Dissolved oxygen (DO) concentrations also varied seasonally. The dependence of dissolved-oxygen concentration on water temperature is indicated by their correlation coefficient of -0.91, based on 10 coincidental measurements. Gases, such as oxygen, become less soluble as the water temperature increases. Riffle areas upstream from the East Creek site apparently aerate the water and keep the dissolved oxygen nearly saturated. The DO ranged from only 94 to 105 percent of the saturation concentration, except on April 30, 1980, when it reached 126 percent. This supersaturation could have resulted from photosynthesis in the stream or increased water temperatures that reduced the oxygen solubility downstream from the aeration point.

Measurements of pH showed that East Creek is somewhat alkaline. The pH varied no more than 0.4 unit around the mean of 7.9 and showed no discernible seasonal trends.

Turbidity of the creek water had a mean of 4.3 nephelometric turbidity units (NTU). Although only 2.5 NTU was measured in the March snowmelt-runoff sample, turbidity was highest, 17 NTU, in the June rainfall-runoff sample. Soils exposed to erosion probably contributed substantial quantities of sediment, increasing the turbidity of this sample.

Turbidity had a fair correlation with 11 coincidental measurements of suspended-solids concentration, resulting in a coefficient of 0.63. Suspended-solids concentration was also highest, 25 mg/L (milligrams per liter), in the June runoff sample, but was at the mean of 15 mg/L in the March runoff sample. Suspended-solids concentration also was high, 23 mg/L, in the January 14, 1980, sample and will be discussed later.

The 11 measurements of dissolved-solids concentration in East Creek correlated strongly with 11 measurements of specific conductance, resulting in a coefficient of 0.96. Both had coincidental variations during the sampling. The dissolved-solids concentration and specific conductance were lowest in samples obtained during the highest discharge (August 1979 and March and June 1980), because of dilution. Higher concentrations of dissolved solids at lower discharges imply that East Creek is supplied by a base flow of ground water high in dissolved constituents. Both the dissolved-solids concentration and specific conductance were highest in the sample collected January 14, 1980, 664 mg/L and 1,022 umhos/cm (umhos per centimeter at 25°C), respectively.

Dissolved-sulfate concentrations in East Creek ranged from 30 to 68 mg/L, having a mean concentration of 45 mg/L. A correlation coefficient of -0.79 between 10 measurements of sulfate and streamflow suggests that the dissolved sulfate in East Creek may

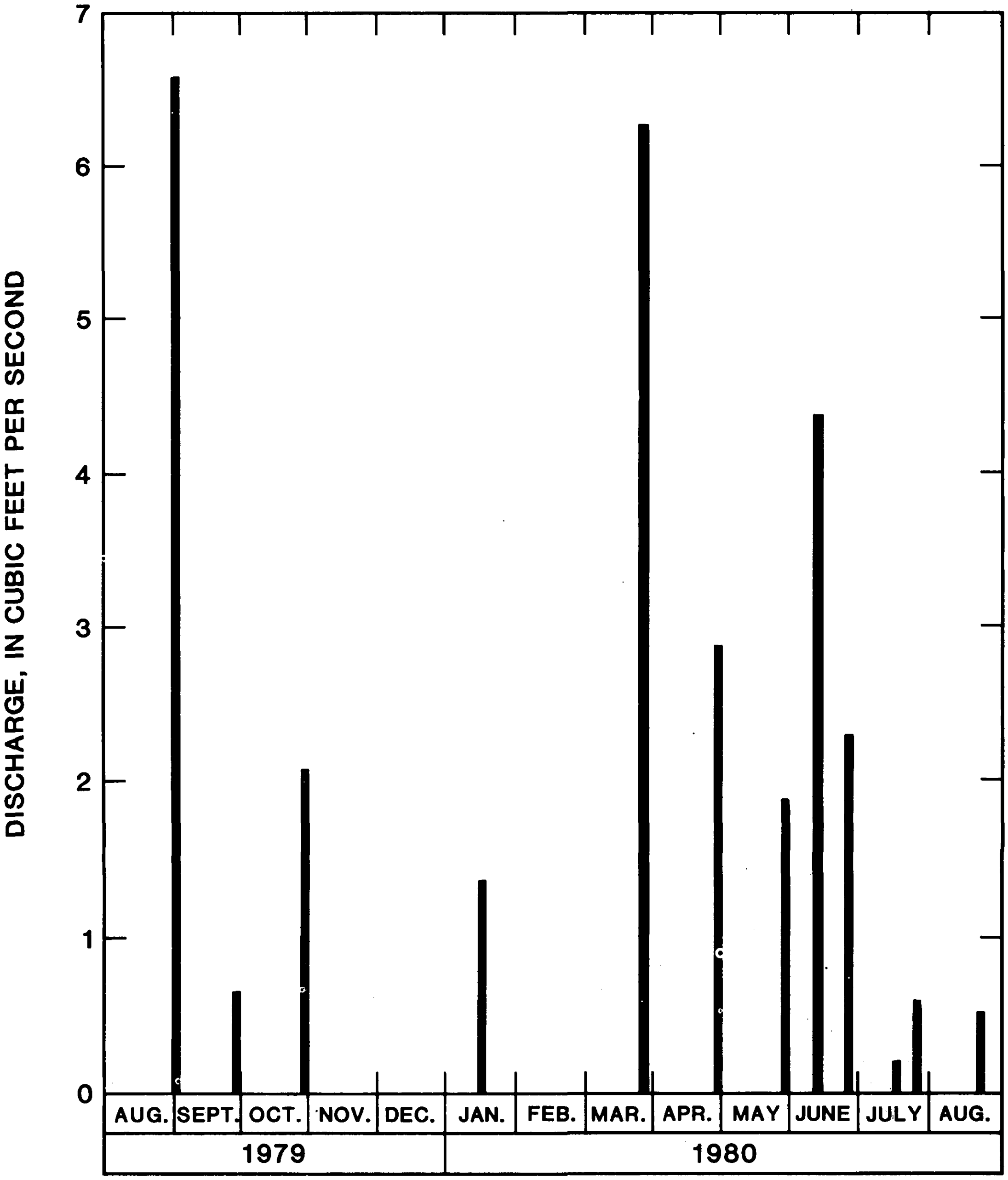


Figure 2.--Measurements of discharge at East Creek

be from ground water. A sample of ground water obtained from outwash near Chaska had 1.2 milliequivalents per liter or 58 mg/L of dissolved sulfate. A range in dissolved-sulfate concentration from 5 to 500 mg/L and a median concentration of 120 mg/L was observed in glacial sand and gravel aquifers in the area (Anderson and others, 1974).

Concentrations of chloride in East Creek ranged from 20 to 31 mg/L, having a mean concentration of 25 mg/L, except for the sample collected January 14, 1980. Variations in chloride concentration, including the January 1980 sample, correlated well with the specific conductance and dissolved-solids concentrations in 11 coincidental samples, resulting in coefficients of 0.88 and 0.87, respectively.

The sample collected January 14, 1980, had an extremely high chloride concentration of 180 mg/L. High dissolved- and suspended-solids concentrations and high specific conductance were also observed in this sample. East Creek was probably receiving drainage from a site with a high concentration of chloride, such as a snow-dumping site or a road treated with salt.

Nitrogen, Phosphorus, Organic Carbon, and Biochemical Oxygen Demand

Figure 3 shows the concentrations of various nitrogen species determined in East Creek. Total ammonia plus organic nitrogen concentrations correlated well with streamflow in 10 coincidental measurements, resulting in a coefficient of 0.92. About 47 percent of the ammonia was suspended in the runoff samples collected in August 1979 and March 1980. The total and dissolved ammonia plus organic nitrogen concentrations were highest during spring runoff, 2.4 and 1.5 mg/L, respectively, and lowest when the measured discharge was lowest. The dissolved organic nitrogen averaged 88 percent of the dissolved ammonia plus organic nitrogen. These two nitrogen forms showed strongly similar variations in concentration.

The measured concentrations of dissolved ammonia nitrogen are shown in figure 3 as the difference between the dissolved ammonia plus organic nitrogen and the dissolved organic nitrogen. Ammonia concentrations were generally low, but increased during winter and reached a peak concentration of 0.43 mg/L during spring runoff. This increase is considered a normal occurrence. Ammonia is released from decomposition of accumulated detritus and there are minimal plant populations to utilize it (Reid and Wood, 1976).

The average concentration of nitrite plus nitrate nitrogen was 0.29 mg/L, or 30 percent of the total-dissolved nitrogen, except in January and March 1980 when the nitrite plus nitrate nitrogen concentrations were much higher. The 1.6 mg/L in January comprised about 55 percent of the total dissolved nitrogen. A possible source of nitrates in East Creek could be runoff from livestock-feeding pens, but the presence of feeding pens in the watershed has not been determined.

Total phosphorus concentration in East Creek averaged 0.06 mg/L, except during spring runoff in March when the concentration was 0.73 mg/L. This high spring concentration was probably the result of runoff of phosphorus applied as fertilizer or leached from detritus accumulated in the watershed. Minor increases in concentration were also observed during runoff in August 1979 and June 1980 (fig. 4), but the magnitude was less than in spring.

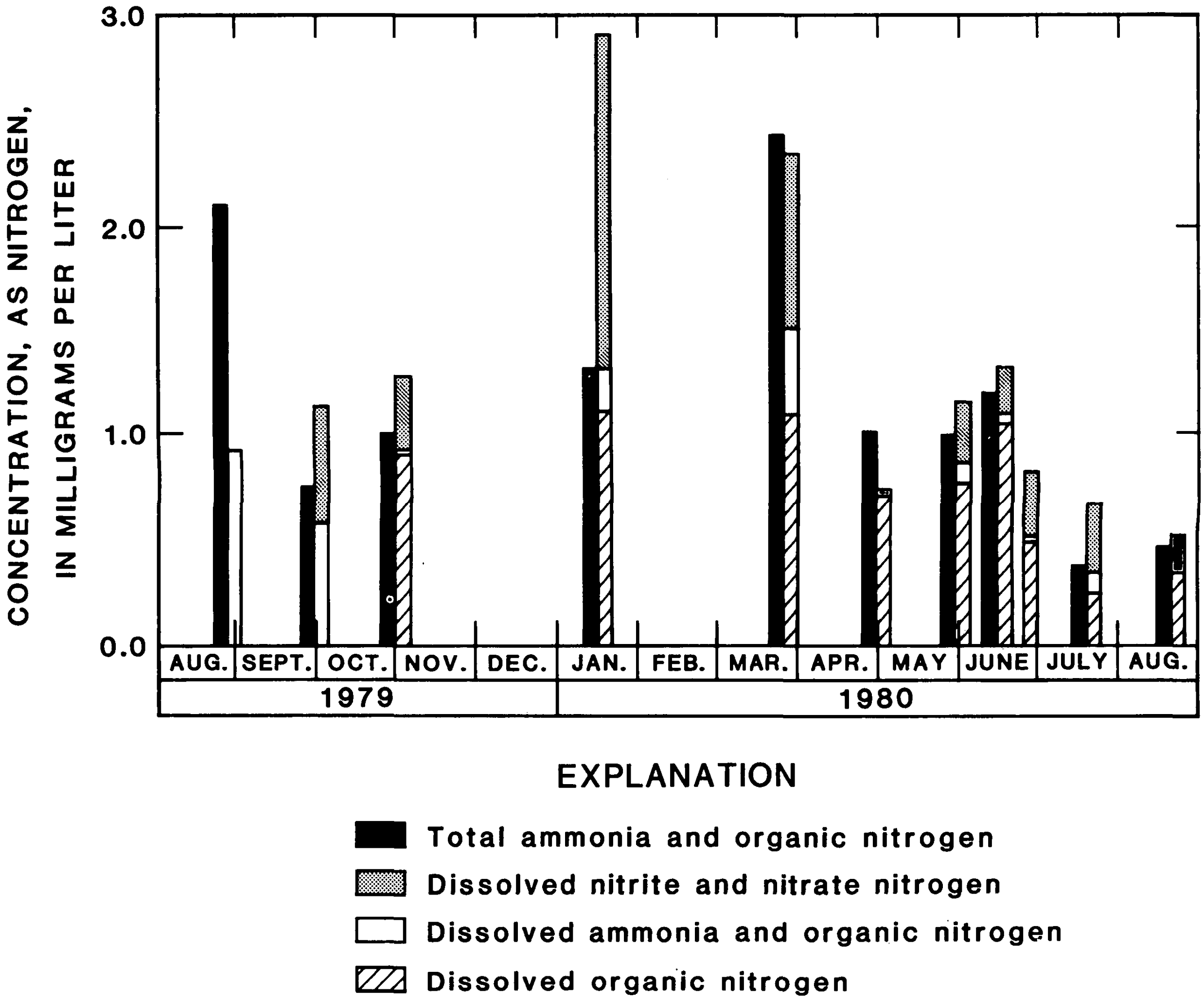


Figure 3.--Concentration of nitrogen forms at East Creek

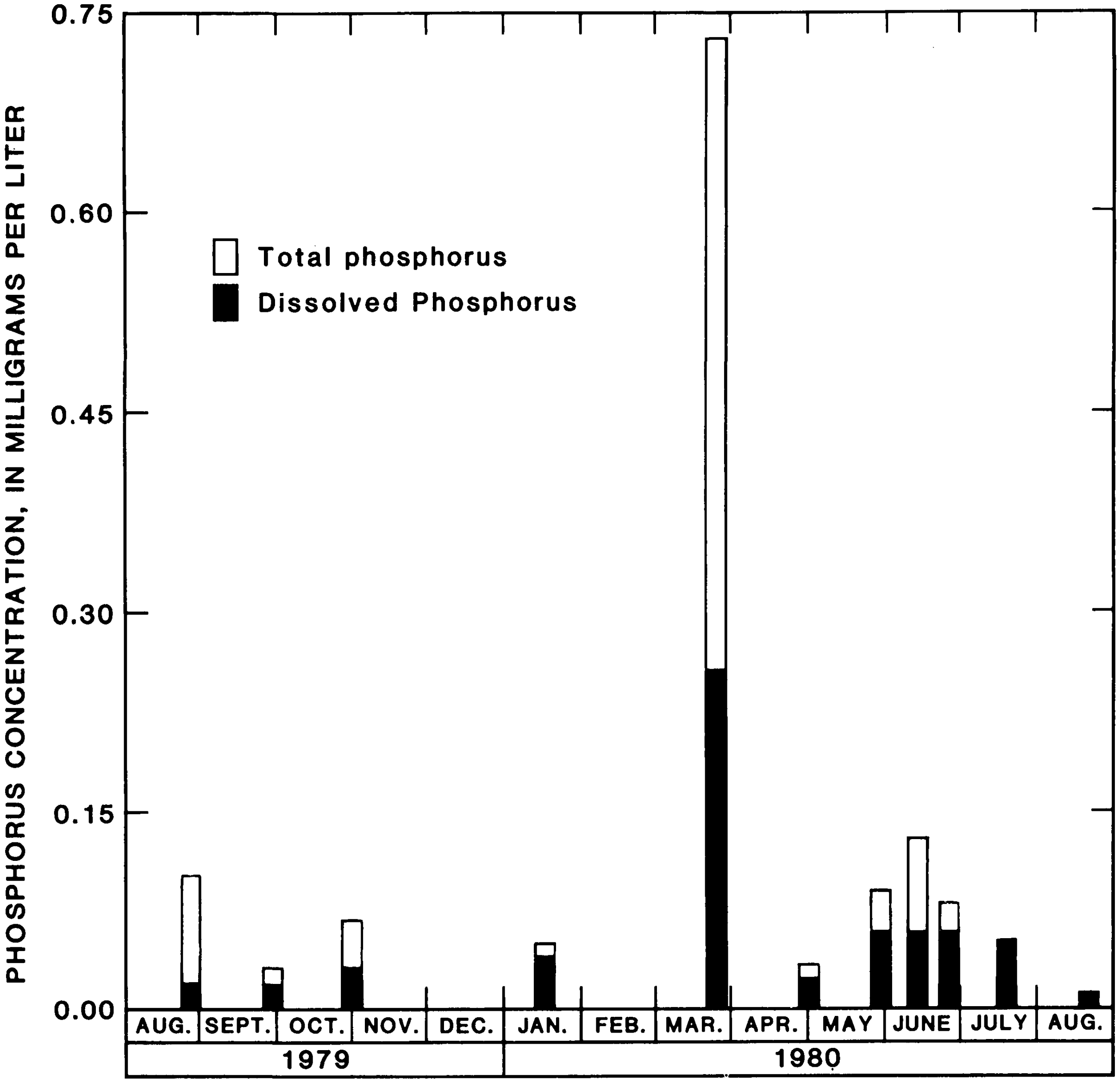


Figure 4.--Concentrations of total and dissolved phosphorus at East Creek

Dissolved phosphorus generally comprised about 50 percent of the total phosphorus. During spring runoff, 0.26 mg/L dissolved phosphorus was found. The average concentration during the rest of the year was 0.04 mg/L.

Much of the phosphorus during runoff was suspended, indicating that runoff probably washed particulate phosphorus into the stream. A correlation coefficient of 0.71 between 11 suspended phosphorus measurements and discharge supports this relationship.

Dissolved organic carbon (DOC) concentrations were reasonably constant during the sampling, having a mean concentration of 10 mg/L. A substantial decline in DOC concentration occurred in the last two samples (fig. 5). Observations by Wetzel (1975) support the suspicion that DOC concentrations introduced during runoff in August 1979 declined toward the low levels found in ground water, but increased and were maintained through winter as organic carbon was leached from accumulated leaf litter. During spring runoff DOC was diluted by snowmelt and concentrations did not increase, but the DOC load was about 3 times the average load during the sampling program. Low runoff in July and August 1980 introduced little DOC to the creek, probably because most was derived from ground water that generally has low concentrations of organic carbon.

Generally, 10 percent of the organic carbon in East Creek was in the suspended form (SOC). The percentage increased during spring runoff to as much as 23 percent.

Eight samples of raw, untreated East Creek water were analyzed for 5-day BOD. Runoff was only measured in August 1979. The highest BOD, 4.0 mg/L, occurred in this sample, followed by a decline to 1.1 mg/L in the following sample. The BOD increased in October 1979 to 3.9 mg/L, probably because of the influx of decaying vegetation.

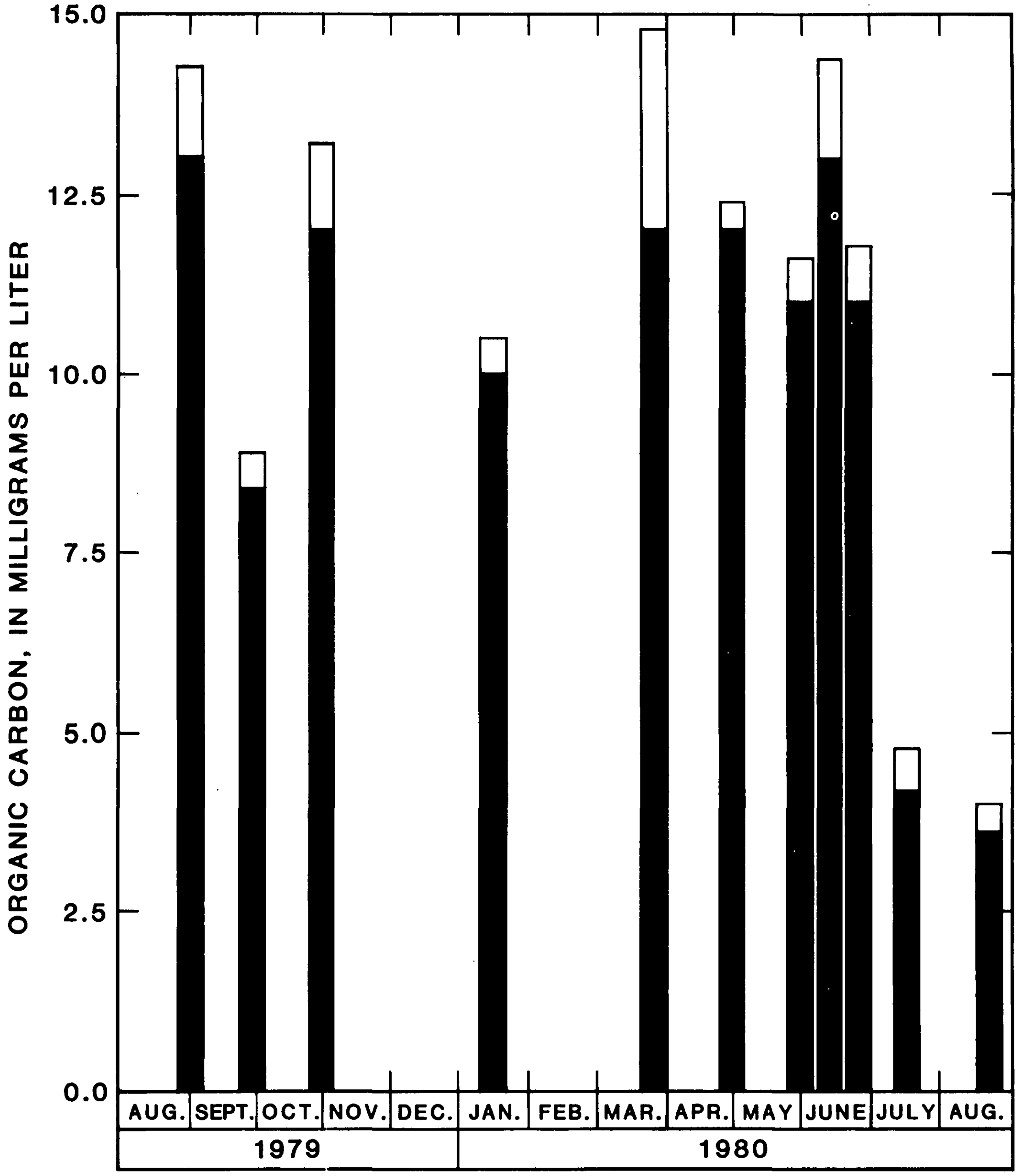
BOD was determined again on April 30, 1980, and had declined to 2.1 mg/L. BOD increased again on May 30 to 3.4 mg/L, although discharge decreased. The BOD declined in the final three samples to 0.9 mg/L on August 22, probably because fewer biodegradable materials were present in the creek at the lower discharges.

These BOD's were uninhibited, allowing oxidation of both carbonaceous and nitrogenous materials in the water. BOD had correlation coefficients greater than 0.80 with dissolved, suspended, and total organic carbon, dissolved organic nitrogen, and total phosphorus. A correlation coefficient of 0.72 between eight BOD measurements and streamflow indicates that much of the BOD in East Creek is derived from surface runoff.

Metals, Oil and Grease, and Pesticides

Concentrations of selected metals and oil and grease were determined from two samples collected at East Creek. A high-flow measurement was made on March 25, 1980, at a discharge of 6.3 ft^3/s, and a base-flow measurement was made on July 17, 1980, when the discharge was 0.22 ft^3/s.

The base-flow concentrations of metals are probably similar to the concentrations in the ground water. No oil and grease, cadmium, or copper were found in the base-flow sample from East Creek. The concentrations of other metals were at low levels, and most had lower concentrations than in the runoff. Chromium, however, had a concentration of 23 ug/L (micrograms per liter) in the base-flow sample, compared to 1 ug/L in the runoff sample. Virtually the same concentrations of chromium occurred in samples from



EXPLANATION

■ Dissolved organic carbon

□ Suspended organic carbon

Figure 5.--Concentrations of organic carbon at East Creek

Chaska Creek, indicating that this concentration of chromium occurs in ground water discharging to these creeks.

Oil and grease and copper, not detected in the base-flow sample, were found at low concentrations during spring runoff. Cadmium was not detected during runoff, and concentration of mercury, less than 0.1 ug/L, was the same as during base flow.

Concentrations of oil and grease (2 mg/L) and lead (130 ug/L) in runoff exceeded recommended limits of no oil and grease and 50 ug/L lead for public water supplies (National Academy of Sciences, National Academy of Engineering, 1972). Iron and manganese concentrations exceeded recommended limits in both the base-flow and high-flow samples, but the recommendations are for the soluble phase of these constituents and the analysis determined only the total concentrations. The concentration of chromium at base flow was about half the recommended maximum concentration, 0.05 mg/L.

The concentration of selected pesticides in East Creek was determined from the sample obtained June 12, 1980. Organochlorine and organophosphorus insecticides, PCB, and PCN were not detected in the sample. 2,4-D was the only chlorinated phenoxy acid herbicide detected. The 2,4-D concentration of 0.07 ug/L was far below the 48-hour LC50 (the concentration lethal to 50 percent of the test subjects in a 48-hour period) of more than 50 mg/L for spot fish, Leiostomus xanthurus (Stewart and others, 1975).

Atrazine and simazine were the only triazine herbicides detected in East Creek. Atrazine, which had a concentration of 0.40 ug/L, was the second-highest-selling herbicide by weight in Carver County in 1976 (Minnesota Department of Agriculture, written commun., 1977). The concentration of atrazine was far below 12.6 mg/L, the acute oral LC50 for fish (Stewart and others, 1975). The concentration of 0.06 ug/L simazine was also well below the 48-hour LC50 of 5.0 mg/L for fish (Stewart and others, 1975).

Alachlor, an anilide herbicide, had a concentration of 0.32 ug/L. In 1976, alachlor was the highest-selling herbicide by weight in Carver County, Minn. (Minnesota Department of Agriculture, written commun., 1977). The 48-hour LC50 of alachlor for bluegills is 2.3 mg/L (Stewart and others, 1975).

WATER QUALITY OF CHASKA CREEK

Physical Characteristics and Major Inorganic Constituents

Flow in Chaska Creek averaged twice that of East Creek. The highest measured discharge, 24.0 ft^3/s, occurred on March 25, 1980, during snowmelt runoff. The lowest discharge, 0.51 ft^3/s, was measured on July 23 when a previously missed BOD was sampled. Two rainfall runoff events were sampled on August 30, 1979, and June 12, 1980, having discharges of 11.0 and 11.7 ft^3/s, respectively.

The DO of Chaska Creek was nearly saturated throughout the sampling. It ranged from 14.1 mg/L on March 25 to 8.2 mg/L on July 17.

Chaska Creek had an alkaline mean pH of 7.9 units. The range from 7.5 to 8.2 units followed no discernible trends.

The mean turbidity of 10.7 NTU at Chaska Creek was much higher than at East Creek. The highest turbidity of 50 NTU was found during spring runoff on March 25. The 11 measurements of turbidity correlated with discharge, resulting in a correlation coefficient of 0.96, substantially higher than the coefficient of 0.31 for East Creek.

The concentration of suspended solids generally varied with the turbidity and discharge. The highest concentration, 860 mg/L, occurred in May 1980, and did not coincide with peaks in other constituents or physical measurements. This May concentration seems to be erroneous because it was well above the mean of 27.3 mg/L for the other suspended-solids samples and the next highest concentration, 76 mg/L on June 12.

Dissolved solids and specific conductance, although generally strongly associated, had a correlation coefficient of only 0.70 in 11 measurements. However, both had negative correlation coefficients of about -0.80 with streamflow, turbidity, and some forms of nitrogen, phosphorus, and organic carbon. These constituents and physical measurements are associated with runoff, indicating that the dissolved solids and specific conductance are probably associated with some other source of input to the stream, such as ground water.

Dissolved sulfate is also probably introduced to the creek from ground-water discharge. The highest concentration, 53 mg/L, occurred at the lowest sampled discharge, and the lowest concentration, 17 mg/L, occurred during spring runoff. The mean sulfate concentration, 35 mg/L, was lower than the concentration in East Creek.

Ground water seems to be the primary source of chloride in Chaska Creek. The highest concentration of 28 mg/L occurred on July 17, and the lowest of 14 mg/L occurred during spring runoff. The mean concentration was about 20 mg/L, having no anomalous concentrations. Chaska Creek chloride concentrations had correlation coefficients of 0.55 with specific conductance and 0.65 with dissolved-solids concentrations, much lower than East Creek.

Nitrogen, Phosphorus, Organic Carbon, and Biochemical Oxygen Demand

The mean concentration of all forms of nitrogen regularly sampled at Chaska Creek, except suspended ammonia plus organic nitrogen, were higher than at East Creek. The highest concentration of most forms of nitrogen occurred during spring runoff. Peak concentrations also occurred during rainfall runoff (fig. 6).

Nitrite plus nitrate nitrogen concentrations were high during the winter. The highest concentration, 2.0 mg/L, was found in the January 14 sample. The concentration of 1.1 mg/L determined on June 12 was probably the result of runoff from agricultural fertilizer applications. These forms of nitrogen in Chaska Creek are probably introduced from a source similar to that of East Creek.

Ammonia nitrogen concentrations were negligible throughout most of the year. In January, 0.17 mg/L ammonia was detected in the water. The highest concentration, 1.5 mg/L, occurred in the runoff sampled in March. The average ammonia concentration in Chaska Creek was more than twice the concentration in East Creek.

The mean concentration of dissolved organic nitrogen in Chaska Creek was 0.78 mg/L, about the same as in East Creek. Greater variations in concentration occurred at Chaska Creek with peak concentrations of 1.7 and 1.4 mg/L coinciding with the runoff in

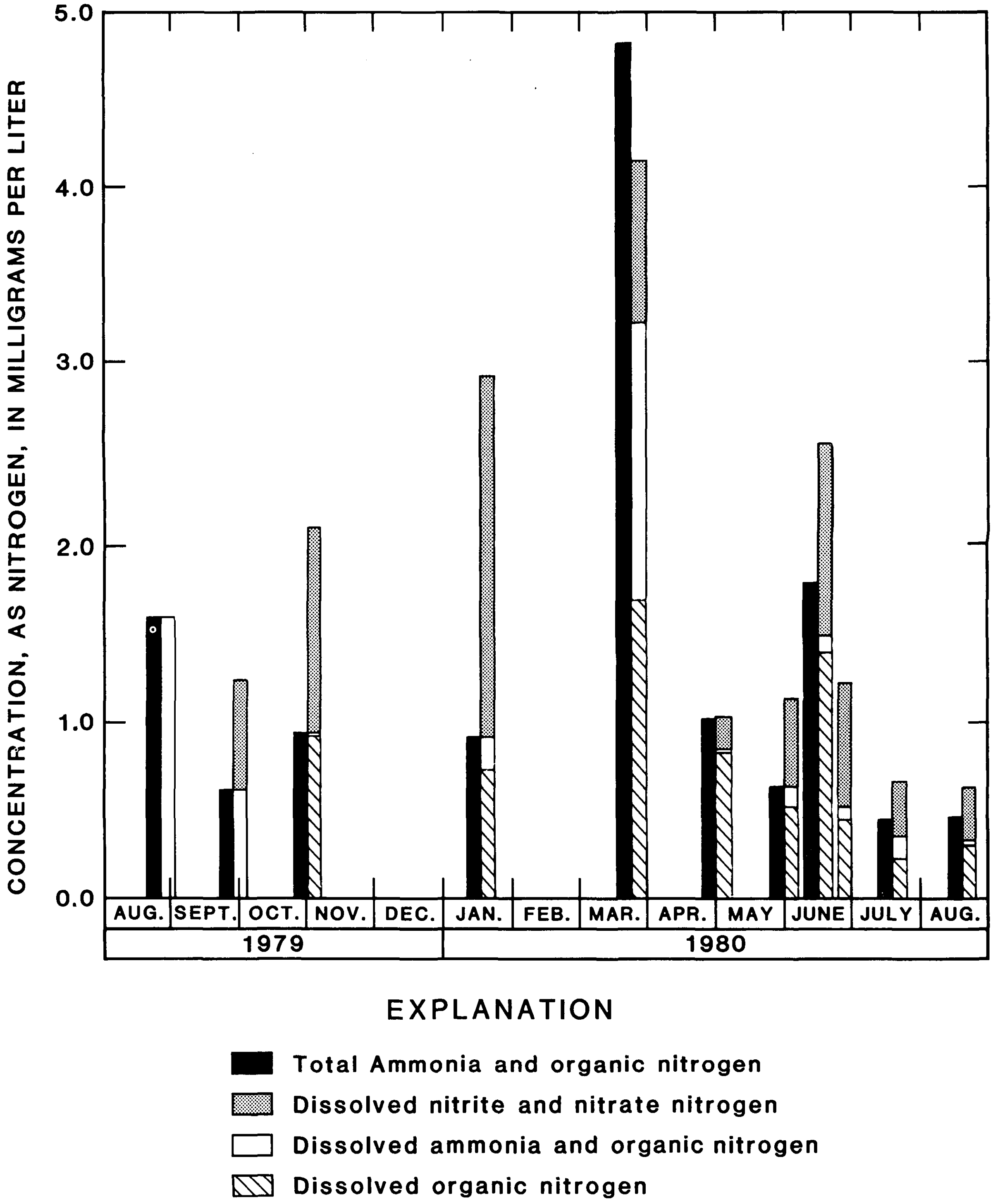


Figure 6.--Concentration of nitrogen forms at Chaska Creek

March and June, respectively. Dissolved organic nitrogen concentrations were lowest, 0.21 mg/L, when the measured discharge was lowest.

The mean total ammonia plus organic nitrogen concentration in Chaska Creek was 12 percent higher than in East Creek, but Chaska Creek had an average 29 percent less suspended ammonia plus organic nitrogen than East Creek. Comparing figure 3 with figure 6 shows that suspended ammonia plus organic nitrogen concentrations at Chaska Creek were negligible during most of the year, including the runoff sampled in August 1979 when East Creek had 1.2 mg/L of this constituent. Suspended ammonia plus organic nitrogen comprised 33 percent of the total, 4.8 mg/L, in the March sample of runoff, and 17 percent of the total in the June runoff sample. The lowest concentration of total ammonia plus organic nitrogen, 0.42 mg/L, occurred during the lowest sampled discharge in July 1980. Total ammonia plus organic nitrogen concentrations in Chaska Creek had a 0.97 correlation coefficient with 10 measurements of streamflow.

The mean total-phosphorus concentration at Chaska Creek, 0.19 mg/L, was 54 percent higher than at East Creek. In East Creek only 48 percent of the phosphorus was dissolved, but in Chaska Creek 76 percent of the phosphorus was dissolved.

Phosphorus in runoff is generally attached to sediment particles or bound in compounds of low solubility. Phosphorus in runoff in Chaska Creek was generally in the undissolved or suspended form.

The peaks in total phosphorus concentration at Chaska Creek coincide with runoff in August 1979 and in March and June 1980 (fig. 7). In the August and June samples, dissolved phosphorus represented 79 and 60 percent of the total phosphorus, respectively. In March, 96 percent of the 0.48 mg/L total phosphorus was dissolved. The high percentage of dissolved phosphorus in Chaska Creek may be the result of runoff from agricultural fertilizers, which are generally applied in a soluble form. Dissolved phosphorus is a nutrient immediately available to enhance phytoplankton growth and could support blooms in receiving waters.

Concentrations of dissolved and suspended organic carbon at Chaska Creek averaged about the same as at East Creek, although the range in concentration was greater. The highest DOC concentration, 15 mg/L, occurred during runoff in both March and June. The July sample had the lowest DOC concentration of 3.8 mg/L. Peak DOC concentrations also occurred in October, apparently from decomposition of leaf litter, and during runoff in August 1979.

The SOC at Chaska Creek represented an average 9 percent of the total organic carbon. Peak concentrations occurred during runoff. The highest concentration, 4.2 mg/L in March, comprised 19 percent of the total organic carbon. The lowest SOC concentration, 0.4 mg/L, occurred in samples collected in October 1979 and in July and August 1980.

Eight samples of Chaska Creek water were analyzed for uninhibited 5-day BOD. Only one runoff event was sampled in August 1979 and had a BOD of 2.2 mg/L. The highest BOD of 3.8 mg/L occurred in the May sample when discharge was only 1.7 ft^3/s. A higher concentration of biogradeable substances apparently were in the creek at this time than at other times. The lowest BOD, 0.8 mg/L, was determined on July 23, 1980, a few days after the chemical sampling. Although not statistically significant, the mean BOD of 1.84 mg/L at Chaska Creek was less than the 2.41 mg/L of East Creek.

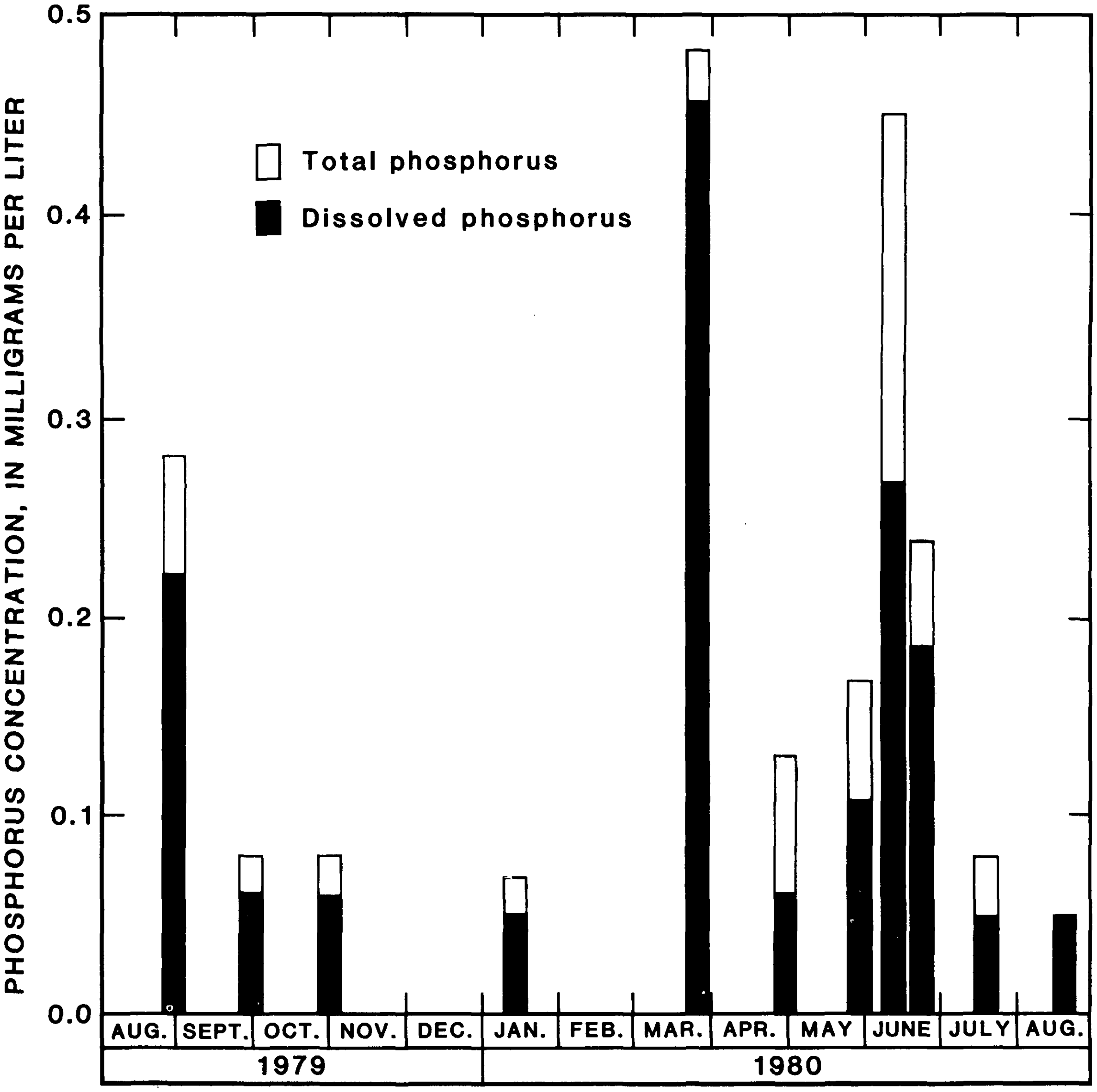


Figure 7.--Concentrations of total and dissolved phosphorus at Chaska Creek

The BOD in Chaska Creek had correlation coefficients greater than 0.75 with five dissolved ammonia and seven suspended phosphorus measurements. The high correlation coefficient of 0.89 between seven BOD and suspended solids measurements is considered inconclusive because the relationship is affected by the erroneously high suspended-solids concentration in the May sample.

Metals, Oil and Grease, and Pesticides

Two samples of Chaska Creek water were analyzed for concentrations of selected metals and oil and grease. High-flow was measured on March 25, when the discharge was 24 ft^3/s. Base flow was measured on July 17, when the discharge in the creek was 0.99 ft^3/s.

Base-flow concentrations of metals and oil and grease in Chaska Creek were virtually identical to those of East Creek. Notable differences were the lack of lead, the detection of only 1 ug/L copper, and higher concentrations of iron and manganese, 670 and 340 ug/L, respectively.

The high-flow sample had increased concentrations of most of the metals analyzed. Low concentrations of lead and oil and grease were found, 4 ug/L and 2 mg/L, in addition to increased concentrations of arsenic, copper, iron, manganese, and zinc.

Cadmium was not found in the high-flow measurement, and mercury remained at the concentration of less than 0.1 ug/L. The concentration of chromium in Chaska Creek was highest in the base-flow measurement, 22 ug/L, and only 1 ug/L was found in the high-flow measurement. Relatively higher concentrations of chromium are probably present in the ground water supplying base flow to these creeks.

Chaska Creek generally meets water-quality criteria for public water supplies, except the concentration of 2 mg/L oil and grease. The National Academy of Sciences, National Academy of Engineering (1972) recommends that none should be present.

Analyses for selected pesticides, PCB, and PCN were made on the sample collected from Chaska Creek on June 12, 1980, when the discharge was about 12 ft^3/s. The same pesticides present in East Creek were found in the sample from Chaska Creek. Concentrations of alachlor, atrazine, and 2,4-D were higher in Chaska Creek, but still far below the 48-hour LC50 for these pesticides (Stewart and others, 1975).

WATER QUALITY OF COURTHOUSE LAKE

Vertical Profiles

Measurements of dissolved oxygen (DO), water temperature, pH, and specific conductance were obtained at specific depths in Courthouse Lake with each of the 5 samplings. The DO, pH, water temperature, and Secchi-disk transparency are shown in figure 8. The results of specific-conductance measurements are not shown.

The vertical profile obtained in August 1979 had an epilimnion extending to about the measured Secchi-disk transparency of 16.5 feet. The water temperature, about 22°C, and pH were fairly constant throughout this depth, indicating that the epilimnion is subject to mixing by wind action.

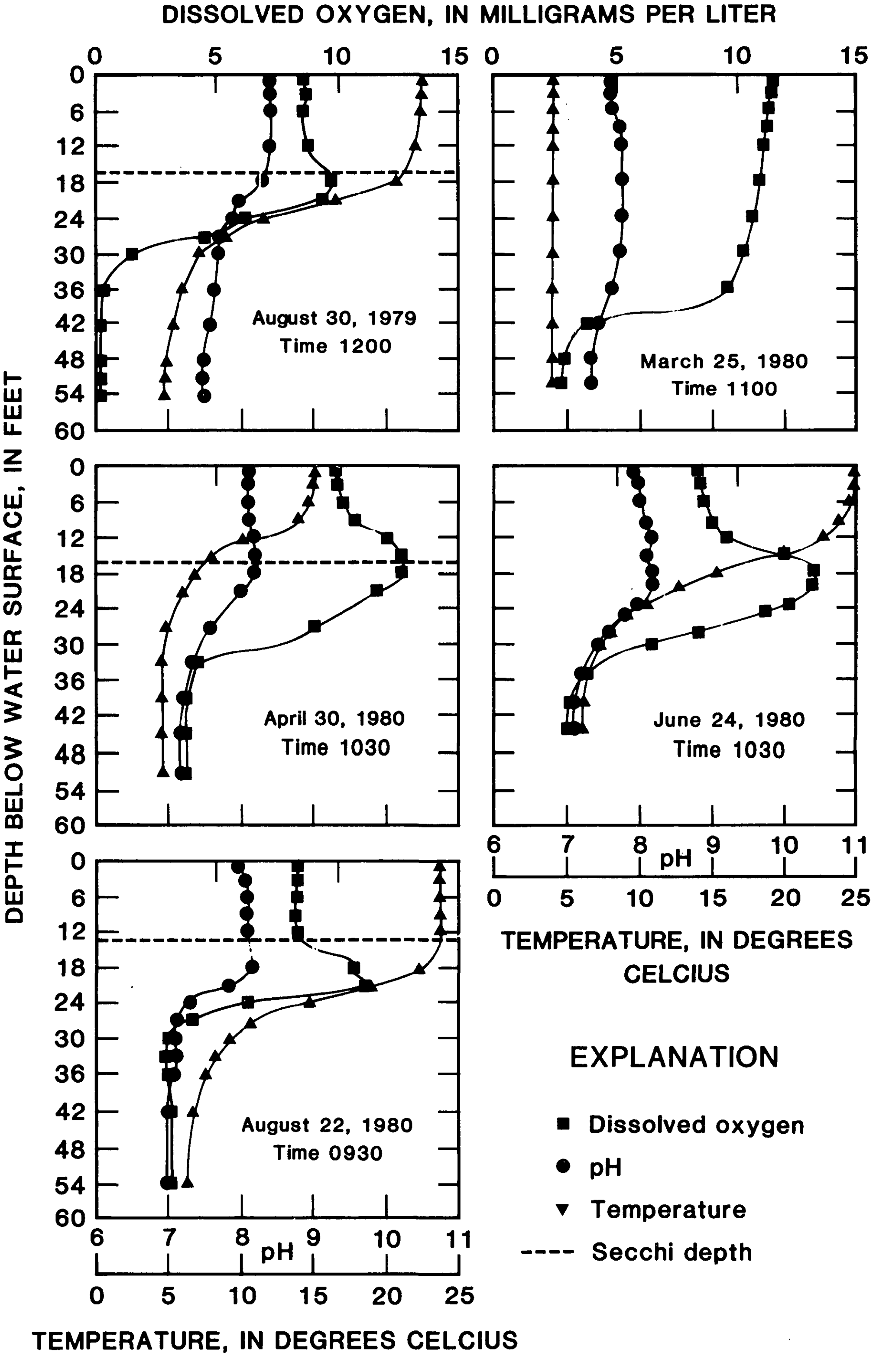


Figure 8.--Vertical profiles of Courthouse Lake

The thermocline (metalimnion) occurred from about 18 to 30 feet in depth. The temperature in this region declined from 21.0° to 7.0°C. Below about 30 feet the temperature in the hypolimnion decreased slowly with depth to 5.0°C at 48 feet.

The concentration of DO in August 1979 was nearly saturated near the surface but was supersaturated between 10 and 21 feet. The protuberance in the DO curve between 10 and 21 feet delineates the region where light intensity is sufficient for phytoplanktonic photosynthesis and nutrient availability is high. DO concentrations declined rapidly below 21 feet to nearly 0 below 36 feet as decompositional processes utilized the available oxygen.

The pH of Courthouse Lake in August 1979 declined rapidly in the thermocline where the production of carbon dioxide from respiration exceeded consumption by photosynthesis. The pH ranged from 8.4 at the surface to 7.5 near the bottom, whereas the pH of more productive lakes in the area at this time of year may range from 10.0 near the surface to 6.5 near the bottom (Tornes and Have, 1980).

The vertical profile of March 1980 was obtained under a decaying ice cover. The water temperature was a constant 4.0°C throughout. The water would ordinarily be 0.0°C near the surface, but solar heating had apparently warmed this water, eliminating the winter inverse stratification. DO concentration was high in the upper 36 feet of the lake. Below 36 feet the DO concentration declined rapidly to a depth of 42 feet, then declined more slowly. DO concentration near the sediments, about 2.5 mg/L, generally reduces the release of phosphates in the sediments to the water, which might occur if the bottom waters were anoxic.

The pH of Courthouse Lake was virtually constant throughout the vertical profile of March 1980. A slight decline in pH occurred below 36 feet in depth where decomposition had apparently increased the concentration of carbon dioxide.

The April 30, 1980, profile showed the beginnings of summer stratification. The upper boundary of the thermocline occurred at a depth of about 9 feet, but there was no distinct lower boundary. Water temperatures decreased with depth from 15.5°C at 1 foot to 4.5 °C at 51 feet.

DO in the April profile was saturated near the surface, but became supersaturated to a depth of about 20 feet. DO concentrations declined rapidly below 20 feet. The maximum measured DO in this profile was 12.7 mg/L at 18 feet in depth. The pH followed a similar pattern, having the highest values between 12 and 18 feet in depth. This layer of water was the region where phytoplankton productivity was highest. The density of phytoplankton in this layer may have reduced the transparency, extinguishing the measured Secchi-disk transparency at this depth.

Two months later, the profile on June 24 still had an indistinct thermocline between 12 and 25 feet in depth. DO was supersaturated to a depth of about 25 feet. The highest DO concentration measured was 13.3 mg/L, which occurred at about the same depth as in the April profile. The pH was highest between 10 and 22 feet, with values ranging between 8.1 and 8.2. Water temperatures near the surface were about 25°C. Secchi-disk transparency was not measured with this profile.

The June profile of Courthouse Lake was extended to a depth of only 44 feet, but at this depth some differences from the April profile can be noted. The water temperature increased 1.5°C indicating that the water at this depth may have mixed with the warmer upper layers by diffusion or conduction. DO and pH declined in the hypolimnion between April and June. This is the result of decompositional processes that utilize sedimenting organic matter and DO and produce carbon dioxide that lowers pH.

The profile on August 22 had a well-mixed epilimnion in the upper 16 feet of the lake. The highest productivity in the lake appeared to be in the thermocline, which extended to a depth of about 27 feet. The magnitude of DO and pH bulges in the profile was reduced compared to profiles obtained earlier in the year. At the time of day these measurements were made, photosynthesis may not have produced the quantity of DO observed in previous measurements made later in the day.

The Secchi-disk transparency of Courthouse Lake in August 1980 was reduced compared to previous samplings. The reduction in transparency probably resulted from the high concentration of phytoplankton in the sample.

The hypolimnetic DO in the profile in August 1980 was much higher than in August 1979. Higher DO was probably the result of more complete oxygenation of the hypolimnion during turnover than in the previous year. Increased DO in the hypolimnion can inhibit the release of soluble phosphates from the lake sediments (Wetzel, 1975), making less of this nutrient available to enhance phytoplankton growth.

Measurements of specific conductance, which correlate closely with dissolved-solids concentrations, had only minor variations between profiles. The specific conductance of about 370 umhos/cm in the epiliminion increased through the thermocline to between 400 and 435 umhos/cm in the hypolimnion. The higher specific conductance in the hypolimnion was probably the result of the release of solutes from the decomposition of detritus.

The only profile of specific conductance that diverged from the usual pattern was obtained in March. The conductance was a virtually constant 400 umhos during most of the profile, increasing about 10 umhos below about 40 feet in depth. Slightly lower conductance near the surface indicates that water from snowmelt or ice melt had mixed with surficial waters.

The DO profiles shown in figure 8 are termed clinograde and are generally considered typical of eutrophic lakes (Wetzel, 1975). Courthouse Lake may, therefore, be considered eutrophic based on the DO profiles only.

Inorganic Constituents

Each sample of Courthouse Lake was analyzed for dissolved-solids concentrations and, except for the hypolimnetic sample in August 1979, dissolved chloride. The average dissolved-solids concentration in the epilimnion of Courthouse Lake was 238 mg/L. The 11-percent precision of the analysis for dissolved solids (Skougstad and others, 1979) adequately accounts for the random flucutations in concentration. The hypolimnetic dissolved-solids concentration was 11 to 16 percent higher than in the epilimnion, based on the samplings in August 1979 and 1980. This probably resulted from dissolution of substances released by decomposition in the hypolimnion.

Dissolved-chloride concentrations ranged from 10 to 12 mg/L having a mean of 10.6 mg/L. The precision of the analysis could allow this range of values around the mean, indicating that chloride concentrations had no discernible fluctuations. Increased chloride concentrations are generally the result of pollution (Wetzel, 1975), so periodic sampling for this constituent might provide evidence of pollution of the lake.

The sample collected at Courthouse Lake in August 1980 was analyzed for concentrations of major cations and anions and silica in both the hypolimnion and epilimnion. These analyses reveal that the ionic constituents of the lake water are predominantly bicarbonates of calcium and magnesium.

Calcium comprised 48 percent of the milliequivalents per liter of the major cations in the epilimnion. The remainder was 42 percent magnesium, 6 percent sodium, and 4 percent potassium. Alkalinity as calcium carbonate was 64 percent of the milliequivalents per liter of the major anions. Sulfate was 28 percent, chloride was 8 percent, and fluoride was less than 1 percent of the anions.

Calcium, magnesium, sodium, and potassium comprised 51, 36, 10, and 3 percent of the cations in the hypolimnion, respectively; and alkalinity (as calcium carbonate), sulfate, chloride, and fluoride accounted for 70, 22, 7, and less than 1 percent of the anions, respectively. Magnesium, potassium, chloride, fluoride, and sulfate each had virtually the same concentration in the hypolimnion and epilimnion.

The concentration of 10 mg/L sodium in the hypolimnion was almost twice the 5.4 mg/L measured in the epilimnion. An explanation for this difference was not found and, according to Wetzel (1975), the distribution of sodium is uniform and has very little seasonal variation. This difference may be related to the hydrology of the lake, because ground water containing a relatively high concentration of sodium may be flowing into the hypolimnion.

The calcium concentration and alkalinity were substantially higher in the hypolimnion than in the epilimnion of the lake. During periods of high productivity, phytoplankton and macrophytes utilize carbon dioxide in the euphotic zone faster than it can be replaced by atmospheric or hypolimnetic carbon dioxide. This will raise the pH of surficial waters and can cause precipitation of calcium carbonate (Kelts and Hsu, 1978). Calculations described by Kelts and Hsu (1978) were used to compute the ratio of the ionic activity product of calcium carbonate to its equilibrium constant at the measured temperatures. The ratio was greater than 1.00 (4.28) in the epilimnion, indicating supersaturation of calcium carbonate, and less than 1.00 (0.16) in the hypolimnion, indicating undersaturation. Calcium concentrations and alkalinity would be reduced in the epilimnion by precipitation of calcium carbonate, much of which probably redissolves in the hypolimnion with reduced pH and the availability of free carbon dioxide.

The silica concentration of 3.0 mg/L in the hypolimnion was substantially higher than the epilimnetic concentration of 0.8 mg/L. This distribution of silica occurs commonly in lakes, primarily because of assimilation of silica by diatoms in the epilimnion, and subsequent sedimentation of the diatoms (Wetzel, 1975).

Phosphorus, Nitrogen, and Organic Carbon

Total and dissolved-phosphorus concentrations were determined for each of the five samples of the Courthouse Lake epilimnion. The concentration of total and dissolved phosphorus in the hypolimnion was determined only for the August 1979 and August 1980 samplings.

Epilimnetic phosphorus depletion is indicated by the concentration of 0.01 mg/L total phosphorus in August 1979. Most of this phosphorus is probably contained in the cells of phytoplankton and should be suspended. The results of the analysis indicate that most of the phosphorus was in the dissolved state. The analysis is not considered accurate at this concentration (Skougstad and others, 1979), so the actual dissolved-phosphorus concentration was probably considerably less than the 0.01 mg/L found in the sample.

The hypolimnetic waters of Courthouse Lake contained substantial quantities of phosphorus in August 1979. The total phosphorus concentration of 0.47 mg/L, sampled 5 feet from the lake bottom, was mostly dissolved phosphorus, 0.43 mg/L. Because the hypolimnetic waters were virtually anoxic, most of this phosphorus was probably released from the lake sediments.

The surficial waters of Courthouse Lake contained 0.05 mg/L total and 0.03 mg/L dissolved phosphorus in March 1980. This probably represents the phosphorus remaining in the upper lake waters following the fall turnover and subsequent phosphorus depletion through the winter by light and temperature-limited phytoplankton activity.

The total and dissolved-phosphorus concentrations, 0.03 and 0.01 mg/L, respectively, found near the surface in April 1980 were less than in the previous sampling. This phosphorus depletion probably resulted from uptake and sedimentation by phytoplankton. A substantial spring turnover could have introduced additional phosphorus to the surface waters of the lake, but because the bottom waters were well oxygenated through the winter (see vertical profiles section), sufficient phosphorus may not have been released from the sediments to raise the surface concentration after turnover.

As the summer progressed, total and dissolved phosphorus became depleted in the epilimnion. By August 1980, analyses for low-level, total-, and dissolved-phosphorus concentrations (applicable range 0.001 to 0.020 mg/L) showed that the epilimnion had only 0.003 mg/L total and 0.000 mg/L dissolved phosphorus.

The hypolimnion of the lake in August 1980 had 0.18 mg/L total and dissolved phosphorus. The greater concentration of dissolved oxygen near the bottom, 3.1 mg/L, was probably preventing the release of soluble phosphate in the quantities seen in the August 1979 sample from the hypolimnion.

The August 1979 sample from Courthouse Lake was analyzed for total concentrations of the major nitrogen species. The 0.40 mg/L nitrogen found in the epilimnion was composed of 0.39 mg total organic and 0.01 mg total ammonia nitrogen. No nitrite or nitrate nitrogen was found. About 75 percent of the organic nitrogen was in the dissolved state because 0.30 mg/L dissolved ammonia and organic nitrogen was found in this sample. Phytoplankton had apparently used up almost all the available forms of nitrogen, leaving only organic forms in the water.

The hypolimnetic sample obtained in August 1979 had 1.3 mg/L nitrogen, all of which was dissolved ammonia plus organic nitrogen. Over 50 percent of this, 0.67 mg/L, was dissolved ammonia, probably released from decomposition at or near the lake bottom. The total organic nitrogen was higher in the hypolimnion than in the epilimnion, and was also probably derived from decomposition of organic material near the bottom.

The measurement made in March 1980 showed that the concentration of total ammonia plus organic nitrogen had declined to 0.23 mg/L through the winter. Dissolved ammonia plus organic nitrogen had a concentration of 0.22 mg/L, leaving only 0.01 mg/L in the seston of Courthouse Lake. The dissolved ammonia concentration of 0.07 mg/L, which probably mixed into surficial waters during fall turnover, leaves only 0.15 mg/L dissolved organic nitrogen of the dissolved ammonia plus organic nitrogen. The reduction in dissolved organic nitrogen after the August 1979 sample was probably the result of bacterial degradation of the organic nitrogen and subsequent conversion to other forms of nitrogen. Some of this may have been lost from the lake as molecular nitrogen but much was probably converted to nitrite plus nitrate nitrogen, which was not found in the previous sample but had a concentation of 0.05 mg/L in March 1980.

Dissolved ammonia was not found in the sample of Courthouse Lake collected in April 1980. Apparently the ammonia had been converted to other forms of nitrogen or utilized by phytoplankton. Nitrite plus nitrate nitrogen concentrations declined to 0.03 mg/L. This decrease continued throughout the summer, as expected, because low quantities of nitrite nitrogen can readily be converted to nitrate nitrogen, which is the form of nitrogen best utilized by green plants (Wetzel, 1975).

Total dissolved nitrogen, dissolved and suspended ammonia plus organic nitrogen, and dissolved organic nitrogen all had substantially higher concentrations in April than in the previous sampling. Release of nitrogen from the sediments was not significantly affected by the amount of oxygen present in the water. Nitrogen released to the bottom waters of the lake could have, therefore, increased the surficial nitrogen concentrations during spring turnover, although phosphorus concentrations declined.

In April, 0.17 mg of the 0.60 mg/L ammonia plus organic nitrogen was suspended. The remaining ammonia plus organic nitrogen, 0.43 mg/L, was dissolved organic nitrogen. It can be assumed that the suspended ammonia plus organic nitrogen was all suspended organic nitrogen because ammonia concentrations in the oxygenated epilimnion tend to be very low (Wetzel, 1975). Approximately 28 percent of the organic nitrogen was, therefore, suspended, and most was probably contained in the cells of phytoplankton.

The sample collected in June 1980 showed expected seasonal declines in the concentration of total ammonia plus organic nitrogen and dissolved nitrite plus nitrate nitrogen to 0.44 and 0.01 mg/L, respectively. The presence of 0.03 mg/L ammonia nitrogen in the sample is not easily explained, but could have been derived from sources external to the lake, such as runoff from the surrounding watershed.

The concentration of dissolved ammonia plus organic nitrogen decreased from 0.43 mg/L in April to 0.08 mg/L in June. The dissolved organic nitrogen and suspended ammonia plus organic nitrogen look anomalous because they are computed from this anomalous value. Assuming that the suspended ammonia plus organic nitrogen was all organic nitrogen, it would compose about 88 percent of the total organic nitrogen. This composition does not compare favorably with other samples where the suspended organic nitrogen was less than 30 percent of the total organic nitrogen. According to Wetzel (1975), the dissolved organic nitrogen of lakes and streams is 5 to 10 times greater than particulate (suspended) organic nitrogen. In this lake, the dissolved organic nitrogen was from 2.5 to 15 times greater than the suspended ammonia plus organic nitrogen, but in the June sample it was about 14 percent of the concentration of suspended ammonia plus organic nitrogen. The reported concentration of dissolved ammonia plus organic nitrogen was, therefore, probably erroneously low.

The August 1980 determination showed further seasonal decline in concentrations of total ammonia plus organic nitrogen, 0.35 mg/L, and dissolved nitrite plus nitrate nitrogen, 0.00 mg/L. The concentration of dissolved organic nitrogen also showed a seasonal decline from April. Dissolved ammonia nitrogen was not found in this sample. The suspended ammonia plus organic nitrogen composed only about 9 percent of the estimated total organic nitrogen in this sample.

Nitrogen concentrations near the bottom in August 1980 were not notably higher than epilimnetic concentrations. No dissolved nitrite plus nitrate nitrogen was found in the sample; 0.46 mg/L of the 0.54 mg/L total ammonia plus organic nitrogen was dissolved. The 0.11 mg/L dissolved ammonia leaves 0.35 mg/L dissolved organic nitrogen, only 0.03 mg/L higher than the epilimnetic concentration.

Samples of organic carbon in Courthouse Lake had minor variations in concentration, but no seasonal trends or relationships were discerned. The dissolved organic carbon in the epilimnion ranged from a high of 7.1 mg/L in August 1979 to a low of 4.8 mg/L in August 1980. Suspended organic carbon ranged from a low of 0.2 mg/L in August 1979 to a high of 0.7 mg/L in August 1980.

The ratios of dissolved to suspended organic carbon ranged from about 36:1 in August 1979 to about 7:1 in August 1980 with a mean ratio of 15:1. According to Wetzel (1975), this ratio is a rather constant 10:1 with only minor variations with respect to space and time in lakes with low to moderate productivity. Ratios show greater seasonal fluctuations, decreasing to 1:1 or less, in more eutrophic lakes. The observed fluctuations in the ratios of dissolved and suspended organic carbon may be the result of influences from outside the lake system. Organic carbon introduced to the lake from allochthonous sources could be a factor contributing to the hypolimnetic oxygen consumption observed in the vertical profiles of Courthouse Lake.

Dissolved organic carbon sampled from the hypolimnion in August 1980, 9.6 mg/L, was twice the concentration in the epilimnion. Suspended organic carbon in the hypolimnion, 0.4 mg/L, was about half the concentration in the epilimnion. The significant change in concentration with depth also deviates from the norm expressed by Wetzel (1975).

Phytoplankton

Each sampling of Courthouse Lake included quantification of the phytoplankton genera that composed more than 0.5 percent of the total number of cells per milliliter. These samples were generally composited from discrete multiple-depth samples of the epilimnion and should be representative of the epilimnetic waters, but the gregarious nature of phytoplankton in lake waters may cause the samples to be less than representative.

The total number of phytoplankton cells per milliliter was quite variable, not showing discernible seasonal trends. Lee (1970) proposed that a phytoplankton concentration of 500 to 1,000 cells/mL indicates an algal bloom. All the phytoplankton samples except the one collected in April 1980 had concentrations that exceeded the proposed criteria.

The sample collected in April 1980 had no phytoplankton cells present. This result was confirmed by the laboratory analyzing the sample and is supported by the lack of chlorophyll a. Phytoplankton were probably present in the lake, but sampling failed to retrieve a sufficient number of the organisms.

The major taxonomic groups of phytoplankton in Courthouse Lake appear to exhibit characteristic seasonal trends. Green algae division chlorophyta were well represented in all samples, except in April 1980, composing from 23 percent of the total phytoplankton cells in March to 61 percent in June. Certain types of green algae recurred seasonally and in subsequent samplings (table 2), but there was much variability in the genera that represented this division.

The division chrysophyta, represented primarily by the diatom Cyclotella, was dominant only in the March sample, accounting for 47 percent of the phytoplankton cells. A profusion of cold-water adapted diatoms such as Cyclotella in early spring under ice cover in temperate lakes is a common occurrence (Wetzel, 1975).

The cryptomonads, division cryptophyta, occurred in the greatest numbers and were codominant in the March sample. The genus Chroomonas was the primary representative of this division. Wetzel (1975) states that this division also often develops dense populations during the cold periods of the year when light intensity is relatively low.

The blue-green algae, division cyanophyta, were dominant in both the August 1979 and August 1980 samples, representing 69 and 56 percent of the total cells per milliliter, respectively. Blue-green algae, many species of which are capable of fixing molecular nitrogen, will often become dominant as nitrate and ammonia nitrogen concentrations become depleted during summer (Wetzel, 1975). Oscillatoria comprised about 90 percent of the blue-green algae in August 1979, but was barely present in August 1980, accounting for only about 5 percent of this division. The population of Anacystis increased almost an order of magnitude from 290 cells/mL in June 1980 to 2,200 cells/mL in August 1980 to become the dominant genera of phytoplankton. The changing generic dominance within each division are probably indicative of changes in the lacustrine environment.

The phytoplankton identified in Courthouse Lake are generally considered tolerant of organic pollution based on a compilation of reports from 165 authors (Palmer, 1968). Scenedesmus, Oscillatoria, Chlamydomonas, and Ankistrodesmus, all identified in the samples, are in the top 10 of Palmer's (1968) rating of the 60 most pollution-tolerant algae. Pollution-tolerant genera constituted 92 percent of the phytoplankton population in August 1979, 87 percent in August 1980, and 79 percent in June 1980. The diatom Cyclotella, dominant in March, is also high on the pollution-tolerant list.

Palmer (1968) also presented an algal-pollution index for use in rating water samples for high or low organic pollution. Using the methodology presented, a score was obtained for each sample. A score of 20 or more can be taken as evidence of high organic pollution, while a score of 15 to 19 can be taken as probable evidence of high organic pollution. Lower figures indicate that the pollution is not high, that the sample is not representative, or that something is interferring with algal persistence.

Phytoplankton in Courthouse Lake do not indicate high organic pollution. Samples collected in August 1979 and August 1980 had the highest pollution-index scores of 12 and 11, respectively. Samples collected in March and June 1980 both had a score of 1.

TABLE 2.--IDENTIFICATION OF COURTHOUSE LAKE PHYTOPLANKTON SAMPLES

444720093352401 - COURTHOUSE LAKE AT CHASKA, MN

PHYTOPLANKTON ANALYSES, AUGUST 1979 TO AUGUST 1980

DATE	AUG 30,79	MAR 25,80	APR 30,80	JUN 24,80	AUG 22,80
TIME	1200	1100	1022	1020	0930
TOTAL CELLS/ML	2000	7100	0	1400	5200
DIVERSITY: DIVISION	1.0	1.5	0.0	1.4	1.2
.CLASS	1.0	1.5	0.0	1.4	1.2
..ORDER	1.1	1.5	0.0	1.4	1.6
...FAMILY	1.9	1.5	0.0	1.6	2.0
....GENUS	2.0	1.5	0.0	1.6	2.6

ORGANISM	CELLS /ML	PER-CENT	CELLS /ML	PER-CENT	CELLS /ML	PER-CENT	CELLS /ML	PER-CENT	CELLS /ML	PER-CENT
CHLOROPHYTA (GREEN ALGAE)										
.CHLOROPHYCEAE										
..CHLOROCOCCALES										
...CHARACIACEAE										
....SCHROEDERIA	--	-	1600#	23	--	-	43	3	*	0
...COELASTRACEAE										
....COELASTRUM	81	4	--	-	--	-	--	-	--	-
...HYDRODICTYACEAE										
....PEDIASTRUM	81	4	--	-	--	-	--	-	--	-
...OOCYSTACEAE										
....ANKISTRODESMUS	--	-	--	-	--	-	--	-	41	1
....CHLORELLA	260	13	--	-	--	-	--	-	--	-
....OOCYSTIS	--	-	--	-	--	-	800#	57	320	6
...SCENEDESMACEAE										
....CRUCIGENIA	81	4	--	-	--	-	--	-	550	11
....SCENEDESMUS	81	4	--	-	--	-	--	-	1100#	21
..TETRASPORALES										
...COCCOMYXACEAE										
....ELAKATOTHRIX	--	-	--	-	--	-	--	-	160	3
..VOLVOCALES										
...CHLAMYDOMONADACEAE										
....CHLAMYDOMONAS	--	-	--	-	--	-	14	1	--	-
CHRYSOPHYTA										
.BACILLARIOPHYCEAE										
..CENTRALES										
...COSCINODISCACEAE										
....CYCLOTELLA	15	1	3300#	47	--	-	--	-	41	1
..PENNALES										
...NITZSCHIACEAE										
....NITZSCHIA	*	0	--	-	--	-	--	-	--	-
.CHRYSOPHYCEAE										
..CHRYSOMONADALES										
...OCHROMONADACEAE										
....OCHROMONAS	--	-	--	-	--	-	--	-	96	2
CRYPTOPHYTA (CRYPTOMONADS)										
.CRYPTOPHYCEAE										
..CRYPTOMONADALES										
...CRYPTOCHRYSIDACEAE										
....CHROOMONAS	--	-	2100#	30	--	-	260#	18	--	-
...CRYPTOMONADACEAE										
....CRYPTOMONAS	--	-	--	-	--	-	--	-	*	0
CYANOPHYTA (BLUE-GREEN ALGAE)										
.CYANOPHYCEAE										
..CHROOCOCCALES										
...CHROOCOCCACEAE										
....ANACYSTIS	--	-	--	-	--	-	290#	20	2200#	43
....COCCOCHLORIS	--	-	--	-	--	-	--	-	300	6
..HORMOGONALES										
...NOSTOCACEAE										
....ANABAENA	130	7	--	-	--	-	--	-	--	-
...OSCILLATORIACEAE										
....OSCILLATORIA	1200#	62	--	-	--	-	--	-	150	3
....PHORMIDIUM	--	-	--	-	--	-	--	-	110	2
...RIVULARIACEAE										
....RAPHIDIOPSIS	--	-	--	-	--	-	--	-	82	2
PYRRHOPHYTA (FIRE ALGAE)										
.DINOPHYCEAE										
..PERIDINIALES										
...CERATIACEAE										
....CERATIUM	25	1	--	-	--	-	--	-	--	-

NOTE: # - DOMINANT ORGANISM; EQUAL TO OR GREATER THAN 15%
* - OBSERVED ORGANISM, MAY NOT HAVE BEEN COUNTED; LESS THAN 1/2%

Table 2 and figure 9 show the diversity indices for each taxonomic level of the phytoplankton samples from Courthouse Lake. These indices were computed by use of the method proposed by Wilhm and Dorris (1968). The sample collected in April was not considered to be representative and was not included in figure 9.

High diversity generally indicates a healthy environment where conditions are suitable for many phytoplankton types. Low diversity generally indicates conditions where only more specialized phytoplankton types are able to survive and dominate the population. On a seasonal basis, particularly in eutrophic temperate waters, diversity tends to increase in summer and decrease in winter (Wetzel, 1975).

The diversity indices were the same for each taxonomic level in March 1980. Table 2 shows that this is the result of having only one genus representing each division. The greatest divergences in the diversity indices of phytoplankton taxa were in August 1979 and August 1980 when many genera were identified from many divisions.

The diversity index of phytoplankton divisions and classes were coincidental and tended to be low in summer and high in spring and possibly winter. Both August samples had low division diversity because they were composed predominantly of blue-green algae, whereas the March and June samples had better representation from each division.

The diversity indices at the generic level followed the seasonal pattern described by Wetzel (1975), and were opposite that found at the division level. Although blue-green algae dominated the August 1979 and August 1980 samples, many genera within this and the other divisions identified were able to survive. The diversity indices for the other taxonomic levels fell between those for division and genus.

Trophic Status

The trophic status of Courthouse Lake was determined using Carlson's (1977) Trophic-State Index (TSI) based on three trophic variables, surface chlorophyll *a* concentration, surface total phosphorus concentration, and Secchi-disk transparency. The TSI for each of these variables is shown in figure 10. The formulas used to calculate the TSI are:

$$\mathrm{TSI}_{(SD)} = 10\left[6 - \frac{\ln SD}{\ln 2}\right]$$

$$\mathrm{TSI}(chla) = 10\left[6 - \frac{2.04-0.68\ln chla}{\ln 2}\right]$$

$$\mathrm{TSI}_{(TP)} = 10\left[6 - \frac{\ln \frac{65}{TP}}{\ln 2}\right]$$

where:

SD = Secchi-disk transparency, in meters,
chla = chlorophyll *a* concentration, in micrograms per liter, and
TP = total phosphorus concentration, in micrograms per liter.

The chlorophyll *a* TSI's shown were both about 36. No chlorophyll *a* was found in April 1980, so the TSI was zero. Carlson (1977) recommends using the summer values of

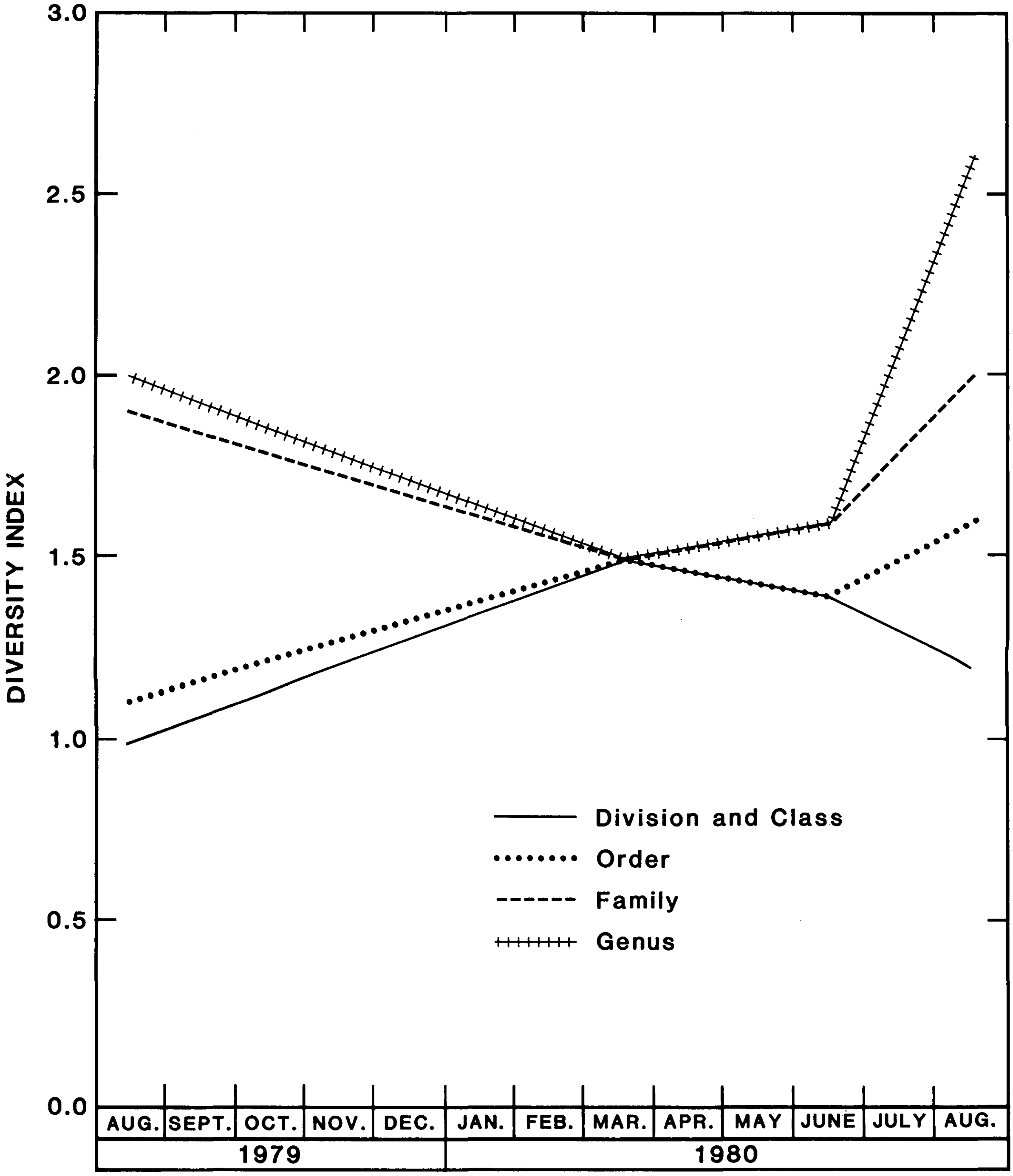


Figure 9.--Diversity indices for phytoplankton samples from Courthouse Lake

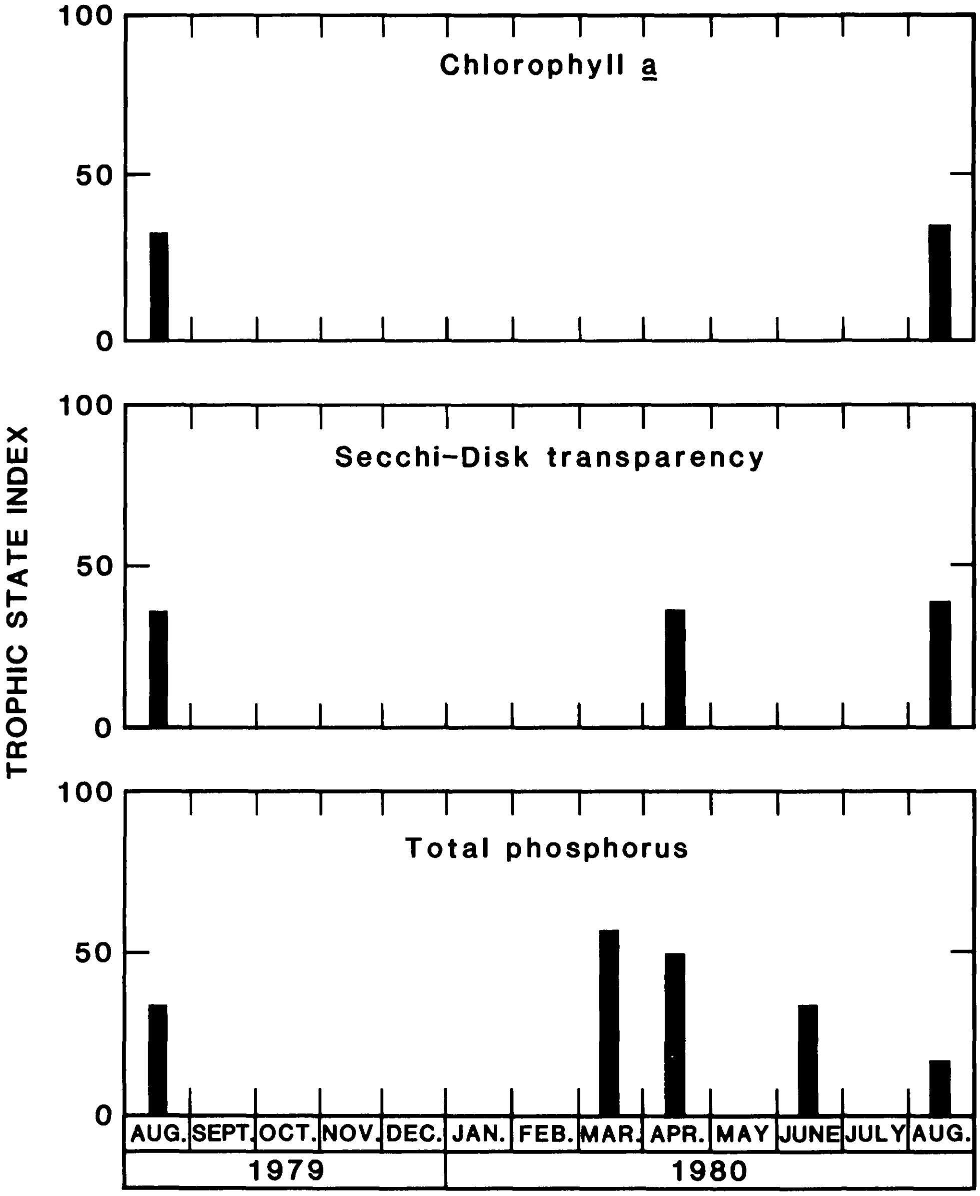


Figure 10.--Trophic state indices for Courthouse Lake

the trophic variables, therefore, this April value may be ignored. According to Reckhow (1979), a lake having a TSI less than about 40 can be considered oligotrophic, a TSI greater than about 50 can be considered eutrophic, and a TSI between about 40 and 50 can be considered mesotrophic. Based on the chlorophyll a concentration, therefore, Courthouse Lake can be considered oligotrophic.

Measurements of Secchi-disk transparency in August 1979 and in April and August 1980 provided TSI's of 36, 36, and 40, respectively. Although the April TSI may be ignored, all the Secchi-disk TSI's also indicate that Courthouse Lake is oligotrophic.

Surface samples were collected for analysis of total phosphorus during each of the five visits to Courthouse Lake. The last sample (August 1980) was analyzed for low-level concentrations (greater than or equal to 0.001 mg/L) of phosphorus. The other samples were analyzed for phosphorus only to an accuracy of 0.01 mg/L. This may affect the significance of the results obtained in August 1979 and June 1980, because both had concentrations of total phosphorus at the detection limit of 0.01 mg/L.

The total phosphorus TSI's for March and April 1980 were high because of the abundance of phosphorus introduced to the epilimnion during fall turnover. These spring TSI's are not representative of the overall trophic status of Courthouse Lake, but they do display a seasonal trend that could be observed each year if the mixing from fall and spring turnover introduces adequate quantities of phosphorus to the epilimnion. Total-phosphorus TSI's decline during summer (fig. 10) as phytoplankton utilize available phosphorus in the epilimnion and carry much of it to the hypolimnion and bottom sediments in their dead cells.

Total phosphorus concentrations in August 1979 and June 1980 each yielded a TSI of 33.0. This value compares favorably with the TSI's for the Secchi-disk transparency and the chlorophyll a concentration in August 1979.

The concentration of total phosphorus in August 1980 was only 0.003 mg/L. This gave a TSI of 16, less than half of all but the April chlorophyll a TSI. Total phosphorus concentration is used as a TSI variable because it is the nutrient usually available in quantities low enough to be limiting to phytoplankton growth. If phosphorus was not limiting, the additional phosphorus would tend to raise the TSI to a value that would exceed the TSI's of the other two variables measured. The TSI's for the other variables in the sample seem to be accurate compared to other samples and the mean summer TSI of 35, excluding the total phosphorus sample. This suggests that the total phosphorus concentration in the sample collected in August 1980 may have been lower than the actual epilimnetic concentration. However, re-analysis of the sample verified the concentration of total phosphorus. Analysis of the vertical profile indicates that phytoplankton productivity is limited to an unusually narrow range in depth. The August 1980 phosphorus sample may not have included a representative part of the epilimnetic waters because most of the phosphorus in the epilimnion is probably contained in the cells of these phytoplankton.

Measurements of Secchi-disk transparency obtained from the Minnesota Department of Natural Resources (written commun., 1980) provide a historical perspective of the trophic status of Courthouse Lake. Figure 11 shows the TSI's derived from these measurements. Included is the TSI for one surface sample of total phosphorus obtained on July 11, 1967.

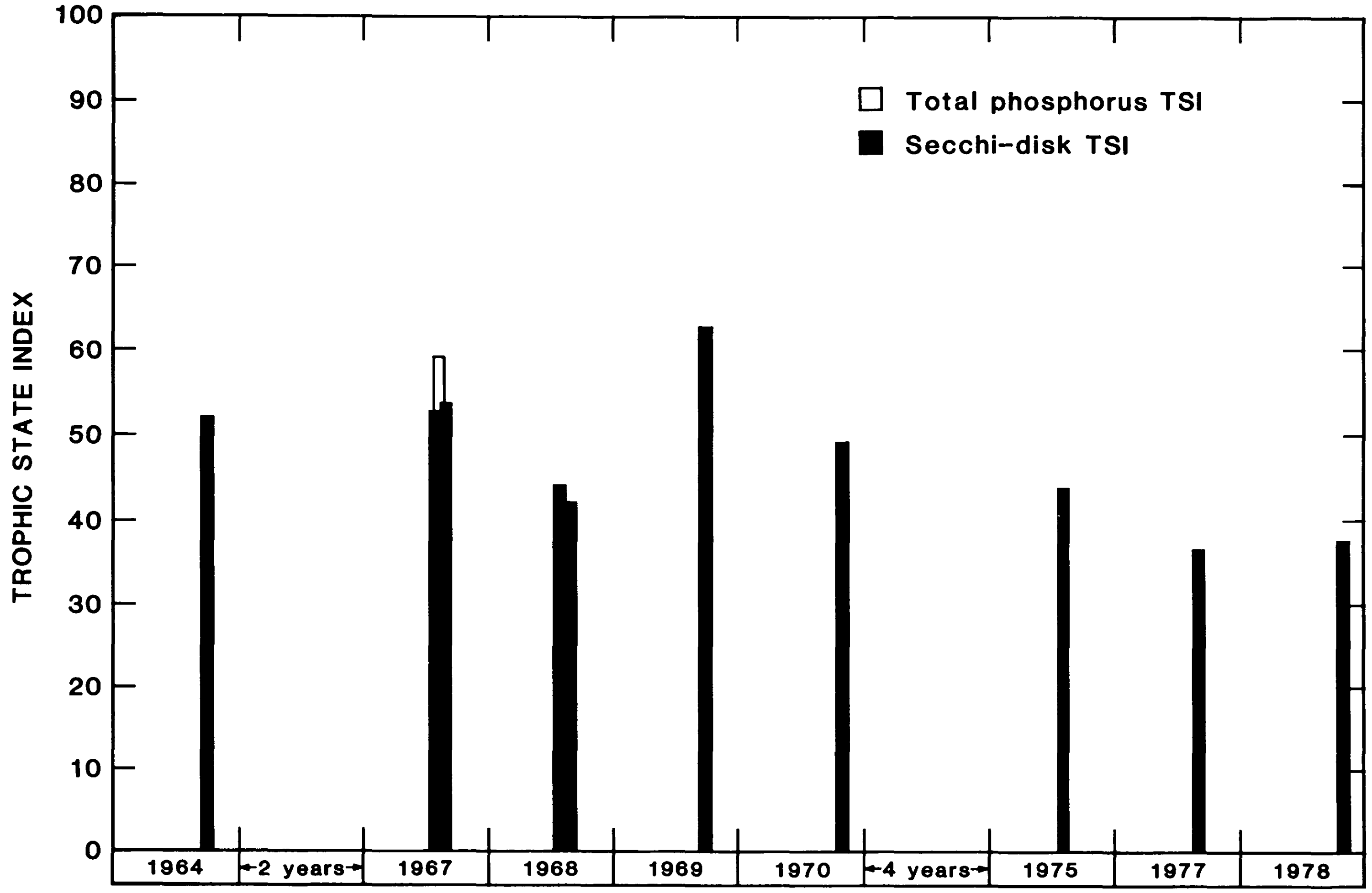


Figure 11.--Historical trophic state indices for Courthouse Lake

The 1964 and 1967 TSI's were more than 50 and the total phosphorus TSI was near 60. This indicates that additional unutilized phosphorus may have been available in the epilimnion for phytoplankton growth. The TSI declined to almost 40 by 1968.

The TSI increased substantially in 1969 to more than 62. The following measurements show a rather steady decline to values less than 40 in 1977 and 1978.

Courthouse Lake was flooded by the Minnesota River in 1952, 1953, 1965, and 1969 (Minnesota Department of Natural Resources, written commun., 1980). The apparent effects of the contamination of Courthouse Lake by the floodwater, which contained 0.66 mg/L total phosphorus near Jordan on March 14, 1977 (U.S. Geological Survey, 1978), are shown in 1967 and 1969 by the increased Secchi-disk TSI's. The reduction in TSI's following the contamination indicates that Courthouse Lake is capable of assimilating the load of phosphorus by holding the phosphorus in the bottom sediments.

DESCRIPTION OF THE PROPOSED FLOOD-CONTROL PROJECT

The Chaska flood-control project proposed by the U.S. Army Corps of Engineers involves modification of a city-owned levee and construction of a new levee to protect the city of Chaska from high-water levels on the Minnesota River (fig. 12). Courthouse Lake will be behind this levee and will be protected from high-water levels on the Minnesota River up to the 100-year frequency elevation (H. A. Nelson, St. Paul District Corps of Engineers, written commun., 1981).

During high water on the Minnesota River, the flow of East and Chaska Creeks will be diverted east and west of the city, respectively (fig. 12). High flows on the creeks (greater than 200 ft^3/s on East Creek) will also be diverted away from the city. Potential flooding from the internal drainage of four subareas of the East and Chaska Creek watersheds below the diversion points will be controlled by ponding areas, gravity outlets through the levee, and a pumping station.

Runoff from 1,070 acres of the East Creek watershed below the diversion point will be directed into a natural depression and the creek channel behind the levee adjacent to Courthouse Lake. The runoff will discharge to the Minnesota River through a gravity outlet in the levee designed to convey more water than expected from the 100-year rainfall-runoff event.

A flap-gate in the gravity outlet will prevent the inflow of Minnesota River floodwaters, but will allow discharge from the ponding area when the water level is at least 1 foot above the elevation of the river. A combined frequency analysis by the Corps, incorporating the characteristics of the watershed, ponding area, and Minnesota River, indicates that the ponding area will have sufficient capacity to contain slightly more than the coincidental 100-year flood.

Should the volume and rate of interior runoff from the 1,070-acre subarea of Chaska exceed the ponding area capacity, an emergency overflow structure at an altitude of 714 feet (National Geodetic Vertical Datum of 1929) will direct the excess runoff into Courthouse Lake. The lake has a usable capacity of 186 acre-feet for runoff storage from the normal elevation of 703 to 714 feet (Barr Engineering Co., 1979).

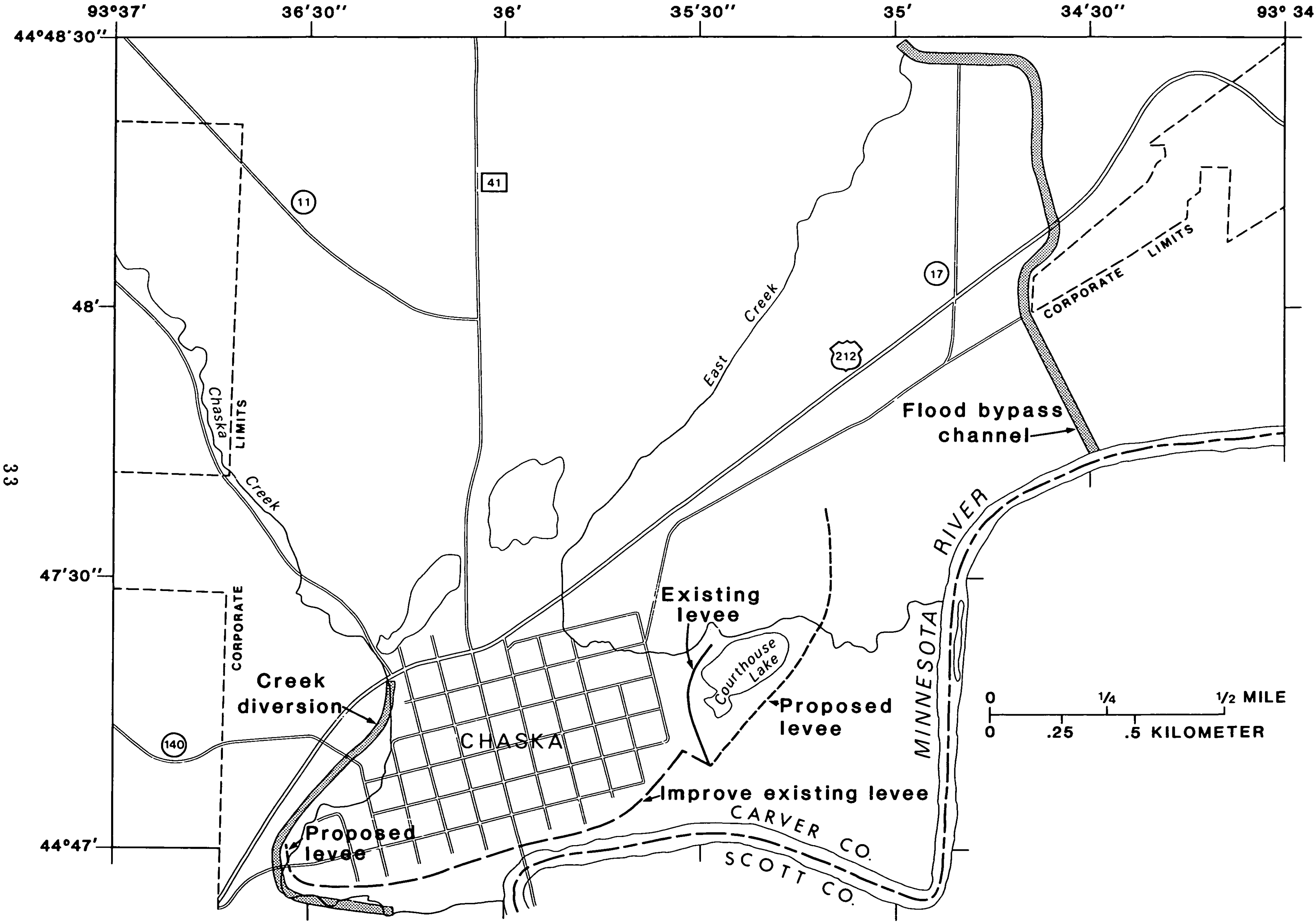


Figure 12.--U. S. Army Corp of Engineers proposed flood-control plan for Chaska, Minnesota

Effects on Courthouse Lake

Runoff from the Chaska subarea could contain many constituents that might alter the present quality of Courthouse Lake. Excessive concentrations of phosphorus are frequently associated with nuisance phytoplankton blooms in lakes and phosphorus seems to be the nutrient occurring in concentrations low enough to be limiting to phytoplankton growth in Courthouse Lake. Phosphorus is commonly a constituent of runoff (M. A. Ayers, oral commun., 1981) and its typical effects on lake quality are well documented and mathematically quantified (Wetzel, 1975).

To evaluate the impact of a large phosphorus load on Courthouse Lake, it will be assumed that the flap-gate is completely closed, allowing none of the runoff to discharge to the river. The proposed project will not be implemented for some time, and because land use in the subarea will determine the quality of runoff received by the lake, the projected development will be used to characterize the Chaska subarea.

The projected development in the 1,070-acre subarea of Chaska by the year 2030 indicates that land use will consist of about 10 pecent of the area in schools, offices, industries, and retail stores, 42 percent in residential area, and 48 percent in park space and undeveloped area (Economics Section, St. Paul District Corps of Engineers, written commun., 1979). Assuming 70 percent of the area in schools, offices, etc., is impervious surface, 30 percent of the residential area is impervious, and none of the undeveloped areas are impervious, a total of about 20 percent of the total watershed can be considered to be impervious. The relief of the watershed was determined from the U.S. Geological Survey 7.5-minute topographic map to be about 225 feet.

No data are available to characterize the quality of runoff from the Chaska watershed, but the quality of runoff from a similar watershed was determined by Ayers and others (1980). The watershed, named State Highway 100 Storm Sewer, is located in Hennepin County and has a drainage area of approximately 301 acres, about 26 percent of which is considered to be impervious. The relief of the watershed is about 45 feet.

Data from the State Highway 100 watershed were examined and the storm producing the largest phosphorus load, which occurred on July 24-25, 1980, was chosen as a basis for estimating the phosphorus load from a hypothetical storm in the Chaska watershed. The 1.03 inches of rain recorded by a gage at the State Highway 100 site resulted in 0.23 inches or 5.77 acre-feet of runoff, which contained a total of 2.73 kilograms of phosphorus. Assuming that runoff from the Chaska watershed after development would be roughly equivalent to runoff from the State Highway 100 watershed, an equivalent storm in the larger Chaska watershed would produce 20.5 acre feet of runoff containing 9.70 kilograms of phosphorus. The initial concentration of phosphorus in the temporary pond, capacity 34 acre feet, adjacent to Courthouse Lake would, therefore, be 0.38 mg/L.

To estimate the impact of a large runoff on Courthouse Lake, assume that enough additional runoff from the hypothetical storm is routed through the pond to fill the lake to the same level as the pond, 714 feet. The three final samplings of the July 1980 storm at Highway 100 had an average phosphorus concentration of 0.24 mg/L. Assuming that this would be the phosphorus concentration in sustained runoff from the hypothetical Chaska storm, an additional 199.5 acre-feet of this water would amount to 220 acre-feet of runoff in the pond and lake combined, with an average phosphorus concentration of 0.25 mg/L.

Some of the phosphorus and other constituents in the runoff will generally have time to settle out before the water enters the lake because runoff from the Chaska watershed will fill the pond before spilling into Courthouse Lake. The quantity of phosphorus lost in this way will depend on the rate at which the pond and lake are filled with runoff. It is assumed that no phosphorus is lost to settling in the high-intensity storm considered here.

Adding 186 acre-feet of this runoff to the 261-acre-foot volume of the lake at normal elevation (Minnesota Department of Natural Resources, written commun., 1980) having the spring concentration of 0.03 mg/L total phosphorus, would fill the lake basin to a 447 acre-foot volume containing 0.12 mg/L total phosphorus, assuming the waters mix completely. After the recession of the Minnesota River, the lake will be drained to its original elevation and volume leaving about an additional 0.09 mg/L total phosphorus in Courthouse Lake.

The impact of this phosphorus load on the lake is uncertain, but it is estimated that Carlson's (1977) trophic-state index (TSI) for total phosphorus would increase from 49 to 69. Assuming TSI's for phosphorus and Secchi-disk transparency are interchangeable, the calculated Secchi-disk transparency would be 0.54 meter. Measured Secchi-disk transparencies were as low as 0.8 meter after flooding of Courthouse Lake by the Minnesota River (Department of Natural Resources, written commun., 1980). The total phosphorus concentration in the lake calculated from the TSI for this September 1969 measurement would have been about 0.08 mg/L. The actual input of phosphorus from the river to the lake cannot be determined; however, the concentration of total phosphorus in the Minnesota River during spring 1977 was 0.66 mg/L (U.S. Geological Survey, 1978). The recovery of Courthouse Lake from phosphorus introduced by the Minnesota River indicates that the lake should easily assimilate periodic phosphorus loading in runoff from the Chaska area.

SUMMARY AND CONCLUSIONS

Water-quality samples were collected for 1 year from East Creek, Chaska Creek, and Courthouse Lake in Chaska, Minn. This report defines the quality of these waters and evaluates the potential effects of a flood-control project proposed by the U.S. Army Corps of Engineers.

The creeks had similar water-quality characteristics with mean pH values of 7.9 and DO concentrations that were nearly saturated throughout the year.

Concentrations of dissolved solids, sulfate, and chloride were associated with base flow in the creeks, and were probably introduced from ground water. Chromium concentrations of about 22 ug/L found in base flow were probably also introduced from ground water.

Organic carbon, BOD, and many forms of nitrogen and phosphorus had concentrations that were generally highest during runoff. Concentrations of oil and grease and most metals were also higher in runoff.

Pesticide samples detected alachlor, atrazine, simazine, and 2,4-D in both creeks. Chaska Creek had the highest concentration of these pesticides.

Vertical profiles show that Courthouse Lake develops thermal stratification with an indistinct thermocline and temperatures that range as much as 19°C from surface to bottom. The hypolimnion was anoxic in August 1979, which could allow the release of soluble phosphates from the lake sediments.

Calcium, silica, phosphorus, and nitrogen concentrations and alkalinity became depleted in the epilimnion of the lake relative to the hypolimnetic concentrations. This was apparently the result of biological activity, which should not cause the observed variations in organic carbon and sodium concentrations.

Phytoplankton populations varied seasonally during the sampling. Diatoms and cryptomonads were predominant in winter and spring, and blue-green algae were predominant in late summer. Green algae were present throughout the year, and were dominant in early summer. The genera of phytoplankton identified did not provide evidence of high organic pollution in Courthouse Lake.

Courthouse Lake had a mean summer trophic state index of 35. Trophic state indices from past measurements of Secchi-disk transparency indicate that Courthouse Lake has recovered from flood waters of the Minnesota River with total phosphorus concentrations as high as 0.66 mg/L.

The recovery of Courthouse Lake from flooding suggests that the lake will also recover from the possible input of phosphorus expected as a result of implementing the flood-control project planned by the Corps. The runoff could raise the total phosphorus concentration from 0.03 to 0.12 mg/L, raising the spring trophic-state index from 49 to 69.

Depending on the quality and volume of runoff received by the lake, a temporary decline in the recreational and esthetic value of the lake, including destruction of the trout fishery, could result.

Should Courthouse Lake receive appreciable amounts of runoff following implementation of the proposed flood-control project, interested persons may wish to monitor the trophic variables in the lake and determine the quality of the runoff water. This would provide a basis for determining what, if any, detrimental effects could be expected from the runoff inputs to the lake.

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WATER-QUALITY DATA

TABLE 3.--WATER-QUALITY DATA

444728093355201 - EAST CREEK AT CHASKA, MN

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	SPE-CIFIC CON-DUCT-ANCE (UMHOS)	PH (UNITS)	TEMPER-ATURE (DEG C)	TUR-BID-ITY (NTU)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN, DIS-SOLVED (PER-CENT SATUR-ATION)	OXYGEN DEMAND, BIO-CHEM-ICAL, 5 DAY (MG/L)
AUG , 1979									
30...	1520	6.6	466	8.2	22.5	6.0	8.2	96	4.0
SEP									
27...	1015	.66	690	8.3	16.5	2.0	9.9	104	1.1
OCT									
30...	1115	2.1	625	8.2	9.5	2.0	11.2	99	3.9
JAN , 1980									
14...	1120	1.4	1022	8.0	1.0	5.0	13.0	94	—
MAR									
25...	1300	6.3	428	7.5	3.7	2.5	13.5	105	—
APR									
30...	1245	2.9	522	8.3	16.4	.56	12.1	126	2.1
MAY									
30...	1120	1.9	624	7.8	17.4	6.0	9.5	101	3.4
JUN									
12...	1010	4.4	558	7.8	17.5	17	9.0	97	—
24...	0940	2.3	491	8.3	20.0	.50	—	—	2.5
JUL									
17...	1115	.22	630	8.2	29.5	4.0	7.9	105	—
23...	1445	.61	—	—	—	—	—	—	1.4
AUG									
22...	1300	.52	650	7.7	23.1	2.0	8.4	99	.9

TABLE 3.--WATER-QUALITY DATA--Continued

444728093355201 - EAST CREEK AT CHASKA MN--Continued

DATE	SULFATE DIS- SOLVED (MG/L AS SO4)	CHLO- RIDE, DIS- SOLVED (MG/L AS CL)	SOLIDS, RESIDUE AT 180 DEG. C DIS- SOLVED (MG/L)	SOLIDS, RESIDUE AT 105 DEG. C, SUS- PENDED (MG/L)	NITRO- GEN, NO2+NO3 TOTAL (MG/L AS N)	NITRO- GEN, NO2+NO3 DIS- SOLVED (MG/L AS N)	NITRO- GEN, AMMONIA TOTAL (MG/L AS N)	NITRO- GEN, AMMONIA DIS- SOLVED (MG/L AS N)	NITRO- GEN, ORGANIC TOTAL (MG/L AS N)
AUG , 1979									
30...	--	20	321	19	.12	--	.170	--	1.9
SEP									
27...	62	28	421	10	--	.56	--	--	--
OCT									
30...	40	23	396	12	--	.37	--	.010	--
JAN , 1980									
14...	54	180	664	23	--	1.6	--	.170	--
MAR									
25...	30	25	300	17	--	.82	--	.430	--
APR									
30...	37	24	418	15	--	.03	--	.000	--
MAY									
30...	39	28	449	11	--	.31	--	.100	--
JUN									
12...	37	22	361	25	--	.23	--	.050	--
24...	35	20	325	16	--	.30	--	.030	--
JUL									
17...	53	28	439	14	--	.32	--	.120	--
23...	--	--	--	--	--	--	--	--	--
AUG									
22...	68	31	450	6	--	.19	--	.000	--

TABLE 3.--WATER-QUALITY DATA--Continued

444728093355201 - EAST CREEK AT CHASKA. MN--Continued

DATE	NITRO-GEN, ORGANIC DIS-SOLVED (MG/L AS N)	NITRO-GEN, AM-MONIA + ORGANIC TOTAL (MG/L AS N)	NITRO-GEN, AM-MONIA + ORGANIC DIS. (MG/L AS N)	NITRO-GEN, TOTAL (MG/L AS N)	NITRO-GEN, DIS-SOLVED (MG/L AS N)	PHOS-PHORUS, TOTAL (MG/L AS P)	PHOS-PHORUS, DIS-SOLVED (MG/L AS P)	CARBON, ORGANIC DIS-SOLVED (MG/L AS C)	CARBON, ORGANIC SUS-PENDED TOTAL (MG/L AS C)
AUG , 1979									
30...	--	2.10	.93	2.2	--	.110	.020	13	1.5
SEP									
27...	--	.74	.59	--	1.2	.030	.020	8.4	.5
OCT									
30...	.92	1.00	.93	--	1.3	.070	.030	12	1.2
JAN , 1980									
14...	1.1	1.30	1.3	--	2.9	.050	.040	10	.5
MAR									
25...	1.1	2.40	1.5	--	2.3	.730	.260	12	2.8
APR									
30...	.69	1.00	.69	--	.72	.030	.020	12	.4
MAY									
30...	.76	.99	.86	--	1.2	.090	.060	11	.6
JUN									
12...	1.1	1.20	1.1	--	1.3	.130	.060	13	1.4
24...	.48	--	.51	--	.81	.080	.060	11	.8
JUL									
17...	.22	.36	.34	--	.66	.050	.050	4.2	.6
23...	--	--	--	--	--	--	--	--	--
AUG									
22...	.32	.45	.32	--	.51	.010	.010	3.6	.4

TABLE 3.--WATER-QUALITY DATA--Continued

444728093355201 - EAST CREEK AT CHASKA, MN--Continued

DATE	TIME	ARSENIC TOTAL (UG/L AS AS)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD)	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB)	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN)	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG)	ZINC, TOTAL RECOV-ERABLE (UG/L AS ZN)
MAR , 1980										
25...	1300	6	0	1	4	1400	130	400	<.1	80
JUL										
17...	1115	3	0	23	0	440	1	100	<.1	10

TABLE 3.--WATER-QUALITY DATA--Continued

444728093355201 - EAST CREEK AT CHASKA, MN--Continued

DATE	TIME	PCB, TOTAL (UG/L)	NAPH-THA-LENES, POLY-CHLOR. TOTAL (UG/L)	ALA-CHLOR (UG/L)	ALDRIN, TOTAL (UG/L)	ATRA-ZINE, TOTAL (UG/L)	CHLOR-DANE, TOTAL (UG/L)	DDD, TOTAL (UG/L)	DDE, TOTAL (UG/L)	DDT, TOTAL (UG/L)	DI-AZINON, TOTAL (UG/L)	DI-ELDRIN TOTAL (UG/L)
JUN , 1980												
12...	1010	.00	.00	.32	.00	.40	.00	.00	.00	.00	.00	.00

DATE	ENDO-SULFAN, TOTAL (UG/L)	ENDRIN, TOTAL (UG/L)	ETHION, TOTAL (UG/L)	HEPTA-CHLOR, TOTAL (UG/L)	HEPTA-CHLOR EPOXIDE TOTAL (UG/L)	LINDANE TOTAL (UG/L)	MALA-THION, TOTAL (UG/L)	METH-OXY-CHLOR, TOTAL (UG/L)	METHYL PARA-THION, TOTAL (UG/L)	METHYL TRI-THION, TOTAL (UG/L)	MIREX, TOTAL (UG/L)
JUN , 1980											
12...	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

DATE	PARA-THION, TOTAL (UG/L)	PER-THANE TOTAL (UG/L)	PROME-TONE TOTAL (UG/L)	PROME-TRYNE TOTAL (UG/L)	SILVEX, TOTAL (UG/L)	SIMA-ZINE TOTAL (UG/L)	SIME-TRYNE TOTAL (UG/L)	TOX-APHENE, TOTAL (UG/L)	TOTAL TRI-THION (UG/L)	2,4-D, TOTAL (UG/L)	2,4,5-T TOTAL (UG/L)
JUN , 1980											
12...	.00	.00	.0	.0	.00	.06	.0	0	.00	.07	.00

TABLE 3.--WATER-QUALITY DATA--Continued

05330700 - CHASKA CREEK AT CHASKA, MN

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	SPE-CIFIC CON-DUCT-ANCE (UMHOS)	PH (UNITS)	TEMPER-ATURE (DEG C)	TUR-BID-ITY (NTU)	OXYGEN, DIS-SOLVED (MG/L)	OXYGEN, DIS-SOLVED (PER-CENT SATUR-ATION)	OXYGEN DEMAND, BIO-CHEM-ICAL, 5 DAY (MG/L)
AUG , 1979									
30...	1430	11	548	8.0	19.6	15	8.7	97	2.2
SEP									
27...	1200	1.7	740	8.3	15.5	2.0	10.6	109	1.2
OCT									
30...	1330	3.3	720	8.3	10.0	4.0	10.6	94	1.7
JAN , 1980									
14...	1250	1.6	783	7.9	1.5	1.1	13.6	99	--
MAR									
25...	1500	24	327	7.5	2.4	50	14.1	106	--
APR									
30...	1400	3.2	638	8.3	17.1	.65	12.0	126	2.1
MAY									
30...	1300	1.7	724	7.7	15.2	9.0	9.1	92	3.8
JUN									
12...	1145	11	684	7.7	16.8	28	9.4	99	--
24...	0915	2.4	589	8.2	20.0	1.0	--	--	1.9
JUL									
17...	1015	.99	686	8.2	29.0	4.5	8.2	108	--
23...	1600	.51	--	--	--	--	--	--	.8
AUG									
22...	1130	1.2	729	7.7	16.5	2.6	11.3	116	1.0

TABLE 3.--WATER-QUALITY DATA--Continued

05330700 - CHASKA CREEK AT CHASKA, MN--Continued

DATE	SULFATE DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)	SOLIDS, RESIDUE AT 105 DEG. C, SUS-PENDED (MG/L)	NITRO-GEN, NO2+NO3 TOTAL (MG/L AS N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	NITRO-GEN, AMMONIA TOTAL (MG/L AS N)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N)	NITRO-GEN, ORGANIC TOTAL (MG/L AS N)
AUG , 1979									
30...	—	16	384	50	1.6	—	.080	—	1.5
SEP									
27...	39	19	327	1	—	.63	—	—	—
OCT									
30...	38	20	458	11	—	1.2	—	.010	—
JAN , 1980									
14...	45	21	456	21	—	2.0	—	.170	—
MAR									
25...	17	14	229	60	—	.94	—	1.50	—
APR									
30...	37	21	473	15	—	.19	—	.010	—
MAY									
30...	34	23	487	860	—	.50	—	.110	—
JUN									
12...	27	18	368	76	—	1.1	—	.100	—
24...	19	21	435	15	—	.70	—	.070	—
JUL									
17...	53	28	432	16	—	.31	—	.130	—
23...	—	—	—	—	—	—	—	—	—
AUG									
22...	39	18	439	8	—	.31	—	.030	—

TABLE 3.--WATER-QUALITY DATA--Continued

05330700 - CHASKA CREEK AT CHASKA, MN--Continued

DATE	NITROGEN, ORGANIC DISSOLVED (MG/L AS N)	NITROGEN, AMMONIA + ORGANIC TOTAL (MG/L AS N)	NITROGEN, AMMONIA + ORGANIC DIS. (MG/L AS N)	NITROGEN, TOTAL (MG/L AS N)	NITROGEN, DISSOLV (MG/L AS N)	PHOSPHORUS, TOTAL (MG/L AS P)	PHOSPHORUS, DISSOLVED (MG/L AS P)	CARBON, ORGANIC DISSOLVED (MG/L AS C)	CARBON, ORGANIC SUSPENDED TOTAL (MG/L AS C)
AUG , 1979									
30...	—	1.60	1.6	3.2	—	.280	.220	15	.8
SEP									
27...	—	.61	.61	—	1.2	.080	.060	7.7	.5
OCT									
30...	.91	.92	.92	—	2.1	.080	.060	12	.4
JAN , 1980									
14...	.74	.91	.91	—	2.9	.070	.050	5.4	.2
MAR									
25...	1.7	4.80	3.2	—	4.1	.480	.460	18	4.2
APR									
30...	.82	1.00	.83	—	1.0	.130	.060	11	.6
MAY									
30...	.51	.62	.62	—	1.1	.170	.110	9.3	.5
JUN									
12...	1.4	1.80	1.5	—	2.6	.450	.270	18	3.2
24...	.44	--	.51	—	1.2	.240	.190	15	.5
JUL									
17...	.21	.42	.34	—	.65	.080	.050	3.8	.4
23...	--	--	--	--	--	--	—	—	—
AUG									
22...	.29	.45	.32	—	.63	.050	.050	4.1	.4

TABLE 3.--WATER-QUALITY DATA--Continued

05330700 - CHASKA CREEK AT CHASKA, MN--Continued

DATE	TIME	ARSENIC TOTAL (UG/L AS AS)	CADMIUM TOTAL RECOVERABLE (UG/L AS CD)	CHROMIUM, TOTAL RECOVERABLE (UG/L AS CR)	COPPER, TOTAL RECOVERABLE (UG/L AS CU)	IRON, TOTAL RECOVERABLE (UG/L AS FE)	LEAD, TOTAL RECOVERABLE (UG/L AS PB)	MANGANESE, TOTAL RECOVERABLE (UG/L AS MN)	MERCURY TOTAL RECOVERABLE (UG/L AS HG)	ZINC, TOTAL RECOVERABLE (UG/L AS ZN)
MAR , 1980										
25...	1500	7	0	1	6	3100	4	670	<.1	30
JUL										
17...	1015	4	0	22	1	670	0	340	<.1	10

TABLE 3.--WATER-QUALITY DATA--Continued

05330700 - CHASKA CREEK AT CHASKA, MN--Continued

DATE	TIME	PCB, TOTAL (UG/L)	NAPH-THA-LENES, POLY-CHLOR. TOTAL (UG/L)	ALA-CHLOR (UG/L)	ALDRIN, TOTAL (UG/L)	ATRA-ZINE, TOTAL (UG/L)	CHLOR-DANE, TOTAL (UG/L)	DDD, TOTAL (UG/L)	DDE, TOTAL (UG/L)	DDT, TOTAL (UG/L)	DI-AZINON, TOTAL (UG/L)	DI-ELDRIN TOTAL (UG/L)
JUN , 1980												
12...	1145	.00	.00	.46	.00	3.3	.00	.00	.00	.00	.00	.00

DATE	ENDO-SULFAN, TOTAL (UG/L)	ENDRIN, TOTAL (UG/L)	ETHION, TOTAL (UG/L)	HEPTA-CHLOR, TOTAL (UG/L)	HEPTA-CHLOR EPOXIDE TOTAL (UG/L)	LINDANE TOTAL (UG/L)	MALA-THION, TOTAL (UG/L)	METH-OXY-CHLOR, TOTAL (UG/L)	METHYL PARA-THION, TOTAL (UG/L)	METHYL TRI-THION, TOTAL (UG/L).	MIREX, TOTAL (UG/L)
JUN , 1980											
12...	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

DATE	PARA-THION, TOTAL (UG/L)	PER-THANE TOTAL (UG/L)	PROME-TONE TOTAL (UG/L)	PROME-TRYNE TOTAL (UG/L)	SILVEX, TOTAL (UG/L)	SIMA-ZINE TOTAL (UG/L)	SIME-TRYNE TOTAL (UG/L)	TOX-APHENE, TOTAL (UG/L)	TOTAL TRI-THION (UG/L)	2,4-D, TOTAL (UG/L)	2,4,5-T TOTAL (UG/L)
JUN , 1980											
12...	.00	.00	.0	.0	.00	.05	.0	0	.00	.09	.00

WATER-QUALITY DATA--Continued

444720093352401 - COURTHOUSE LAKE AT CHASKA, MN

DATE	TIME	SAMPLING DEPTH (FT)	RESERVOIR DEPTH (FEET)	SPECIFIC CONDUCTANCE (UMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	TRANSPARENCY (SECCHI DISK) (M)	OXYGEN, DISSOLVED (MG/L)	OXYGEN, DISSOLVED (PERCENT SATURATION)	HARDNESS (MG/L AS CACO3)
AUG , 1979										
30...	1205	12	56	375	8.4	22.0	5.2	8.8	102	—
30...	1215	51	56	434	7.5	4.8	—	.1	8	--
MAR , 1980										
25...	1100	9.0	54	398	7.7	4.1	--	11.3	88	—
APR										
30...	1022	12	53	364	8.2	10.2	5.1	12.2	111	—
JUN										
24...	1020	3.0	47	370	8.0	25.0	—	8.5	104	—
AUG										
22...	0930	15	55	380	8.4	23.7	4.1	8.4	100	170
22...	1001	48	55	423	7.0	6.4	—	3.1	25	200

444720093352401 - COURTHOUSE LAKE AT CHASKA, MN--Continued

DATE	HARD-NESS, NONCAR-BONATE (MG/L CACO3)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY FIELD (MG/L AS CACO3)	SULFATE DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO2)
AUG , 1979										
30...	--	--	--	--	--	--	--	10	--	--
30...	--	--	--	--	--	--	--	--	--	--
MAR , 1980										
25...	--	--	--	--	--	--	--	12	--	--
APR										
30...	--	--	--	--	--	--	--	10	--	--
JUN										
24...	--	--	--	--	--	120	46	10	.2	--
AUG										
22...	48	36	19	5.4	5.0	120	50	11	.3	.8
22...	37	46	20	10	5.1	160	48	12	.3	3.0

WATER-QUALITY DATA--Continued

444720093352401 - COURTHOUSE LAKE AT CHASKA, MN--Continued

DATE	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)	SOLIDS, DIS-SOLVED (TONS PER AC-FT)	NITRO-GEN, NO2+NO3 TOTAL (MG/L AS N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	NITRO-GEN, AMMONIA TOTAL (MG/L AS N)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N)	NITRO-GEN, ORGANIC TOTAL (MG/L AS N)	NITRO-GEN, ORGANIC DIS-SOLVED (MG/L AS N)	NITRO-GEN, AM-MONIA + ORGANIC TOTAL (MG/L AS N)
AUG , 1979										
30...	230	--	.31	.00	--	.01	--	.39	--	.40
30...	266	--	.36	.00	--	.67	--	.63	--	1.3
MAR , 1980										
25...	247	--	.34	--	.05	--	.07	--	.15	.23
APR										
30...	236	--	.32	--	.03	--	.00	--	.43	.60
JUN										
24...	247	--	.34	--	.01	--	.03	--	.05	.44
AUG										
22...	232	200	.32	--	.00	--	.00	--	.32	.35
22...	278	241	.38	--	.00	--	.11	--	.35	.54

WATER-QUALITY DATA--Continued

444720093352401 - COURTHOUSE LAKE AT CHASKA, MN--Continued

DATE	NITRO-GEN, AM-MONIA + ORGANIC DIS. (MG/L AS N)	NITRO-GEN, TOTAL (MG/L AS N)	NITRO-GEN, DISSOLV (MG/L AS N)	PHOS-PHORUS, TOTAL (MG/L AS P)	PHOS-PHORUS, DIS-SOLVED (MG/L AS P)	CARBON, ORGANIC DIS-SOLVED (MG/L AS C)	CARBON, ORGANIC SUS-PENDED TOTAL (MG/L AS C)	PHYTO-PLANK-TON, TOTAL (CELLS PER ML)	CHLOR-A PHYTO-PLANK-TON CHROMO FLUOROM (UG/L)	CHLOR-B PHYTO-PLANK-TON CHROMO FLUOROM (UG/L)
AUG , 1979										
30...	.30	.40	—	.01	.01	7.1	.2	2000	1.26	.000
30...	1.3	1.3	—	.47	.43	—	—	—	—	—
MAR , 1980										
25...	.22	—	.27	.05	.03	5.8	.4	7100	—	—
APR										
30...	.43	—	.46	.03	.01	4.9	.3	0	.000	.000
JUN										
24...	.08	—	.09	.01	.01	5.9	.3	1400	—	—
AUG										
22...	.32	—	.32	.003	.000	4.8	.7	5200	1.69	.000
22...	.46	—	.46	.184	.177	9.6	.4	—	—	—

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