HYPOLIMNETIC CONCENTRATIONS OF DISSOLVED OXYGEN, NUTRIENTS, AND TRACE ELEMENTS IN COEUR D'ALENE LAKE, IDAHO

By Paul F. Woods

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ABSTRACT

A reconnaissance study of Coeur d'Alene Lake done from May through November 1987 assessed water quality throughout the lake. Particular emphasis was on hypolimnetic concentrations of dissolved oxygen, nutrients, and trace elements. Study results enabled refinement of the sampling protocol in a U.S. Geological Survey research proposal for a large-scale investigation of nutrient enrichment and trace-element contamination problems affecting the 129.5-square kilometer lake in northern Idaho. Hypolimnetic dissolved-oxygen concentrations as low as 4.1 milligrams per liter in November and the frequent occurrence of supersaturated dissolved-oxygen concentrations from June through August indicated nutrient enrichment. Secchi-disc depths in the lake's central and southern areas were typical of mesotrophic conditions, whereas oligotrophic conditions prevailed in the northern area. Throughout the study, hypolimnetic concentrations of total recoverable zinc exceeded chronic and acute toxicity criteria for freshwater aquatic life.

INTRODUCTION

Description of the Study Area

Coeur d'Alene Lake, Idaho's second largest, is in the 17,300-km^2 Spokane River basin (fig. 1), which drains to the Columbia River in eastern Washington. The lake's 9,600-km^2 drainage basin is characterized by high, massive mountains and deep, intermontane valleys. Elevations range from 648 m above sea level at the surface of Coeur d'Alene Lake to 2,086 m in the Bitterroot Range to the east. Coniferous forests cover most of the drainage basin. The area receives some of the largest quantities of precipitation in Idaho; about 70 percent is snow, which most commonly falls from October to April. The areal distribution of precipitation is influenced by the basin's topography; for example, the climatological station at Coeur d'Alene (elevation, 658 m) has a mean annual precipitation of 655 mm, whereas the station at Wallace (elevation, 896 m) receives 971 mm. Although winter temperatures at Coeur d'Alene Lake are often below freezing, the lake surface normally does not freeze except in shallow bays.

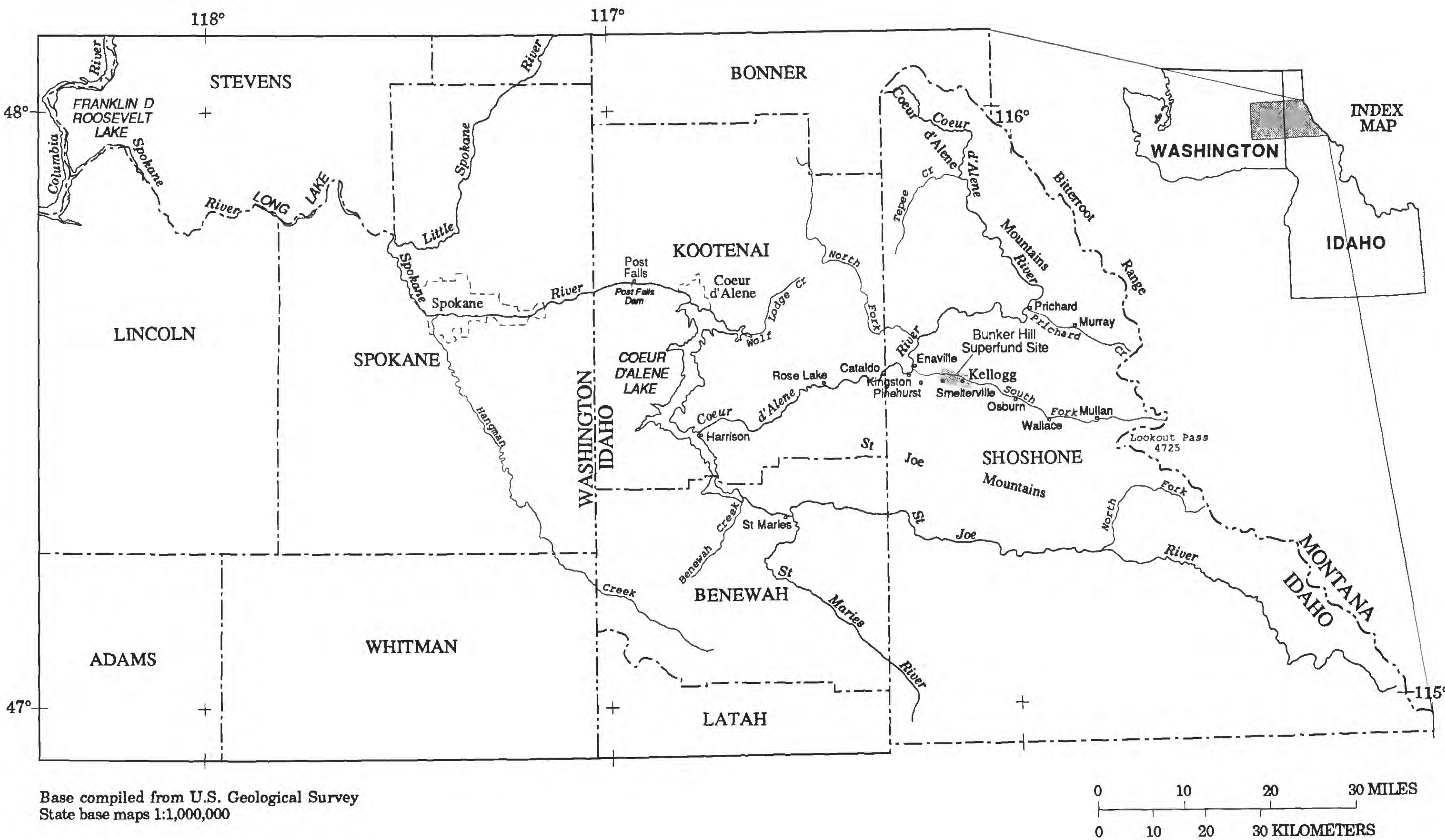

Figure 1.--Location of Coeur d'Alene Lake.

Coeur d'Alene Lake covers 129.5 km^2, contains 2.75 km^3 of water, has mean and maximum depths of 21.2 and 61 m, and has a retention time of 0.48 year. Surface-water inflow to the lake is from two major rivers, the Coeur d'Alene (drainage area, 3,830 km^2) and the St. Joe (drainage area, 4,480 km^2), as well as from numerous minor tributaries. The Coeur d'Alene River annually discharges 2.28 billion m^3 of water into the lake near Harrison, and the St. Joe River annually discharges 2.45 billion m^3 into the lake at its southern end. The lake is drained by the Spokane River, which is regulated at Post Falls Dam for hydroelectric power production, flood control, and irrigation supply.

Land-use activities within the Coeur d'Alene River basin include recreation, logging, agriculture, mining, and ore processing, whereas the predominant land-use activities in the St. Joe River basin are recreation, logging, and mining. Coeur d'Alene Lake has become a prime recreational and summer-home site for residents of northern Idaho and eastern Washington because of the beautiful setting, high-quality fishery, and proximity to the cities of Spokane (metropolitan area population, 285,000) and Coeur d'Alene (population, 25,000). Population growth within 80 km of the lake was 24 percent between 1970 and 1980; by 1980, the lake's 1,950-km shoreline was 80 percent developed (Milligan and others, 1983). Post-1980 shoreline development includes a $60 million resort complex on the lake's northern shore. The economic value of the Coeur d'Alene Lake fishery, considered as one of the most important in the State, was $3 million in 1979--a figure that reflects 350,000 hours of effort expended by fishermen (Rieman and LaBolle, 1980).

Water-Quality Problems

Rapid residential and commercial development of the lake's shoreline and intensive recreational use of Coeur d'Alene Lake have created considerable potential for nutrient enrichment (eutrophication) of the lake. Although numerous point and nonpoint sources of nutrients exist within the lake's drainage basin, the only nutrient loading study of the lake was completed in 1975 as part of the National Eutrophication Survey (U.S. Environmental Protection Agency, 1977). That study classified the lake as mesotrophic, or moderately rich in nutrients, and recommended that additional studies of sources and magnitudes of nutrient loadings be performed prior to development of management plans for controlling eutrophication. However, no definitive studies have yet been undertaken to quantify nutrient loadings into the lake or to model the lake's response to incremental changes in nutrient loading rates.

Another major water-quality problem for Coeur d'Alene Lake is the massive quantity of trace elements, particularly cadmium, lead, and zinc, that have been introduced into the lake as a consequence of more than 100 years of mining and ore-processing activities in the basin. About 104 billion kg of metals-contaminated tailings have been produced within the drainage basin of the South Fork of the Coeur d'Alene River; 65 billion kg have been discharged directly into the river (Tetra Tech, Inc., and Morrison-Knudsen Engineers, Inc., 1987). Large quantities of metals-contaminated tailings have been transported downstream and deposited in the lower reaches of the Coeur d'Alene River and Lake. An extensive delta at the mouth of the Coeur d'Alene River is composed largely of tailings. Sediment cores taken from this delta in the early 1970's contained trace-element concentrations comparable to those measured in the tailings along the South Fork of the Coeur d'Alene River. Also in the early 1970's, high concentrations of trace elements were measured in bottom sediments from the northern two-thirds of Coeur d'Alene Lake (Funk and others, 1973). Sediment cores taken from the lake bottom in 1986 contained trace-element concentrations comparable to those measured in the early 1970's. Concentrations of arsenic, copper, lead, and zinc measured in 1986 far exceeded the upper 95-percent confidence limit for sediments nationwide (E. Hornig, U.S. Environmental Protection Agency, written commun., 1987).

Numerous studies of the Coeur d'Alene River and Lake have addressed the environmental impacts of long-term mining and ore-processing activities; these studies have been summarized by Wai and others (1985), Savage (1986), and Woodward-Clyde Consultants and TerraGraphics (1986). Two significant facts emerge from a review of these studies: (1) Large quantities of trace elements have been deposited in the Coeur d'Alene River and Lake; and (2) trace-element contamination has been detected in terrestrial and aquatic plants, aquatic invertebrates, fish, waterfowl, and humans within the drainage basin. The Coeur d'Alene Indians, whose reservation encompasses the southern part of Coeur d'Alene Lake, are particularly concerned about trace-element contamination because their diet includes fish, game, plants, and water from the Coeur d'Alene River and Lake.

The magnitude of the environmental problems created by these long-term mining activities prompted the U.S. Environmental Protection Agency to establish, in 1983, the Bunker Hill Superfund Site, a 54-km^2 area adjacent to the South Fork of the Coeur d'Alene River (fig. 1). The Superfund Site includes the Bunker Mine (lead and zinc), a milling and concentrating plant, a lead smelter, a silver refinery, an electrolytic zinc plant, a phosphoric acid and phosphate fertilizer plant, a sulfuric acid plant, a cadmium plant, and a 0.65-km^2 mine-tailings and waste-water disposal area. Extensive data-collection and site-rehabilitation activities for the Superfund Site are described in the Remedial Investigation/Feasibility Study document prepared by Tetra Tech, Inc., and Morrison-Knudsen Engineers, Inc. (1987). Although prior studies demonstrated that extensive areas downstream from the Superfund Site (Coeur d'Alene River and Lake) have been contaminated with trace elements, the activities described in the study document do not extend beyond the site boundaries and, in fact, may allow transport of and, hence, further contamination from, metals-contaminated sediments from the site.

Eutrophication and the deposition of trace elements in Coeur d'Alene Lake may appear to be unrelated water-quality problems. However, if a lake's hypolimnion becomes anaerobic as a result of eutrophication, then the reducing conditions produced at the lake's bottom may cause release of large quantities of trace elements and nutrients from bottom sediments (Häkanson and Jansson, 1983; Stumm, 1985). Rieman (1980) reported that the dissolved-oxygen deficit in the lake during the summer of 1979 was severe. Release of trace elements and nutrients from bottom sediments into the water column could have several major consequences for Coeur d'Alene Lake: (1) Acceleration of eutrophication as biological production is increased by internally generated nutrients, (2) increased severity of the hypolimnetic dissolved-oxygen deficit as biological production increases, and (3) increased bioaccumulation of trace elements by aquatic organisms.

Need for Study

Removal of the massive quantity of trace elements in the bottom sediments of Coeur d'Alene Lake is not feasible; therefore, the principal means of keeping those trace elements within the bottom sediments is to manage the lake's nutrient status to curtail development of anaerobic conditions within the hypolimnion. Lake water-quality models are available for predicting the response of a lake to incremental reductions in nutrient loadings. Such models require a more comprehensive data base than that currently available for Coeur d'Alene Lake. The U.S. Geological Survey has proposed that a large-scale investigation of Coeur d'Alene Lake be undertaken to supply the data necessary for implementing a nutrient load/lake response model. Trace-element contamination of the lake also would be assessed by measuring trace-element concentrations within lake-bottom sediments and by quantifying trace-element flux into and out of the lake. Results of the proposed investigation would provide important insight into the two major water-quality problems affecting Coeur d'Alene Lake. Realistic water-quality management strategies then could be developed to control eutrophication and, thus, prevent development of anaerobic conditions within the lake's hypolimnion.

The extensive scope of the investigation proposed by the Geological Survey dictated that a reconnaissance study be performed to aid in design of the sampling program. A reconnaissance study of Coeur d'Alene Lake therefore was done in 1987 to assess hypolimnetic water-quality conditions throughout the lake; particular emphasis was given to concentrations of dissolved oxygen, nutrients, and trace elements. This report describes results of that reconnaissance study.

METHODS

Eight limnological stations, located over the lake's thalweg (fig. 2), were visited monthly from May through November 1987. Station depths ranged from 7.5 to 60 m. A multiparameter water-quality instrument was used to profile temperatures and dissolved-oxygen concentrations through the water column. A spherical quantum sensor was used to determine the depth of the euphotic zone, defined here as the depth at which photosynthetically active radiation is 1 percent of the radiation at the lake's surface. Measurements of secchi-disc depth were made and represented the depth of disappearance and reappearance of a 20-cm diameter secchi disc painted with alternating quadrants of black and white. Water samples for analysis of selected constituents were obtained with an opaque 4.2-L nonmetallic water sampler. One sample was collected within the mid-hypolimnion and a second from 1 m above the lake bottom. The mid-hypolimnion sample was not taken at stations lacking thermal stratification. Mid-hypolimnion samples were analyzed for concentrations of dissolved ammonia, cadmium, lead, orthophosphate, and zinc. Near-bottom samples also were analyzed for those dissolved constituents and for concentrations of total recoverable cadmium, lead, and zinc. Water samples were analyzed by the U.S. Geological Survey's National Water Quality Laboratory according to methods described by Fishman and Friedman (1985).

PHYSICAL CHARACTERISTICS OF COEUR D'ALENE LAKE

Water-temperature profiles were used to determine the presence or absence of thermal stratification and depth of the thermocline at each station. Water-temperature profiles for all eight stations are in tables 1 through 8 (back of report). If a thermocline is present; that is, if water-column temperatures decrease at a rate equal to or greater than 1 °C per meter of depth, a lake's water column is stratified into an epilimnion, a metalimnion, and a hypolimnion. Water columns at each of the eight stations were thermally stratified at some time during the course of this study (fig. 3). During the initial May 21-22 sampling trip, all water columns were stratified except at stations 4 and 6. During June 23-24, all water columns were stratified except at station 8; during July 21-22, all were stratified except at station 7. Water columns at stations 7 and 8 did not stratify for the remainder of the study. The low frequency of thermal stratification at these two stations was largely a result of their shallowness, which allowed wind to induce full-depth circulation of the water columns. Water columns at stations 2 through 6 were thermally stratified from June through October; the water column at station 1 was not stratified during October 21-22. On November 13, water columns at all stations were unstratified. During a limnological study in 1972, water columns were thermally stratified from late June to mid-October (Funk and others, 1973) and, during a study in 1979, were stratified from May until early October (Rieman, 1980). Depth of the thermocline ranged from 5.5 m at station 8 (May 21) and

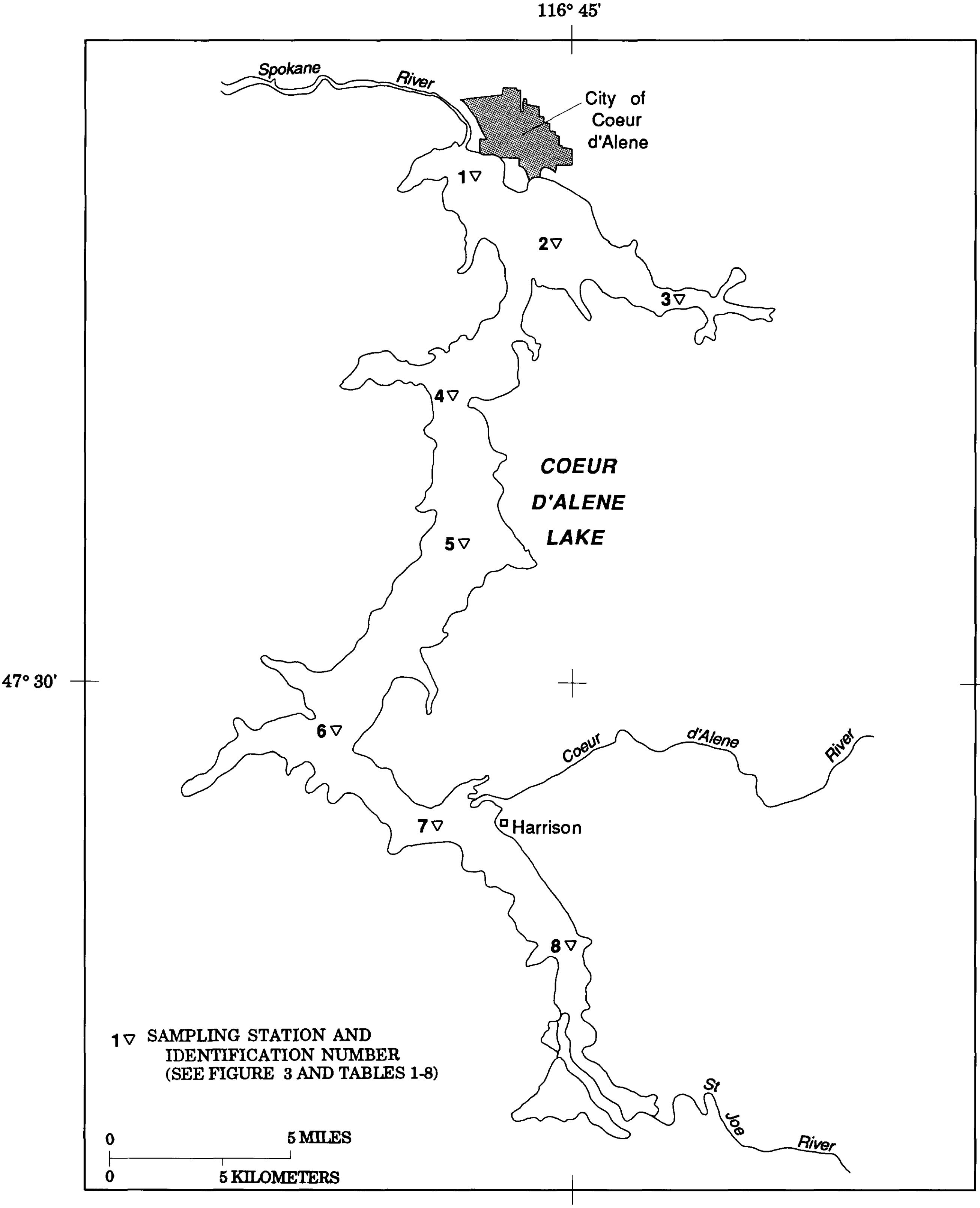

Figure 2.--Sampling stations on Coeur d'Alene Lake.

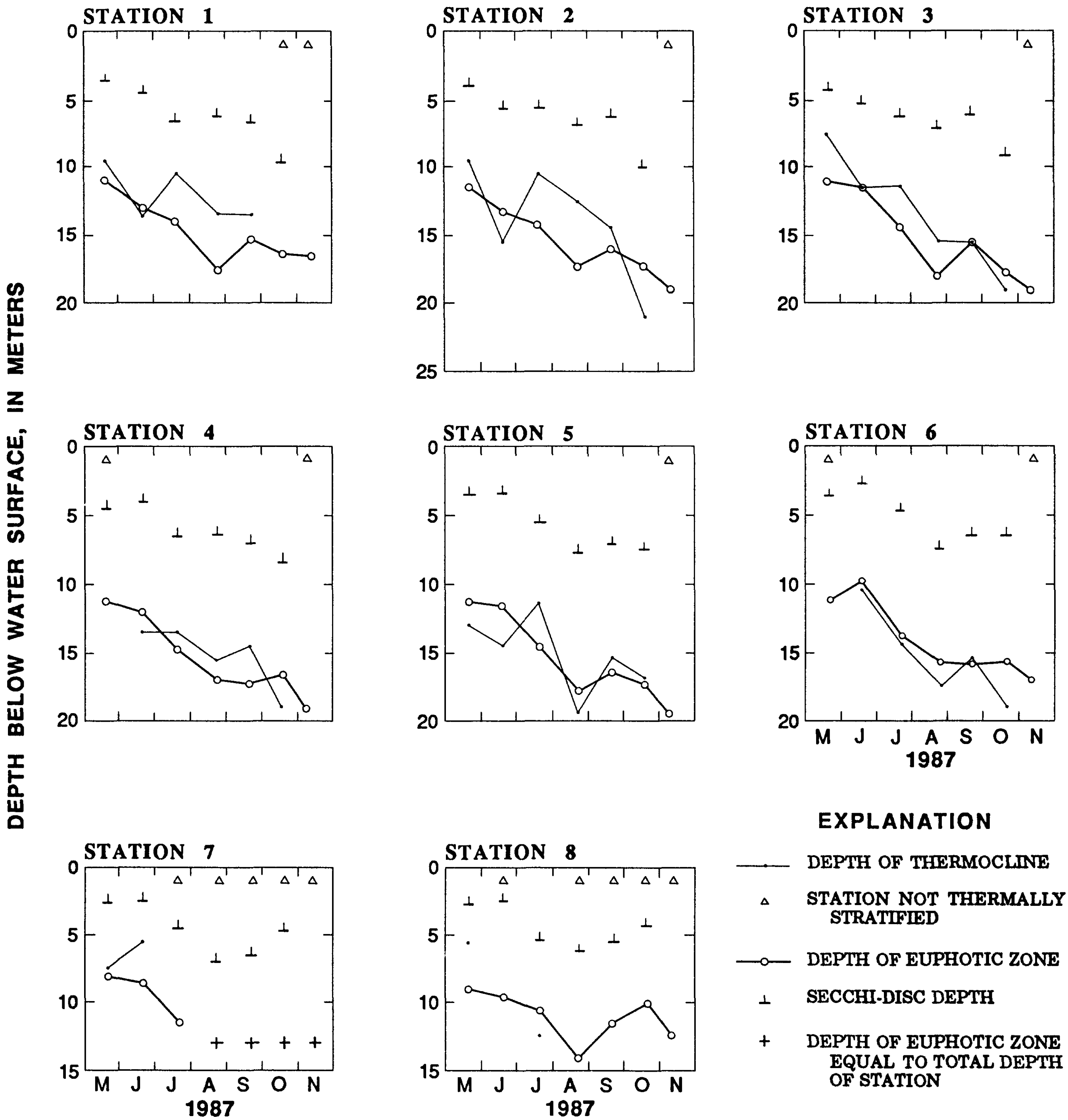

Figure 3.--Depths of the thermocline, euphotic zone, and secchi-disc readings.

station 7 (June 23) to 21 m at station 2 on October 22 (fig. 3). Mean depth, in meters, of the thermocline at the six deepest stations (1-6) varied monthly as follows: May, 10.1; June, 13.2; July, 12.0; August, 15.7; September, 14.8; October, 19.0. Mean water temperature, in degrees Celsius, at 1 m below lake surface for all eight stations, varied monthly as follows: May, 14.1; June, 17.6; July, 19.4; August, 20.1; September, 18.1; October, 12.9; November, 10.8. The lake's maximum surface temperature of 20.5 °C, attained in August during this study, also was attained in August during Rieman's study of 1979.

Secchi-disc depths ranged from 2.7 m in June at stations 7 and 8 to 10 m in October at station 2 (fig. 3). Mean secchi-disc depth, in meters, for all eight stations varied monthly as follows: May, 3.7; June, 3.9; July, 5.7; August, 6.9; September, 6.6; and October, 7.8. This temporal trend was similar to that reported in Rieman's 1979 study, in which secchi-disc depths ranged from 2.5 to 12 m during April through October. Rieman observed that the southern end of the lake had shallower secchi-disc depths than the northern end. A similar conclusion was derived from the 1987 data, which show lower mean values of secchi-disc depth for southern stations 7 and 8 than for northern stations 1 through 3 (table 9).

Secchi-disc measurements have been used widely as indicators of lake trophic state. Ryding and Rast (1989) reviewed trophic-state indicators and concluded that a lake is oligotrophic if its mean annual secchi-disc depth is greater than 6 m and is mesotrophic if the value is between 3 and 6 m. Application of these criteria to Coeur d'Alene Lake indicates that, in 1987, stations 1 through 4 were oligotrophic, whereas stations 5 through 8 were mesotrophic.

Euphotic-zone depths varied spatially and temporally as did secchi-disc depths (fig. 3). The shallowest euphotic zone, 8 m, was measured at station 7 in May and the deepest, 19.5 m, was measured at station 5 in November (fig. 3). On a lakewide basis, euphotic zones were shallowest in May and deepest in either August or November. Because limnologists often have used secchi-disc depth as a predictor of euphotic-zone depth, both variables were measured concurrently in this study. On the average, the euphotic zone in Coeur d'Alene Lake was 2.5 times deeper than its secchi-disc depth, although this ratio ranged between 1.7 and 3.6 for individual comparisons. Thus, prediction of euphotic-zone depth from secchi-disc depth in this lake may not be precise.

HYPOLIMNETIC CONCENTRATIONS OF DISSOLVED OXYGEN, NUTRIENTS, AND TRACE ELEMENTS

Dissolved-oxygen supersaturation and clinograde dissolved-oxygen profiles, both indicators of nutrient enrichment, were apparent during most of the study. Dissolved-oxygen concentrations and percent saturations throughout water columns at

Table 9.--*Mean and range of secchi-disc and euphotic-zone depths*

[--, not measured, >, greater than]

Station No. (fig. 2)	Secchi-disc depth[1] (meters)		Euphotic-zone depth[2] (meters)	
	Mean	Range	Mean	Range
1	6.2	3.7- 9.5	14.8	11.0- 17.5
2	6.6	4.0-10.0	15.4	11.5- 19.0
3	6.3	4.2- 9.1	15.3	11.1- 19.0
4	6.2	4.0- 8.5	15.4	11.2- 19.0
5	5.8	3.4- 7.6	15.5	11.2- 19.5
6	5.4	2.9- 7.6	14.2	9.9- 17.0
7	4.8	2.7- 7.0	--	8.0->12.0
8	4.4	2.7- 6.1	11.0	9.0- 14.0

[1]Six samples from each station, May-October.
[2]Seven samples from each station, May-November.

all eight stations ranged from 3.6 to 11.8 mg/L and from 34 to 132 percent, respectively, during the study (table 10). The complete data set is in tables 1 through 8 (back of report). Profiles of dissolved oxygen were clinograde at all stations except 7 during most of the study. The near-uniform vertical distribution of dissolved oxygen at station 7 was influenced by turbulent mixing produced by inflow currents at the nearby mouth of the Coeur d'Alene River. Concentrations of dissolved oxygen were supersaturated (greater than 100 percent) at all stations during June and August. The lowest dissolved-oxygen concentrations from near-bottom depth samples were collected in September at stations 1, 7, and 8, and in November at stations 2 through 6. Stations 2 through 6 were not thermally stratified on November 13; however, their hypolimnia had not yet been fully saturated with atmospheric dissolved oxygen because of a lack of wind.

Previous investigations of dissolved-oxygen concentrations in the lake are available for comparison to this study's results. Minter (1971) reported a near-bottom dissolved-oxygen concentration of less than 1 mg/L during July near the mouth of the Coeur d'Alene River. Investigations by the U.S. Environmental Protection Agency (1977) and Rieman (1980) determined that dissolved-oxygen profiles in Coeur d'Alene Lake were clinograde during September. The U.S. Environmental Protection Agency reported near-bottom dissolved-oxygen concentrations as low as 0.2 mg/L near the outlet of Coeur d'Alene Lake during August 1986 (E. Hornig, U.S. Environmental Protection Agency, written commun., 1987). Several past studies and this study readily show that Coeur d'Alene Lake has a substantial dissolved-oxygen deficit within its hypolimnion during the late summer and autumn.

Concentrations of dissolved ammonia and orthophosphate within the hypolimnion generally were low (table 11). The complete data set is in table 12 (back of report). Dissolved ammonia reached a maximum concentration of 50 µg/L at station 2 in May. The maximum concentration of dissolved orthophosphate, 13 µg/L, also was recorded at station 2, but in September. Concentrations of these two nutrients in mid-hypolimnion samples were similar to concentrations in near-bottom samples; thus, near-bottom enrichment caused by release of nutrients from the lake sediments was not evident.

The range in concentrations of dissolved and total recoverable cadmium, lead, and zinc within the hypolimnion is shown in table 13. The complete data set is in table 12. Ranges in concentrations of dissolved and total recoverable cadmium were narrow--<1 to 2 µg/L and <1 to 1 µg/L, respectively. The range in concentrations of dissolved lead also was narrow--<5 to 9 µg/L. Concentrations of total recoverable lead peaked at 29 µg/L but, generally, were less than 5 µg/L. The range in concentrations of dissolved zinc was greater--<10 to 170 µg/L in mid-hypolimnion samples and 40 to 150 µg/L in near-bottom samples. Total recoverable zinc was measured only in near-bottom samples; the range in concentrations was 50 to 210 µg/L. Comparison of near-

Table 10.--*Range of concentrations and percent saturations of dissolved oxygen throughout the water column*

Station No. (fig. 2)	Dissolved-oxygen	
	Concentration (milligrams per liter)	Percent saturation
1	6.6 - 10.8	64 - 114
2	4.1 - 11.8	37 - 122
3	4.6 - 11.5	42 - 118
4	5.5 - 11.0	54 - 132
5	5.6 - 10.5	54 - 109
6	3.6 - 10.7	34 - 111
7	7.9 - 11.6	89 - 117
8	4.9 - 11.5	52 - 116

Table 11.--*Range of concentrations of dissolved ammonia and orthophosphate within the hypolimnion*

[Values in micrograms per liter; n, number of samples; MH, mid-hypolimnion; <, less than; NB, near-bottom]

Station No. (fig. 2)	Sample type	Ammonia		Orthophosphate	
		Range	n	Range	n
1	MH	<10 - 20	5	<1	5
	NB	<10 - 20	6	<1 - 1	6
2	MH	<10 - 50	6	<1 - 1	6
	NB	<10 - 40	6	<1 - 13	6
3	MH	<10 - 30	6	<1	6
	NB	<10 - 20	6	<1 - 7	6
4	MH	<10 - 20	6	<1	6
	NB	<10 - 20	6	<1	6
5	MH	<10 - 20	6	<1	6
	NB	<10 - 20	6	<1 - 1	6
6	MH	<10 - 20	6	<1	6
	NB	<10 - 20	6	<1 - 1	6
7	MH	<10 - 40	2	<1	2
	NB	<10 - 40	6	<1 - 1	6
8	MH	<10 - 30	3	<1	3
	NB	<10 - 30	6	<1 - 7	6

Table 13.--*Range of concentrations of dissolved and total recoverable cadmium, lead, and zinc within the hypolimnion*

[Values in micrograms per liter; D, dissolved; TR, total recoverable; MH, mid-hypolimnion; <, less than; --, not measured]

Station No. (fig. 2)	Sample type	Cadmium D	Cadmium TR	Lead D	Lead TR	Zinc D	Zinc TR
1	MH	<1 - 1	--	<5	--	90 - 120	--
	NB	<1 - 1	<1 - 1	<5	<5 - 29	70 - 130	60 - 180
2	MH	<1 - 1	--	<5 - 5	--	110 - 140	--
	NB	<1 - 2	<1 - 1	<5 - 6	<5 - 27	120 - 150	130 - 180
3	MH	<1 - 1	--	<5 - 8	--	110 - 120	--
	NB	<1	<1 - 1	<5	<5	110 - 130	120 - 140
4	MH	<1 - 2	--	<5 - 5	--	120 - 150	--
	NB	<1 - 1	<1 - 1	<5 - 6	<5 - 11	130 - 150	130 - 150
5	MH	<1 - 1	--	<5	--	10 - 140	--
	NB	<1 - 1	<1 - 1	<5	<5	130 - 150	130 - 150
6	MH	<1 - 1	--	<5 - 9	--	100 - 130	--
	NB	<1 - 1	<1 - 1	<5 - 8	<5 - 7	120 - 150	110 - 210
7	MH	<1 - 1	--	<5 - 5	--	80 - 170	--
	NB	<1 - 1	<1 - 1	<5 - 8	<5 - 12	70 - 100	80 - 120
8	MH	<1 - 1	--	<5 - 9	--	<10 - 120	--
	NB	<1 - 1	<1 - 1	<5	<5	40 - 110	50 - 130

bottom and mid-hypolimnion trace-element concentrations indicates no near-bottom enrichment caused by releases of trace elements from lake sediments. Although no spatial or temporal trends were discernible from the trace-element data, a slight gradient in zinc concentrations was apparent between the upper epilimnion and the lower hypolimnion, based on data collected at the lake in August 1986. At that time, total zinc concentrations within the euphotic zone ranged from 61 to 97 μg/L, whereas near-bottom concentrations ranged from 69 to 185 μg/L (E. Hornig, U.S. Environmental Protection Agency, written commun., 1987).

The lack of substantial nutrient and trace-element enrichment in the lower hypolimnion was not surprising because of the lack of anaerobic conditions near the lake bottom during 1987. An important part of the process whereby nutrients and trace elements move from the sediments into the hypolimnion is the creation of a reducing environment near the lake bottom. The reducing environment develops when dissolved-oxygen concentrations are below 0.1 μg/L (Häkanson and Jansson, 1983).

The U.S. Environmental Protection Agency (1986) has established criteria for assessing acute and chronic toxicity to freshwater aquatic biota for many water-quality constituents, including cadmium, lead, and zinc. The acute toxicity criteria are designed to protect freshwater aquatic life if the 1-hour average concentration of the constituent does not exceed the criterion more than once in 3 years. The chronic toxicity criteria specify that the 4-day average concentration should not be exceeded more than once in 3 years. The criteria for cadmium, lead, and zinc are to be applied using total recoverable concentrations and are dependent upon the hardness of the water to which they apply. Coeur d'Alene Lake typically has a total hardness of about 25 μg/L as $CaCO_3$ (E. Hornig, U.S. Environmental Protection Agency, written commun., 1987). Acute and chronic toxicity of cadmium, lead, and zinc for Coeur d'Alene Lake and the equations used to compute those values are shown in table 14. Data in tables 13 and 14 were compared to determine whether the hypolimnetic water contained concentrations of total recoverable cadmium, lead, and zinc that were acutely or chronically toxic to freshwater aquatic life. It was not possible to ascertain the acute or chronic toxicity of most of the cadmium concentrations because the total recoverable concentrations commonly were less than the detection limit of 1 μg/L. On a few occasions, total recoverable cadmium reached concentrations of 1 μg/L, which exceeded the acute and chronic toxicity criteria. Future studies of this lake might employ analytical methods that have a lower detection limit for cadmium. Concentrations of total recoverable lead exceeded the acute toxicity criterion of 14 μg/L in several samples. Chronic toxicity of lead could not be evaluated during this study because most of the concentrations were less than the detection limit of 5 μg/L. Concentrations of total-recoverable zinc exceeded the acute and chronic toxicity criteria throughout the study.

Table 14.--*Concentrations of total recoverable cadmium, lead, and zinc considered acutely or chronically toxic to freshwater aquatic life*

[e, base of natural logarithms; ln, natural logarithm]

Trace element	Toxicity equation[1]	Concentration[2] (micrograms per liter)
Cadmium	Acute: $e^{(1.128\ [\ln (\text{hardness})] - 3.828)}$	0.8
	Chronic: $e^{(0.7852\ [\ln (\text{hardness})] - 3.490)}$	.4
Lead	Acute: $e^{(1.273\ [\ln (\text{hardness})] - 1.460)}$	14.0
	Chronic: $e^{(1.273\ [\ln (\text{hardness})] - 4.705)}$	.5
Zinc	Acute: $e^{(0.8473\ [\ln (\text{hardness})] + 0.8604)}$	36.2
	Chronic: $e^{(0.8473\ [\ln (\text{hardness})] + 0.7614)}$	32.7

[1]From U.S. Environmental Protection Agency (1986).
[2]Computed for hardness concentration of 25 mg/L as $CaCO_3$.

CONCLUSIONS

Analysis of data collected during this study confirmed a substantial dissolved-oxygen deficit within the hypolimnion of Coeur d'Alene Lake during summer stratification. The dissolved-oxygen deficit was, however, not large enough to produce anaerobic conditions in the near-bottom waters. Hypolimnetic dissolved-oxygen concentrations as low as 4.1 mg/L and the frequent occurrence of supersaturated dissolved-oxygen concentrations during the summer indicate that the lake has been enriched with nutrients. These results, in conjunction with the existence of chronically and acutely toxic concentrations of zinc near the lake bottom, emphasize the importance of studying the lake's nutrient enrichment and trace-element contamination problems so that water-quality management strategies can be developed to reduce the likelihood of the lake's hypolimnion becoming anaerobic.

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Table 1.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 1, May-November 1987*

[°C, degrees Celsius; m, meters; mg/L, milligrams per liter]

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
May 22				
	1.0	14.5	10.7	114
	2.0	14.5	10.5	112
	3.0	14.5	10.4	110
	4.0	14.0	10.4	109
	5.0	14.0	10.4	109
	6.0	14.0	10.4	109
	7.0	13.5	10.4	108
	8.0	13.5	10.4	108
	9.0	13.5	10.4	108
	10.0	12.0	10.4	105
	11.0	12.0	10.4	104
	12.0	11.0	10.3	101
	13.0	10.5	10.2	98
	14.0	9.5	10.7	101
	15.0	8.5	10.8	100
	16.0	8.0	10.5	96
	17.0	7.5	10.4	94
	17.6	7.0	10.4	92
June 24				
	1.0	18.0	8.9	101
	2.0	18.0	8.9	101
	3.0	18.0	9.0	102
	4.0	17.5	9.2	104
	5.0	17.5	9.3	105
	6.0	17.5	9.4	106
	7.0	17.5	9.5	107
	8.0	17.5	9.5	107
	9.0	17.5	9.6	108
	10.0	17.5	9.7	109
	11.0	17.5	9.7	109
	12.0	17.5	9.7	109
	13.0	17.0	9.4	105
	14.0	13.5	8.5	88
	15.0	12.5	8.5	86
	16.0	10.0	8.5	81
	17.0	9.5	9.0	84
	18.0	9.0	9.4	87
	19.0	9.0	9.8	91

Table 1.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 1, May-November 1987*--Continued

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
July 22				
	1.0	20.0	9.2	110
	2.0	20.0	9.1	109
	3.0	20.0	8.8	105
	4.0	20.0	8.7	104
	5.0	20.0	8.5	101
	6.0	19.5	8.5	101
	7.0	19.5	8.5	101
	8.0	19.5	8.5	101
	9.0	19.5	8.5	100
	10.0	19.0	8.5	99
	11.0	16.5	8.2	91
	12.0	14.5	8.1	87
	13.0	13.0	7.9	81
	14.0	12.0	7.8	78
	15.0	11.5	7.8	78
	15.7	10.5	7.7	75
August 27				
	1.0	20.0	9.5	112
	2.0	20.0	9.3	110
	3.0	20.0	8.9	105
	4.0	20.0	8.7	103
	5.0	20.0	8.7	103
	6.0	20.0	8.7	103
	7.0	20.0	8.6	102
	8.0	20.0	8.5	101
	9.0	20.0	8.3	98
	10.0	19.5	8.3	98
	11.0	19.5	8.2	97
	12.0	19.5	8.1	95
	13.0	19.5	7.4	87
	14.0	15.5	6.8	74
	15.0	15.5	6.8	74
	16.0	14.0	6.8	71
	17.0	13.5	6.8	71
	18.0	12.5	6.8	69
	19.0	12.0	7.1	71
	20.0	11.5	7.2	71
	21.0	11.0	7.2	71
	22.0	9.5	7.2	68
	23.0	9.0	7.2	67
	24.0	9.0	7.2	67

Table 1.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 1, May-November 1987*--Continued

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
September 23				
	1.0	19.0	9.0	105
	2.0	19.0	8.8	102
	3.0	18.5	8.6	100
	4.0	18.5	8.6	100
	5.0	18.5	8.5	98
	6.0	18.5	8.5	98
	7.0	18.5	8.5	98
	8.0	18.5	8.5	98
	9.0	18.5	8.4	97
	10.0	18.5	8.3	96
	11.0	18.5	8.2	94
	12.0	18.0	8.2	94
	13.0	18.0	7.8	90
	14.0	14.0	6.2	65
	15.0	14.0	6.4	67
	16.0	12.0	6.4	64
	17.0	12.0	6.4	64
	18.0	10.5	6.6	64
October 22				
	1.0	13.0	9.1	94
	2.0	13.0	9.2	95
	3.0	13.0	9.0	93
	4.0	13.0	9.0	93
	5.0	13.0	8.9	92
	6.0	13.0	8.9	92
	7.0	13.0	8.9	92
	8.0	13.0	8.9	92
	9.0	13.0	8.9	92
	10.0	13.0	8.9	92
	12.0	13.0	8.8	90
	14.0	13.0	8.8	90
	16.0	13.0	8.8	90
	18.0	13.0	8.8	90
	19.0	13.0	8.7	89

Table 1.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 1, May-November 1987*--Continued

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
November 13				
	1.0	11.0	9.5	95
	4.0	11.0	9.2	92
	7.0	11.0	9.1	91
	10.0	11.0	9.0	90
	13.0	11.0	9.0	90
	16.0	11.0	9.0	90
	19.0	11.0	9.0	90
	20.9	11.0	8.9	89

Table 2.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 2, May-November 1987*

[°C, degrees Celsius; m, meters; mg/L, milligrams per liter]

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
May 22				
	1.0	14.5	11.0	117
	2.0	14.5	10.7	114
	3.0	14.0	10.3	109
	4.0	14.0	10.2	107
	5.0	14.0	10.2	107
	6.0	14.0	10.2	107
	7.0	14.0	10.2	107
	8.0	14.0	9.6	100
	9.0	11.0	9.4	92
	10.0	9.0	9.4	88
	11.0	8.5	9.1	84
	12.0	7.0	9.3	83
	13.0	7.0	9.5	85
	14.0	7.0	9.6	86
	16.0	6.5	9.8	86
	18.0	6.5	10.0	88
	20.0	6.5	10.0	88
	22.0	6.0	10.2	89
	24.0	6.0	10.2	89
	26.0	6.0	10.3	89
	28.0	6.0	10.0	87
	30.0	6.0	10.0	86
	32.0	6.0	10.0	86
	34.0	5.5	9.9	85
June 24				
	1.0	18.0	9.2	105
	2.0	18.0	9.4	107
	3.0	18.0	9.7	110
	4.0	18.0	9.8	111
	5.0	17.5	10.0	113
	6.0	17.5	10.0	113
	7.0	17.5	10.0	113
	8.0	17.5	10.0	113
	9.0	17.5	10.0	113
	10.0	17.5	10.0	113
	11.0	17.5	9.9	112
	12.0	17.5	9.7	109
	13.0	17.5	9.7	109
	14.0	16.0	9.1	99
	15.0	14.0	8.4	88
	16.0	11.5	8.4	83
	17.0	11.0	8.5	83

Table 2.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 2, May-November 1987*--Continued

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
June 24--Continued				
	18.0	10.0	8.7	83
	19.0	9.5	9.2	87
	20.0	9.0	9.2	85
	22.0	8.5	9.3	86
	24.0	7.5	9.3	84
	26.0	7.0	10.2	91
	28.0	7.0	10.2	90
	30.0	6.5	10.2	90
	32.0	6.5	10.3	90
	34.0	6.5	10.3	90
	36.0	6.5	10.4	91
	38.0	6.5	10.3	90
	40.0	6.0	10.3	90
	40.5	6.0	9.4	82
July 22				
	1.0	19.5	8.9	106
	2.0	19.5	8.7	103
	3.0	19.5	8.7	103
	4.0	19.5	8.5	101
	5.0	19.5	8.5	101
	6.0	19.5	8.5	101
	7.0	19.5	8.5	101
	8.0	18.5	8.5	99
	9.0	18.5	8.5	99
	10.0	18.0	8.3	95
	11.0	15.0	7.9	86
	12.0	14.5	7.9	84
	13.0	13.5	7.9	82
	14.0	12.5	8.1	82
	15.0	12.0	8.1	82
	16.0	11.0	8.1	80
	17.0	11.0	8.0	79
	18.0	10.5	8.0	78
	19.0	9.5	8.1	77
	20.0	8.5	8.2	77
	21.0	8.0	8.5	78
	22.0	7.5	8.7	79
	23.0	7.5	9.0	81

Table 2.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 2, May-November 1987*--Continued

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
August 27				
	1.0	19.5	9.7	115
	2.0	19.5	9.7	115
	3.0	19.5	9.2	109
	4.0	19.5	9.1	107
	5.0	19.5	8.8	104
	6.0	19.5	8.8	104
	7.0	19.5	8.7	103
	8.0	19.5	8.6	101
	9.0	19.5	8.6	101
	10.0	19.0	8.6	100
	11.0	19.0	8.5	99
	12.0	17.5	8.0	91
	13.0	16.0	7.4	81
	14.0	15.0	7.2	77
	15.0	13.5	7.2	75
	16.0	12.5	7.2	73
	17.0	12.0	7.7	77
	18.0	11.0	7.6	74
	19.0	11.0	7.7	75
	23.0	9.5	7.8	74
	26.0	9.5	7.4	70
	29.0	8.0	7.5	68
	32.0	7.5	7.5	68
	35.0	7.0	7.5	66
	38.0	7.0	7.3	65
	40.0	6.5	6.8	60
September 23				
	1.0	18.5	8.7	100
	2.0	18.5	8.6	99
	3.0	18.5	8.6	99
	4.0	18.5	8.5	98
	5.0	18.5	8.4	97
	6.0	18.0	8.5	98
	7.0	18.0	8.6	99
	8.0	18.0	8.6	99
	9.0	18.0	8.4	96
	10.0	18.0	8.4	96
	11.0	18.0	8.6	99
	12.0	18.0	8.3	95
	13.0	18.0	8.3	95

Table 2.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 2, May-November 1987--Continued*

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
September 23--Continued				
	14.0	16.0	7.2	79
	15.0	12.5	6.6	67
	16.0	11.5	6.1	61
	17.0	11.0	6.5	64
	18.0	10.0	6.8	65
	19.0	10.0	7.1	68
	20.0	9.5	7.0	66
	21.0	9.5	6.9	65
	22.0	8.5	7.1	66
	23.0	8.5	7.4	69
	24.0	8.0	7.4	68
	25.0	8.0	7.6	69
	26.0	7.5	7.5	68
	28.0	7.5	7.5	67
	30.0	7.0	7.5	67
	32.0	6.5	7.5	66
	34.0	6.5	7.3	65
	36.0	6.5	7.3	64
	38.0	6.5	7.3	64
	39.0	6.5	7.0	61
October 22				
	1.0	13.0	9.9	102
	2.0	13.0	9.9	102
	3.0	13.0	9.9	102
	4.0	13.0	10.0	103
	5.0	13.0	10.2	105
	6.0	13.0	10.5	108
	7.0	13.0	10.7	110
	8.0	13.0	10.9	112
	9.0	13.0	10.9	112
	10.0	13.0	11.3	116
	12.0	13.0	11.5	118
	14.0	13.0	11.5	119
	16.0	13.0	11.6	119
	18.0	13.0	11.8	122
	20.0	11.5	10.5	105
	22.0	9.5	9.6	91

Table 2.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 2, May-November 1987*--Continued

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
October 22--Continued				
	24.0	8.5	10.2	94
	26.0	8.0	10.3	94
	28.0	7.5	10.6	96
	30.0	7.0	10.8	97
	32.0	7.0	11.0	98
	34.0	7.0	11.0	98
	36.0	6.5	11.3	100
	38.0	6.5	11.2	99
	40.0	6.5	10.8	95
November 13				
	1.0	11.0	9.3	93
	4.0	11.0	9.1	91
	7.0	11.0	9.1	91
	10.0	11.0	9.0	90
	13.0	11.0	9.0	90
	16.0	11.0	9.0	90
	19.0	11.0	9.0	90
	22.0	10.5	8.0	79
	25.0	8.0	6.1	57
	28.0	7.5	6.2	57
	31.0	7.0	6.3	57
	34.0	7.0	5.9	53
	37.0	7.0	5.7	51
	40.0	6.5	4.4	40
	41.0	6.5	4.1	37

Table 3.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 3, May-November 1987*

[°C, degrees Celsius; m, meters; mg/L, milligrams per liter]

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
May 22				
	1.0	14.5	11.1	117
	2.0	14.5	10.7	113
	3.0	14.5	10.4	110
	4.0	14.0	10.0	105
	5.0	13.0	9.9	101
	6.0	11.5	9.6	95
	7.0	10.5	9.3	90
	8.0	8.5	8.6	79
	9.0	7.0	9.0	81
	10.0	7.0	9.7	86
	12.0	6.5	9.7	85
	14.0	6.5	9.8	86
	16.0	6.0	9.9	86
	18.0	6.0	10.0	87
	20.0	6.0	10.1	88
	22.0	6.0	10.1	88
	24.0	6.0	10.1	87
	26.0	6.0	10.1	87
	27.2	6.0	10.1	87
June 24				
	1.0	18.0	10.0	114
	2.0	18.0	10.0	114
	3.0	18.0	10.0	114
	4.0	18.0	10.0	114
	5.0	18.0	10.0	114
	6.0	18.0	10.2	116
	7.0	18.0	10.4	118
	8.0	17.5	10.5	118
	9.0	17.0	10.4	116
	10.0	17.0	10.4	115
	11.0	16.0	10.2	112
	12.0	12.5	9.8	100
	13.0	12.5	9.6	97
	14.0	11.5	9.9	98
	15.0	11.0	10.6	103
	16.0	10.0	10.7	102
	17.0	9.5	11.2	106
	18.0	8.5	11.3	104
	19.0	8.5	11.3	104
	20.0	7.5	11.3	102

Table 3.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 3, May-November 1987*--Continued

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
June 24--Continued				
	21.0	7.5	11.4	102
	22.0	7.0	11.4	101
	23.0	7.0	11.4	101
	24.0	7.0	11.5	102
	25.0	7.0	11.5	102
	26.0	6.5	11.5	101
	27.0	6.5	11.4	100
July 22				
	1.0	20.0	9.2	110
	2.0	19.5	9.0	107
	3.0	19.5	8.7	103
	4.0	19.5	8.0	95
	5.0	19.5	9.0	107
	6.0	19.0	8.9	105
	7.0	19.0	8.9	104
	8.0	18.5	8.8	102
	9.0	17.5	8.8	100
	10.0	16.5	8.8	99
	11.0	16.0	8.8	97
	12.0	14.5	8.4	89
	13.0	14.0	8.4	88
	14.0	13.0	8.4	87
	15.0	12.0	8.4	85
	16.0	11.5	8.0	80
	17.0	11.0	8.0	79
	18.0	10.5	8.0	78
	19.0	10.0	8.0	77
	20.0	9.5	7.9	76
	22.0	9.5	7.9	75
	24.0	8.5	7.6	70
	25.4	8.0	7.6	69
August 27				
	1.0	19.5	9.9	117
	2.0	19.5	9.9	117
	3.0	19.5	9.5	112
	4.0	19.5	9.5	112
	5.0	19.5	9.5	112
	6.0	19.5	9.5	112
	7.0	19.5	9.5	112
	8.0	19.5	9.5	112

Table 3.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 3, May-November 1987*--Continued

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
August 27--Continued				
	9.0	19.5	9.5	112
	10.0	19.0	9.2	107
	11.0	19.0	8.6	100
	12.0	17.0	8.6	96
	13.0	17.0	8.5	95
	14.0	16.0	8.5	93
	15.0	16.0	8.0	87
	16.0	14.5	7.8	82
	17.0	14.0	7.8	82
	18.0	13.5	7.8	81
	19.0	12.0	7.4	74
	20.0	10.5	7.2	70
	21.0	10.5	7.0	68
	22.0	9.5	7.0	66
	23.0	9.5	7.0	66
	24.0	9.0	6.9	65
	25.0	9.0	6.8	64
	26.0	8.0	6.8	62
	27.0	8.0	6.8	62
	28.0	7.5	6.8	62
September 23				
	1.0	18.0	8.3	95
	2.0	18.0	8.3	95
	3.0	18.0	8.3	95
	4.0	18.0	8.3	95
	5.0	18.0	8.3	95
	6.0	18.0	8.3	95
	7.0	18.0	8.5	97
	8.0	18.0	8.5	97
	9.0	18.0	8.5	97
	10.0	18.0	8.5	97
	11.0	18.0	8.4	96
	12.0	18.0	8.5	97
	13.0	18.0	8.5	97
	14.0	18.0	8.5	97
	15.0	17.5	8.2	93
	16.0	13.0	5.7	58
	17.0	12.0	6.0	60
	18.0	11.0	6.0	59
	19.0	10.5	6.0	58
	20.0	9.5	6.0	57
	21.0	9.0	6.0	56

Table 3.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 3, May-November 1987*--Continued

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
September 23--Continued				
	22.0	8.5	6.0	56
	23.0	8.5	6.0	56
	24.0	8.0	6.0	55
	25.0	8.0	6.0	55
	26.0	7.5	5.9	53
	27.0	7.5	5.7	52
October 22				
	1.0	12.5	10.7	109
	2.0	12.5	10.8	110
	3.0	12.5	11.0	112
	4.0	12.5	11.2	114
	5.0	12.5	9.6	98
	6.0	12.5	9.4	96
	7.0	12.5	9.0	92
	8.0	12.5	9.0	92
	9.0	12.5	8.8	90
	10.0	12.5	8.8	90
	12.0	12.5	8.6	88
	14.0	12.5	9.1	93
	16.0	12.5	9.1	93
	18.0	12.5	9.1	93
	20.0	9.5	5.8	55
	22.0	8.0	5.5	50
	24.0	8.0	5.3	48
	26.0	7.5	5.5	49
	27.0	7.0	5.7	51
November 13				
	1.0	11.0	9.2	92
	4.0	11.0	9.2	92
	7.0	11.0	9.1	91
	10.0	11.0	9.1	91
	13.0	11.0	9.0	90
	16.0	11.0	9.0	90
	19.0	11.0	8.9	88
	22.0	9.0	6.2	59
	25.0	7.5	5.3	49
	28.0	7.0	4.6	42

Table 4.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 4, May-November 1987*

[°C, degrees Celsius; m, meters; mg/L, milligrams per liter]

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
May 22				
	1.0	14.0	10.7	113
	2.0	14.0	10.5	111
	3.0	14.0	10.2	108
	4.0	14.0	10.2	107
	6.0	13.0	10.2	105
	8.0	13.0	10.1	103
	10.0	11.5	10.0	99
	12.0	11.0	10.0	98
	14.0	10.0	9.8	94
	16.0	9.5	9.8	93
	18.0	8.0	9.8	90
	21.0	7.5	9.8	89
	24.0	7.0	10.3	92
	27.0	6.5	10.3	91
	30.0	6.0	10.3	90
	33.0	6.0	10.3	89
	36.0	6.0	10.3	89
	39.0	5.5	10.4	90
	42.0	5.5	10.5	90
	45.0	5.5	10.5	90
	48.0	5.5	10.2	87
	51.0	5.5	10.2	87
June 23				
	1.0	17.0	9.4	106
	2.0	17.0	9.4	106
	3.0	17.0	9.4	106
	4.0	17.0	9.4	106
	5.0	17.0	9.4	106
	6.0	17.0	9.4	106
	7.0	17.0	9.4	106
	8.0	17.0	9.4	106
	9.0	17.0	9.4	106
	10.0	17.0	9.4	106
	11.0	17.0	9.4	106
	12.0	17.0	9.3	104
	13.0	17.0	9.3	104
	14.0	14.0	8.3	87
	15.0	12.5	8.2	83

Table 4.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 4, May-November 1987*--Continued

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
June 23--Continued				
	16.0	10.5	7.8	76
	17.0	10.0	8.4	81
	18.0	9.5	8.4	80
	19.0	9.0	9.0	84
	20.0	8.0	9.0	83
	21.0	8.0	9.2	84
	22.0	7.0	9.2	82
	23.0	6.5	9.4	83
	24.0	6.5	9.4	82
	25.0	6.5	9.5	83
	26.0	6.0	9.7	85
	28.0	6.0	9.8	85
	30.0	6.0	9.8	85
	33.0	6.0	9.8	85
	36.0	6.0	9.8	85
	39.0	6.0	9.8	85
	42.0	6.0	9.8	85
	45.0	6.0	9.8	85
	48.0	6.0	9.8	85
July 21				
	1.0	20.0	9.1	110
	2.0	20.0	9.3	112
	3.0	20.0	9.7	117
	4.0	20.0	10.0	120
	5.0	20.0	10.5	126
	6.0	20.0	10.7	129
	7.0	20.0	10.8	130
	8.0	19.5	11.0	132
	9.0	18.5	10.9	128
	10.0	18.0	10.9	126
	11.0	17.5	10.9	124
	12.0	16.0	10.6	118
	13.0	14.5	10.3	111
	14.0	12.5	10.0	103
	15.0	11.5	10.0	101
	16.0	9.5	10.5	100
	17.0	9.0	10.5	99
	18.0	8.5	10.5	99
	19.0	8.0	10.2	95
	20.0	8.0	9.9	92

Table 4.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 4, May-November 1987*--Continued

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
July 21--Continued				
	22.0	7.5	9.8	90
	24.0	7.0	9.8	89
	26.0	7.0	9.8	88
	28.0	7.0	9.8	88
	30.0	6.5	9.5	85
	32.0	6.5	10.5	94
	34.0	6.5	10.5	94
	36.0	6.5	10.5	93
	38.0	6.5	10.5	93
	40.0	6.5	10.0	89
	44.0	6.5	9.8	87
	48.0	6.5	9.8	87
	52.0	6.5	9.8	87
	56.0	6.5	9.6	85
August 27				
	1.0	20.0	9.2	109
	2.0	20.0	9.2	109
	3.0	20.0	8.9	105
	4.0	20.0	8.9	105
	5.0	20.0	8.8	104
	6.0	20.0	8.8	104
	7.0	20.0	8.8	104
	8.0	19.5	8.8	104
	9.0	19.5	8.8	104
	10.0	19.5	8.8	104
	11.0	19.5	8.8	104
	12.0	18.0	8.1	93
	13.0	17.5	7.8	88
	14.0	16.5	7.4	82
	15.0	16.5	6.8	75
	16.0	13.5	6.5	67
	17.0	13.5	6.5	67
	18.0	11.0	6.5	64
	19.0	11.0	6.3	62
	20.0	9.5	6.8	64
	21.0	9.5	6.8	64
	22.0	8.5	7.3	68
	25.0	8.0	7.4	67
	28.0	7.5	7.7	69
	31.0	7.5	7.8	70

Table 4.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 4, May-November 1987*--Continued

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
August 27--Continued				
	34.0	7.0	8.0	71
	37.0	7.0	8.0	71
	40.0	6.5	8.0	71
	43.0	6.5	7.9	70
	46.0	6.5	7.9	69
	49.0	6.5	7.8	69
	52.0	6.5	7.7	68
	55.0	6.5	7.6	67
	57.0	6.5	7.4	65
September 22				
	1.0	18.5	8.4	97
	2.0	18.5	8.4	96
	3.0	18.5	8.2	94
	4.0	18.0	8.2	94
	5.0	18.0	8.1	93
	6.0	18.0	8.4	96
	7.0	18.0	8.4	96
	8.0	18.0	8.4	96
	9.0	18.0	8.4	96
	10.0	18.0	8.4	96
	11.0	18.0	8.2	93
	12.0	18.0	8.2	93
	13.0	18.0	8.2	93
	14.0	18.0	8.2	93
	15.0	15.5	6.5	70
	16.0	14.0	6.1	64
	17.0	13.0	5.5	56
	18.0	10.5	5.6	54
	19.0	10.5	5.7	55
	20.0	9.0	5.9	55
	21.0	9.0	6.1	57
	22.0	8.0	6.4	58
	24.0	8.0	6.7	61
	26.0	7.5	6.9	62
	28.0	7.5	7.0	63
	30.0	7.0	7.1	63
	33.0	7.0	7.1	63
	36.0	7.0	7.3	64
	39.0	6.5	7.3	64
	42.0	6.5	7.3	64

Table 4.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 4, May-November 1987*--Continued

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
September 22--Continued				
	45.0	6.5	7.3	64
	48.0	6.5	7.2	63
	51.0	6.5	7.2	63
	54.0	6.5	7.0	61
	55.0	6.5	6.9	61
October 21				
	1.0	13.5	9.5	99
	2.0	13.5	9.5	98
	3.0	13.5	9.7	100
	4.0	13.5	9.8	102
	5.0	13.5	9.8	102
	6.0	13.5	9.9	103
	7.0	13.5	10.1	105
	8.0	13.5	10.2	106
	9.0	13.5	10.3	107
	10.0	13.5	10.4	107
	12.0	13.5	10.5	109
	14.0	13.5	10.7	111
	16.0	13.5	10.6	110
	18.0	12.0	9.7	98
	20.0	10.0	8.3	79
	22.0	8.5	8.4	78
	24.0	8.0	8.7	80
	26.0	7.5	8.8	79
	28.0	7.0	9.4	84
	30.0	7.0	9.8	87
	32.0	7.0	10.2	91
	34.0	7.0	10.6	94
	36.0	7.0	10.6	94
	38.0	7.0	10.6	94
	40.0	6.5	10.6	94
	42.0	6.5	10.6	94
	44.0	6.5	10.8	95
	46.0	6.5	10.7	95
	48.0	6.5	10.7	94
	50.0	6.5	10.6	93
	52.0	6.5	10.4	92
	54.0	6.5	10.3	91
	55.0	6.5	10.1	89

Table 4.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 4, May-November 1987*--Continued

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
November 13				
	1.0	11.0	9.4	94
	4.0	11.0	9.0	90
	7.0	11.0	9.0	90
	10.0	11.0	9.0	90
	13.0	11.0	9.0	90
	16.0	11.0	9.0	90
	19.0	11.0	9.0	90
	22.0	8.5	8.6	81
	25.0	7.5	6.2	57
	28.0	7.0	6.2	56
	31.0	7.0	6.3	57
	34.0	7.0	6.1	55
	37.0	7.0	6.1	55
	40.0	7.0	6.0	54
	43.0	7.0	6.0	54
	46.0	7.0	6.0	54
	49.0	7.0	6.0	54
	52.0	7.0	6.0	54
	55.0	7.0	6.0	54

Table 5.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 5, May-November 1987*

[°C, degrees Celsius; m, meters; mg/L, milligrams per liter]

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
May 21				
	1.0	14.5	9.8	104
	2.0	13.5	10.2	107
	3.0	13.5	10.2	107
	4.0	13.5	10.4	108
	6.0	13.0	10.4	107
	8.0	13.0	10.3	105
	10.0	12.5	10.2	103
	12.0	12.0	10.2	102
	14.0	8.5	9.7	90
	16.0	8.0	10.0	91
	18.0	7.0	10.4	93
	20.0	7.0	10.5	93
	22.0	6.5	10.4	92
	24.0	6.0	10.2	89
	27.0	6.0	10.1	87
	30.0	5.5	10.1	87
	33.0	5.5	10.2	88
	36.0	5.5	10.2	88
June 23				
	1.0	17.5	9.3	105
	2.0	17.5	9.4	106
	3.0	17.0	9.5	107
	4.0	17.0	9.5	107
	5.0	17.0	9.5	107
	6.0	17.0	9.5	107
	7.0	17.0	9.5	107
	8.0	17.0	9.6	107
	9.0	17.0	9.7	109
	10.0	17.0	9.6	107
	11.0	16.5	9.4	104
	12.0	16.0	9.4	103
	13.0	14.5	8.9	95
	14.0	12.5	8.4	86
	15.0	10.5	8.2	79
	16.0	10.0	8.2	78
	18.0	9.0	8.6	81
	20.0	8.5	8.8	81
	22.0	8.5	9.1	84

Table 5.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 5, May-November 1987*--Continued

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
June 23--Continued				
	24.0	7.5	9.2	83
	26.0	7.5	9.4	85
	28.0	6.5	9.4	83
	30.0	6.5	9.5	84
	32.0	6.5	9.6	84
	34.0	6.0	9.7	85
	36.0	6.0	9.7	84
	38.0	6.0	9.7	84
July 21				
	1.0	19.5	9.3	111
	2.0	19.5	9.0	107
	3.0	19.5	8.8	105
	4.0	19.0	8.8	104
	5.0	19.0	8.8	104
	6.0	19.0	8.8	104
	7.0	19.0	8.8	104
	8.0	18.5	8.8	103
	9.0	18.5	8.7	102
	10.0	18.5	8.7	102
	11.0	18.0	8.3	96
	12.0	16.0	7.6	84
	13.0	13.5	7.1	75
	14.0	11.5	6.7	67
	15.0	11.0	7.2	71
	16.0	10.5	7.2	71
	17.0	10.0	7.4	72
	18.0	9.0	7.5	71
	19.0	8.5	8.0	75
	20.0	8.5	8.2	76
	22.0	8.0	8.7	80
	24.0	7.5	8.8	81
	26.0	7.5	9.0	82
	28.0	7.0	9.0	81
	30.0	6.5	9.0	80
	32.0	6.5	9.0	80
	34.0	6.5	9.0	80
	36.0	6.5	9.0	80

Table 5.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 5, May-November 1987*--Continued

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
August 26				
	1.0	20.5	8.5	102
	2.0	20.5	8.5	102
	3.0	20.5	8.5	102
	4.0	20.5	8.5	101
	5.0	20.5	8.5	101
	6.0	20.5	8.5	101
	7.0	20.0	8.5	101
	8.0	20.0	8.5	101
	9.0	20.0	8.5	101
	10.0	20.0	8.5	101
	11.0	20.0	8.5	100
	12.0	19.5	8.5	100
	13.0	19.5	8.5	100
	14.0	17.5	7.7	87
	15.0	17.5	6.5	73
	16.0	17.5	5.8	65
	17.0	17.0	5.6	62
	18.0	16.0	5.8	64
	19.0	16.0	5.9	65
	20.0	14.0	6.3	66
	21.0	14.0	6.5	68
	22.0	13.0	6.8	70
	23.0	12.5	7.0	71
	24.0	10.0	7.5	72
	26.0	9.5	7.6	72
	28.0	8.0	7.8	71
	30.0	8.0	8.1	73
	32.0	7.5	8.1	73
	34.0	7.5	8.1	73
	36.0	7.0	8.1	72
	37.0	7.0	8.1	72
September 22				
	1.0	18.5	8.8	101
	2.0	18.5	8.8	101
	3.0	18.5	8.5	98
	4.0	18.0	8.5	97
	5.0	18.0	8.5	97
	6.0	18.0	8.5	97
	7.0	18.0	8.5	97

Table 5.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 5, May-November 1987*--Continued

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
September 22--Continued				
	8.0	18.0	8.5	97
	9.0	18.0	8.5	97
	10.0	18.0	8.5	97
	11.0	18.0	8.5	97
	12.0	18.0	8.5	97
	13.0	18.0	8.5	97
	14.0	18.0	7.8	--
	15.0	16.5	6.3	69
	16.0	13.0	5.6	57
	17.0	12.0	5.6	56
	18.0	11.0	5.6	54
	19.0	10.0	6.3	60
	20.0	9.0	6.3	59
	21.0	9.0	6.5	61
	22.0	8.0	6.5	59
	23.0	8.0	7.0	64
	24.0	7.5	7.3	66
	25.0	7.5	7.3	66
	26.0	7.0	7.4	66
	28.0	7.0	7.5	67
	30.0	7.0	7.6	67
	32.0	6.5	7.6	67
	34.0	6.5	7.3	64
	36.0	6.5	7.2	63
	37.0	6.5	7.2	63
October 21				
	1.0	13.5	9.5	99
	2.0	13.5	9.4	98
	3.0	13.5	9.4	98
	4.0	13.5	9.4	98
	5.0	13.5	9.4	98
	6.0	13.5	9.4	98
	7.0	13.5	9.5	99
	8.0	13.5	9.5	98
	9.0	13.5	9.4	97
	10.0	13.5	9.5	98
	12.0	13.5	9.6	99
	14.0	13.5	9.6	99
	16.0	13.5	9.5	98

Table 5.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 5, May-November 1987*--Continued

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
October 21--Continued				
	18.0	10.0	6.6	63
	20.0	9.5	6.5	61
	22.0	8.0	6.7	61
	24.0	8.0	7.0	64
	26.0	7.0	7.1	64
	28.0	7.0	7.4	66
	30.0	7.0	7.4	66
	32.0	7.0	7.5	66
	34.0	6.5	7.4	65
	36.0	6.5	7.1	63
	37.0	6.5	7.0	62
November 13				
	1.0	11.0	9.6	96
	4.0	11.0	9.3	93
	7.0	11.0	9.2	92
	10.0	11.0	9.2	92
	13.0	11.0	9.1	91
	16.0	11.0	9.1	91
	19.0	9.5	6.4	62
	22.0	8.0	6.3	59
	25.0	7.5	6.5	60
	28.0	7.5	6.5	59
	31.0	7.0	6.4	58
	34.0	7.0	6.5	59
	37.0	7.0	6.0	54

Table 6.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 6, May-November 1987*

[°C, degrees Celsius; m, meters; mg/L, milligrams per liter]

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
May 21				
	1.0	13.0	10.2	105
	2.0	12.5	10.2	104
	3.0	12.5	10.5	107
	4.0	12.0	10.6	107
	5.0	12.0	10.6	107
	6.0	12.0	10.6	107
	8.0	12.0	10.6	107
	10.0	12.0	10.6	107
	12.0	12.0	10.6	107
	14.0	12.0	10.6	107
	16.0	12.0	10.6	107
	18.0	12.0	10.6	106
	20.0	11.5	10.7	107
	22.0	10.5	10.7	104
	24.0	10.0	10.7	103
	26.0	9.5	10.6	100
	28.0	9.0	10.6	99
June 23				
	1.0	17.5	8.6	98
	2.0	17.5	8.7	99
	3.0	17.5	9.1	103
	4.0	17.5	9.1	103
	5.0	17.0	9.5	106
	6.0	16.5	9.6	107
	7.0	16.5	9.9	110
	8.0	16.5	9.9	109
	9.0	16.0	10.1	111
	10.0	15.0	9.8	106
	11.0	14.0	9.6	101
	12.0	13.5	9.5	98
	13.0	13.0	9.4	96
	14.0	12.0	9.3	93
	15.0	11.5	9.5	94
	16.0	11.0	9.5	93
	18.0	10.5	9.5	92
	20.0	9.5	9.5	90
	22.0	8.5	9.5	88
	24.0	7.5	9.5	86
	26.0	7.0	9.8	88
	28.0	7.0	9.9	88
	30.0	6.5	10.0	89

Table 6.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 6, May-November 1987*--Continued

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
July 21				
	1.0	18.5	9.2	107
	2.0	18.5	9.1	106
	3 0	18.5	8.8	102
	4.0	18.5	8.8	102
	5.0	18.5	8.7	101
	6.0	18.5	8.7	101
	7.0	18.5	8.7	101
	8.0	18.0	8.7	101
	9.0	18.0	8.7	101
	10.0	18.0	8.7	101
	11.0	18.0	8.7	101
	12.0	18.0	8.7	101
	13.0	18.0	8.7	101
	14.0	17.0	8.3	94
	15.0	13.5	6.1	64
	16.0	12.5	6.0	61
	17.0	10.5	5.8	56
	18.0	9.5	6.1	58
	19.0	9.5	6.3	60
	20.0	9.0	6.5	62
	21.0	9.0	7.1	67
	22.0	9.0	7.4	70
	23.0	9.0	7.8	73
	24.0	9.0	7.8	73
	26.0	8.5	7.8	73
	28.0	8.0	7.9	72
	29.8	7.0	8.2	74
August 26				
	1.0	20.5	7.6	91
	2.0	20.5	7.9	94
	3.0	20.5	8.0	96
	4.0	20.5	8.0	96
	5.0	20.5	8.5	102
	6.0	20.0	8.6	102
	7.0	20.0	8.8	105
	8.0	20.0	9.0	107
	9.0	20.0	9.2	109
	10.0	19.5	9.2	108
	11.0	19.5	9.2	108
	12.0	19.0	9.2	107
	13.0	19.0	7.2	84

Table 6.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 6, May-November 1987*--Continued

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
August 26--Continued				
	14.0	19.0	6.7	78
	15.0	19.0	6.6	77
	16.0	19.0	6.6	77
	17.0	18.5	7.7	89
	18.0	17.5	7.7	87
	19.0	17.5	8.3	94
	20.0	17.5	8.4	95
	21.0	17.0	9.3	103
	22.0	16.5	9.3	103
	23.0	16.0	9.6	105
	24.0	15.0	9.7	104
	25.0	15.0	10.3	111
	26.0	14.5	10.3	109
	27.0	14.5	10.5	111
	28.0	14.0	10.5	110
	30.5	10.5	10.3	99
September 22				
	1.0	18.0	8.5	97
	2.0	18.0	8.4	95
	3.0	18.0	8.3	94
	4.0	18.0	8.2	93
	5.0	18.0	8.2	93
	6.0	18.0	8.2	93
	7.0	18.0	8.2	93
	8.0	18.0	8.2	93
	9.0	18.0	8.1	92
	11.0	18.0	8.1	92
	12.0	17.5	8.1	92
	13.0	17.5	7.9	89
	14.0	17.5	7.8	88
	15.0	17.5	7.4	83
	16.0	11.5	4.0	40
	17.0	10.5	3.8	37
	18.0	10.0	3.7	35
	19.0	10.0	3.6	34
	20.0	9.0	5.4	50
	21.0	9.0	5.4	50
	22.0	8.0	5.8	53
	23.0	8.0	5.9	54
	24.0	7.5	6.0	54
	26.0	7.5	6.7	60
	28.0	7.0	6.8	60
	30.0	7.0	6.8	60
	31.0	7.0	6.8	60

Table 6.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 6, May-November 1987*--Continued

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
October 21				
	1.0	13.0	9.8	101
	2.0	13.0	9.8	101
	3.0	13.0	9.3	96
	4.0	13.0	9.5	98
	5.0	13.0	9.4	97
	6.0	13.0	9.4	97
	7.0	13.0	9.4	97
	8.0	13.0	9.4	97
	9.0	13.0	9.4	97
	10.0	13.0	9.4	97
	12.0	13.0	9.4	97
	14.0	13.0	9.4	97
	16.0	13.0	9.4	97
	18.0	12.0	8.9	90
	20.0	9.5	5.5	52
	22.0	8.5	5.6	52
	24.0	8.0	6.3	58
	26.0	7.5	6.5	59
	28.0	7.5	6.5	58
	30.0	7.0	6.5	58
	31.0	7.0	6.5	58
November 13				
	1.0	11.0	9.7	96
	4.0	11.0	9.6	95
	7.0	11.0	9.5	94
	10.0	11.0	9.4	93
	13.0	11.0	9.1	90
	16.0	10.5	8.8	87
	19.0	10.0	8.3	81
	22.0	7.5	6.2	57
	25.0	7.0	6.1	56
	28.0	7.0	5.8	53
	30.0	7.0	4.9	44

Table 7.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 7, May-November 1987*

[°C, degrees Celsius; m, meters; mg/L, milligrams per liter]

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
May 21				
	1.0	14.0	9.6	101
	2.0	14.0	9.7	102
	3.0	13.5	9.7	101
	4.0	13.5	0.1	104
	5.0	13.0	0.1	104
	6.0	13.0	9.6	99
	7.0	13.0	9.1	93
	8.0	11.5	9.9	98
	8.5	11.0	0.4	102
June 23				
	1.0	18.5	8.9	103
	2.0	18.5	9.0	104
	3.0	18.0	9.0	104
	4.0	18.0	9.0	103
	5.0	17.5	9.0	102
	6.0	16.0	9.0	99
	7.0	15.5	8.8	96
	8.0	14.5	8.8	94
July 21				
	1.0	19.0	9.2	108
	2.0	19.0	9.3	109
	3.0	19.0	9.5	111
	4.0	18.5	9.6	112
	5.0	18.5	9.6	112
	6.0	18.5	9.7	113
	7.0	18.5	9.7	112
	8.0	18.5	9.7	112
	9.0	18.5	9.6	111
	10.0	18.0	9.6	111

Table 7.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 7, May-November 1987*--Continued

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
August 26				
	1.0	20.5	8.6	103
	2.0	20.5	8.4	100
	3.0	20.5	7.9	94
	4.0	20.5	8.3	99
	5.0	20.5	8.3	99
	6.0	20.0	8.0	95
	7.0	20.0	8.0	95
	8.0	20.0	8.1	96
	9.0	20.0	8.0	95
	10.0	20.0	8.1	96
	11.5	20.0	8.1	96
September 22				
	1.0	17.5	8.5	96
	2.0	17.5	8.3	93
	3.0	17.5	8.1	91
	4.0	17.5	8.1	91
	5.0	17.5	8.0	90
	6.0	17.5	8.0	90
	7.0	17.5	8.0	90
	8.0	17.5	8.0	90
	9.0	17.5	8.0	90
	10.0	17.5	7.9	89
October 21				
	1.0	12.5	1.1	112
	2.0	12.5	1.5	116
	3.0	12.5	1.6	117
	4.0	12.5	9.6	97
	5.0	12.5	9.3	94
	6.0	12.5	9.3	94
	7.0	12.5	9.3	94
	8.0	12.5	9.0	91
	9.0	12.5	9.0	91
November 13				
	1.0	10.5	9.7	95
	4.0	10.5	9.6	94
	7.0	10.5	9.6	94

Table 8.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 8, May-November 1987*

[°C, degrees Celsius; m, meters; mg/L, milligrams per liter]

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
May 21				
	1.0	13.0	9.3	95
	2.0	13.0	9.3	95
	3.0	13.0	9.3	95
	4.0	12.5	9.6	98
	5.0	12.5	9.6	98
	6.0	10.0	10.0	96
	7.0	9.5	10.0	94
	8.0	9.0	10.0	94
	9.0	8.5	10.0	93
	10.0	7.5	10.0	91
	11.0	7.0	10.0	89
	12.0	6.5	9.7	86
June 23				
	1.0	16.5	9.8	108
	2.0	16.5	9.8	108
	3.0	15.0	9.5	102
	4.0	14.5	9.5	101
	5.0	14.5	9.8	104
	6.0	14.0	9.8	103
	7.0	13.5	9.6	100
	8.0	13.0	9.6	98
	9.0	12.5	9.5	96
	10.0	11.5	9.1	90
	11.0	10.5	8.9	86
	12.0	10.0	8.9	--
	13.0	9.5	8.8	83
	14.0	8.5	8.8	82

Table 8.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 8, May-November 1987*--Continued

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
July 21				
	1.0	19.0	8.8	104
	2.0	19.0	8.8	104
	3.0	19.0	8.8	104
	4.0	19.0	8.8	103
	5.0	19.0	9.1	107
	6.0	19.0	9.1	107
	7.0	19.0	9.1	107
	8.0	19.0	9.1	107
	9.0	18.0	8.3	96
	10.0	18.0	8.3	96
	11.0	18.0	8.3	96
	12.0	17.5	7.4	84
	13.0	14.5	5.8	62
	14.0	12.5	5.8	59
August 26				
	1.0	20.0	8.2	97
	2.0	20.0	8.2	97
	3.0	20.0	8.7	103
	4.0	20.0	8.7	103
	5.0	20.0	8.8	104
	6.0	20.0	8.8	104
	7.0	20.0	8.9	105
	8.0	20.0	9.2	109
	9.0	20.0	9.2	109
	10.0	19.5	9.3	110
	11.0	19.5	9.3	110
	12.0	19.5	9.1	107
	13.0	19.0	8.3	97
	14.0	19.0	8.2	95
	15.0	18.5	7.4	85
	15.5	18.5	7.1	82

Table 8.--*Water temperatures and dissolved-oxygen concentrations and percent saturations at station 8, May-November 1987*--Continued

Date (1987)	Sampling depth (m)	Temperature, water (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved, (percent saturation)
September 22				
	1.0	17.0	8.0	90
	2.0	17.0	8.2	92
	3.0	17.0	8.2	92
	4.0	17.0	8.2	92
	5.0	17.0	8.3	93
	6.0	17.0	8.3	93
	7.0	17.0	8.3	93
	8.0	17.0	8.3	93
	9.0	17.0	8.3	93
	10.0	17.0	8.1	91
	11.0	17.0	7.2	80
	12.0	16.5	6.9	76
	13.0	16.5	5.9	65
	14.0	15.0	5.2	56
	15.0	15.0	4.9	52
October 21				
	1.0	12.0	9.8	99
	2.0	12.0	9.9	100
	3.0	12.0	10.3	104
	4.0	12.0	10.5	106
	5.0	12.0	10.7	108
	6.0	12.0	10.7	108
	7.0	12.0	10.7	108
	8.0	12.0	11.1	112
	9.0	12.0	11.1	112
	10.0	12.0	11.5	116
	11.0	12.0	9.4	95
	12.5	12.0	9.0	91
November 13				
	1.0	10.0	9.4	92
	4.0	10.0	9.4	92
	7.0	10.0	9.4	92
	10.0	10.0	9.4	92
	13.0	10.0	9.1	88
	15.0	9.0	9.2	88

Table 12.--*Concentrations of ammonia, orthophosphate, cadmium, lead, and zinc at stations 1-8, May-October 1987*

[m, meters; mg/L, milligrams per liter; µg/L, micrograms per liter; --, no data; <, less than detection limit]

Date (1987)	Sampling depth (m)	Nitrogen, ammonia, dissolved (mg/L as N)	Phosphorus, ortho, dissolved (mg/L as P)	Cadmium, total recoverable (µg/L as Cd)	Cadmium, dissolved (µg/L as Cd)	Lead, total recoverable (µg/L as Pb)	Lead, dissolved (µg/L as Pb)	Zinc, total recoverable (µg/L as Zn)	Zinc, dissolved (µg/L as Zn)
				Station 1					
5-22	13.0	0.020	<0.001	--	<1	--	<5	--	100
5-22	18.0	.010	<.001	<1	<1	<5	<5	110	120
6-24	15.0	.010	<.001	--	1	--	<5	--	100
6-24	19.0	.020	<.001	<1	<1	29	<5	180	110
7-22	12.0	<.010	<.001	--	1	--	<5	--	90
7-22	16.5	<.010	<.001	1	1	<5	<5	120	110
8-27	18.0	<.010	<.001	--	<1	--	<5	--	110
8-27	23.0	<.010	<.001	<1	<1	<5	<5	130	120
9-23	15.0	.020	<.001	--	<1	--	<5	--	120
9-23	18.0	.020	.001	<1	<1	<5	<5	120	130
10-22	19.0	<.010	<.001	1	<1	<5	<5	60	70
				Station 2					
5-22	25.0	0.050	<0.001	--	<1	--	<5	--	110
5-22	35.0	.040	<.001	<1	<1	<5	<5	130	130
6-24	30.0	.020	<.001	--	<1	--	<5	--	120
6-24	40.0	.020	<.001	<1	2	27	6	140	120
7-22	32.0	<.010	<.001	--	1	--	<5	--	130
7-22	42.0	<.010	<.001	<1	<1	<5	<5	130	140
8-27	31.0	<.010	<.001	--	<1	--	<5	--	130
8-27	41.0	<.010	.002	<1	<1	7	<5	170	150
9-23	30.0	.020	.001	--	1	--	5	--	140
9-23	40.0	.020	.013	1	1	<5	<5	180	150
10-22	30.0	.010	<.001	--	1	--	<5	--	130
10-22	40.0	<.010	<.001	1	1	<5	<5	150	150

Table 12.--*Concentrations of ammonia, orthophosphate, cadmium, lead, and zinc at stations 1-8, May-October 1987*--Continued

Date (1987)	Sampling depth (m)	Nitrogen, ammonia, dissolved (mg/L as N)	Phosphorus, ortho, dissolved (mg/L as P)	Cadmium, total recoverable (µg/L as Cd)	Cadmium, dissolved (µg/L as Cd)	Lead, total recoverable (µg/L as Pb)	Lead, dissolved (µg/L as Pb)	Zinc, total recoverable (µg/L as Zn)	Zinc, dissolved (µg/L as Zn)
				Station 3					
5-22	18.0	0.010	<0.001	--	<1	--	<5	--	110
5-22	27.0	.010	<.001	<1	<1	<5	<5	130	120
6-24	20.0	.020	<.001	--	<1	--	8	--	110
6-24	27.0	.020	<.001	--	--	--	--	120	--
7-22	19.4	<.010	<.001	--	<1	--	<5	--	110
7-22	27.0	<.010	<.001	<1	<1	<5	<5	130	110
8-27	20.0	<.010	<.001	--	<1	--	<5	--	120
8-27	28.0	<.010	<.001	<1	<1	<5	<5	130	120
9-23	20.0	.030	<.001	--	<1	--	<5	--	120
9-23	27.0	.020	.007	<1	<1	<5	<5	120	120
10-22	22.0	<.010	<.001	--	1	--	<5	--	120
10-22	27.0	<.010	<.001	1	<1	<5	<5	140	130
				Station 4					
5-22	42.0	0.020	<0.001	--	<1	--	<5	--	130
5-22	52.0	.020	<.001	<1	<1	<5	<5	130	130
6-23	30.0	.020	<.001	--	2	--	5	--	120
6-23	41.0	.020	<.001	<1	1	11	6	140	130
7-21	47.0	<.010	<.001	--	1	--	<5	--	120
7-21	57.0	<.010	<.001	<1	1	<5	<5	140	130
8-27	48.0	<.010	<.001	--	<1	--	<5	--	150
8-27	58.0	<.010	<.001	<1	<1	<5	<5	140	140
9-22	45.0	<.010	<.001	--	1	--	<5	--	150
9-22	55.0	<.010	<.001	1	1	<5	<5	140	150
10-21	44.0	<.010	<.001	--	1	--	<5	--	140
10-21	54.0	<.010	<.001	1	1	<5	<5	150	140

Table 12.--*Concentrations of ammonia, orthophosphate, cadmium, lead, and zinc at stations 1-8, May-October 1987*--Continued

Date (1987)	Sampling depth (m)	Nitrogen, ammonia, dissolved (mg/L as N)	Phosphorus, ortho, dissolved (mg/L as P)	Cadmium, total recoverable (µg/L as Cd)	Cadmium, dissolved (µg/L as Cd)	Lead, total recoverable (µg/L as Pb)	Lead, dissolved (µg/L as Pb)	Zinc, total recoverable (µg/L as Zn)	Zinc, dissolved (µg/L as Zn)
				Station 5					
5-21	26.0	0.020	<0.001	--	<1	--	<5	--	10
5-21	36.0	.020	<.001	<1	<1	<5	<5	130	140
6-23	28.0	.020	<.001	--	1	--	<5	--	120
6-23	38.0	.020	<.001	<1	<1	<5	<5	140	130
7-21	28.0	.020	<.001	--	<1	--	<5	--	130
7-21	38.0	.020	<.001	1	1	<5	<5	130	140
8-26	28.0	<.010	<.001	--	1	--	<5	--	130
8-26	38.0	.020	<.001	<1	1	<5	<5	150	130
9-22	28.0	.020	<.001	--	1	--	<5	--	140
9-22	38.0	.020	.001	<1	<1	<5	<5	140	150
10-21	27.0	<.010	<.001	--	1	--	<5	--	140
10-21	37.0	<.010	<.001	<1	1	<5	<5	150	140
				Station 6					
5-21	20.0	0.020	<0.001	--	<1	--	<5	--	100
5-21	28.0	.020	<.001	<1	<1	7	8	110	120
6-23	22.0	.020	<.001	--	<1	--	9	--	120
6-23	31.0	.020	<.001	<1	--	<5	--	120	--
7-21	20.0	.020	<.001	--	<1	--	<5	--	110
7-21	30.0	.020	<.001	1	<1	<5	<5	210	130
8-26	24.0	<.010	<.001	--	1	--	<5	--	130
8-26	32.0	.020	.001	<1	1	<5	<5	170	150
9-22	20.0	<.010	<.001	--	<1	--	<5	--	120
9-22	30.0	<.010	<.001	1	1	<5	<5	140	150
10-21	22.0	<.010	<.001	--	<1	--	<5	--	120
10-21	30.0	<.010	<.001	<1	1	<5	<5	140	140

Table 12.--*Concentrations of ammonia, orthophosphate, cadmium, lead, and zinc at stations 1-8, May-October 1987*--Continued

Date (1987)	Sampling depth (m)	Nitrogen, ammonia, dissolved (mg/L as N)	Phosphorus, ortho, dissolved (mg/L as P)	Cadmium, total recoverable (µg/L as Cd)	Cadmium, dissolved (µg/L as Cd)	Lead, total recoverable (µg/L as Pb)	Lead, dissolved (µg/L as Pb)	Zinc, total recoverable (µg/L as Zn)	Zinc, dissolved (µg/L as Zn)
				Station 7					
5-21	6.0	<0.040	<0.001	--	<1	--	<5	--	170
5-21	9.5	<.040	<.001	<1	<1	<5	<5	90	70
6-23	7.0	.010	<.001	--	<1	--	5	--	80
6-23	8.5	.020	<.001	<1	<1	5	8	110	90
7-21	11.0	<.010	<.001	<1	<1	<5	<5	80	70
8-26	11.0	<.010	<.001	<1	1	12	<5	110	80
9-22	10.0	.020	.001	<1	<1	<5	<5	80	90
10-21	9.0	<.010	<.001	1	<1	5	<5	120	100
				Station 8					
5-21	9.0	0.030	<0.001	--	<1	--	<5	--	<10
5-21	12.0	.020	<.001	<1	<1	<5	<5	110	120
6-23	11.0	.010	<.001	--	<1	--	9	--	100
6-23	14.0	.020	.007	<1	<1	<5	<5	120	110
7-21	13.0	<.010	<.001	--	<1	--	<5	--	90
7-21	15.5	<.010	<.001	<1	<1	<5	<5	130	110
8-26	15.0	.020	<.001	<1	<1	<5	<5	90	70
9-22	15.5	.030	.001	<1	<1	<5	<5	110	100
10-21	14.0	<.010	<.001	1	1	<5	<5	50	40