HYDROLOGY AND WATER QUALITY OF DELAVAN LAKE IN SOUTHEASTERN WISCONSIN

By
Stephen J. Field *and* Marvin D. Duerk

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Appendices are available at the U.S. Geological Survey, WRD, Wisconsin District office on request.

CONVERSION TABLE AND ABBREVIATIONS

For the use of readers who prefer the metric (International System) units, the conversion factors for the inch-pound terms used in this report are listed below.

Multiply inch-pound unit	By	To obtain metric unit
inch (in.)	25.4	millimeter (mm)
inch (in.)	25.4×10^{-3}	micrometers (μm)
mile (mi)	1.609	kilometer (km)
pound (lb)	453.6	gram (g)
acre	4,047	square meter (m^2)
gallon (gal)	3.785×10^{-3}	cubic meter (m^3)
foot (ft)	0.3048	meter (m)
yard (yd)	0.9144	meter (m)
acre-foot (acre-ft)	1.233×10^{3}	cubic meter (m^3)
cubic foot (ft^3)	2.832×10^{-2}	cubic meter (m^3)
Other Conversions		
micrograms per liter (μg/L)	1×10^{-3}	milligrams per liter (mg/L)

Temperature, in degrees Fahrenheit (°F) can be converted to degrees Celsius (°C) by use of the following equation:

$$°C = 5/9(°F - 32).$$

Sea level: In this report "*sea level*" refers to the 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 of 1929."

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ABSTRACT

Delavan Lake is a eutrophic, recreational lake in a densely populated area of southeastern Wisconsin. Sewage effluent and septic tank drainage were diverted out of the drainage basin of the lake to improve its water quality in 1981. The worst known blue-green algal bloom occurred in the lake in the summer of 1983. A comprehensive hydrologic and water-quality investigation was started in October 1983 to determine why the water quality in the lake apparently had not improved after cessation of influxes of waste waters. This report describes the hydrology and water quality of Delavan Lake and its drainage basin during the 1984 and 1985 water years.

All major external inputs and outputs of phosphorus and nitrogen to the lake were measured to assess the importance of each source. Internal loading of phosphorus was calculated as a residual of a mass-balance budget. The in-lake phosphorus mass during the 2-year study shows a gradual declining trend that suggests an improving lake condition but also could be due to a random phosphorus decline. Future monitoring will be needed to determine whether the decline in phosphorus has indeed occurred as a result of waste-water diversion.

Continuous streamflow and water-quality monitoring in the subbasins of the Delavan Lake watershed showed a wide range of annual phosphorus and nitrogen yields during the study. Jackson Creek tributary, which predominantly drains the city of Elkhorn, had the highest average yields of phosphorus (838 pounds per square mile) and Kjeldahl nitrogen (3,600 pounds per square mile). These yields were almost three times those found in the Jackson Creek basin, which has the largest livestock population. The other major tributary, Delavan Lake tributary 2, had much lower average annual yields of phosphorus (53.1 pounds per square mile) and Kjeldahl nitrogen (550 pounds per square mile). The lower yields in this tributary result from significantly reduced runoff caused by storage and evapotranspiration in a large pond that is surrounded by a wetland in the stream's basin.

External loading of phosphorus and nitrogen were sufficient to cause eutrophic conditions. Internal loading of phosphorus was more than two times the external phosphorus supply. Most of the internal loading occurred when the hypolimnion was anoxic during summer. Internal loading of phosphorus during the 1985 water year was significantly reduced from that of 1984 because of a shorter anoxic period.

INTRODUCTION

BACKGROUND

Delavan Lake is a eutrophic, dimictic lake located in Walworth County in southeastern Wisconsin. Much of the lake's eutrophication can be attributed to the input of phosphorus by sewage effluent in the past. The Environmental Protection Agency (EPA) found during a 1972 survey that about three-quarters of the annual external phosphorus input came from three sewage-treatment plants (Environmental Protection Agency, National Eutrophication Survey, 1974). The city of Elkhorn contributed the largest amount (75 percent) of the sewage-treatment plant effluent.

A sewage diversion was begun in April 1979 to reduce phosphorus and nitrogen input. By October 1981, at an expense of 42 million dollars, all sewage-treatment plant effluent from the basin was diverted and all homes and businesses within 0.3 mi (mile) of the lakeshore were sewered. These effluents and domestic wastes are pumped out of the basin for treatment.

A severe blue-green algal bloom in the lake during the summer of 1983 caused complaints from the residents and businesses located around the lake. In October 1983 the U.S. Geological Survey, in cooperation with the Delavan Lake Sanitary District (DLSD) and the Wisconsin Department of Natural Resources (DNR), began a 2-year water-quality and hydrologic investigation to describe water-quality conditions in Delavan Lake and its drainage basin and probable causes of continuing algal problems.

Significant changes in the Delavan Lake ecosystem have occurred during the past 50 years. Rooted aquatic vegetation was treated heavily with arsenic in the 1930's and lakeshore property owners initiated copper sulfate applications in 1939 (Schumacher and Burns, 1978). A decline of rooted aquatic vegetation occurred from 1950 to 1958 and it changed the base of primary productivity from a combination of rooted aquatics and algal production to a system solely of algal production. Large algal blooms, composed generally of *Microcystis* sp. began to appear consistently in about 1955. Bigmouth buffalo, *Ictiobus cyprinellus*, were able to outcompete carp, *Cyprinus carpio*, for the planktivorous food base and gain predominance in the system (Schumacher and Burns, 1978).

PURPOSE AND SCOPE

The purpose of the study was to provide information on the hydrology and water quality of Delavan Lake and its drainage basin for use by local and State agencies in developing lake- and land-management alternatives for improving the water quality of Delavan Lake.

The primary objectives of this study were to determine the nutrient loads into the lake from surface water, ground water, and precipitation. The in-lake objectives are as follows: (1) to determine nutrient loads from internal recycling; (2) to determine the chemical characteristics of the water and bottom sediments of the lake and other physical characteristics, and to determine the chemical characteristics and volume of the soft sediments in Delavan Lake Inlet; (3) to identify the phytoplankton, zooplankton, benthic invertebrates, and rooted aquatic macrophytes present; and (4) to determine the nutrient discharges from the lake from surface and ground water.

This report summarizes the results of the intensive monitoring program from October 1983 through September 1985, and provides an evaluation and interpretation of the data. Streamflow and water-quality monitoring of Delavan Lake and its basin were continued in the 1986 water year, at a much reduced schedule from that described in this report. Appendices of phytoplankton and zooplankton populations and benthic macroinvertebrates; daily water-quality loads at Jackson Creek, Jackson Creek tributary, Delavan Lake tributary 2, and Delavan Lake outlet are available at the Wisconsin District office upon request.

ACKNOWLEDGMENTS

We would like to give special recognition to Marvin D. Duerk, who died on December 20, 1987. Marv provided valuable assistance in collection of and analysis of the data for this study. His efforts in assuring that data were collected during a variety of adverse conditions were an important part in establishing the excellent data base for this study. His contributions to water-resources studies in Wisconsin will be sorely missed in the future.

We would like to thank personnel from the Delavan Lake Sanitary District, especially Barry Kjelland, who assisted with most of the data collection; Neal O'Reilly, Wisconsin Department of Natural Resources, who assisted in the design of the monitoring program; Robert A. Lidwin, U.S. Geological Survey, who identified the benthic invertebrates; and Robert Wakeman, Wisconsin Department of Natural Resources, who identified macrophytes and wrote the part of this report about them.

PHYSICAL SETTING

LAKE BASIN AND SHORELINE CHARACTERISTICS

Delavan Lake was formed during the late Wisconsin glaciation, which ended 10,000 years ago. The basin has moderate relief with gently undulating plains. The lake's drainage basin is part of the Turtle Creek system. Major surface-water inflow to the lake is from Jackson Creek, through Delavan Lake inlet, at the northeastern end of the lake (fig. 1). The second largest inflow to the lake is from an unnamed tributary at the southwestern end of the lake. The immediate drainage area surrounding the lake is occupied mostly by 2,200 homes and businesses.

Delavan Lake inlet (fig. 1) upstream of State Highway 50 is extremely shallow [less than 3 ft (feet) deep], 0.2 mi wide, and 1.8 mi long. Many carp and bigmouth buffalo search for food in this area and also use it during spawning. The outlet of the lake is at the northwestern end, 2 mi from the inlet.

A dam at the outlet was constructed in the mid 1930's (K. L. MacKinnon, DLSD, written commun., 1985), to deepen the lake about 8 ft. The practice of dropping lake levels 0.75 ft about the first of October to prevent ice damage to shoreline structures and raising water levels to pre-October levels in April to May has been followed for many years. Lake levels are controlled by the town of Delavan. Basic hydrographic and morphometric data of Delavan Lake are presented in table 1.

WATERSHED CHARACTERISTICS

Geology

Delavan Lake was formed by the Delavan Lobe of the Lake Michigan glacier during Wisconsin Glaciation. The drainage basin contains glacial deposits of unconsolidated material of Quaternary age (Borman, 1976) that range from 150 ft in thickness in the northeastern part of the basin to 450 ft thick in the southeastern part. These sediments are end and ground moraine deposits. End moraines are present at the very southwestern end of Delavan Lake, southwestward to the basin divide, and in two small locations about 1 mi² (square mile) in size near the central part of the basin. The rest of the basin is ground moraine.

The predominant surface bedrock in the basin is undifferentiated dolomites of Silurian age in the western one-third of the basin, Maquoketa Shale of Ordovician age in the central part of the basin, and undifferentiated rocks (mostly dolomite) of Ordovician age in the eastern one-third of the basin. The Cambrian sandstone underlies the Ordovician and Silurian rocks that overlie the crystalline, Precambrian rocks. The Maquoketa Shale is a barrier to vertical ground-water movement.

Water-bearing sand and gravel is present throughout much of the basin. It may extend down from the surface or be buried below relatively impermeable materials (fig. 2). The saturated thickness of the unconsolidated deposits ranges from 100 ft in the northeastern part of the basin to 400 ft in the southwestern part of the basin.

Soils

Soils in the Delavan Lake basin are clay loams, silty clay loams, and sandy clay loams and are described by Haszel (1971). There are three soil associations in the Delavan Lake basin: Pella-Kendall-Elburn, Miami-McHenry, and the

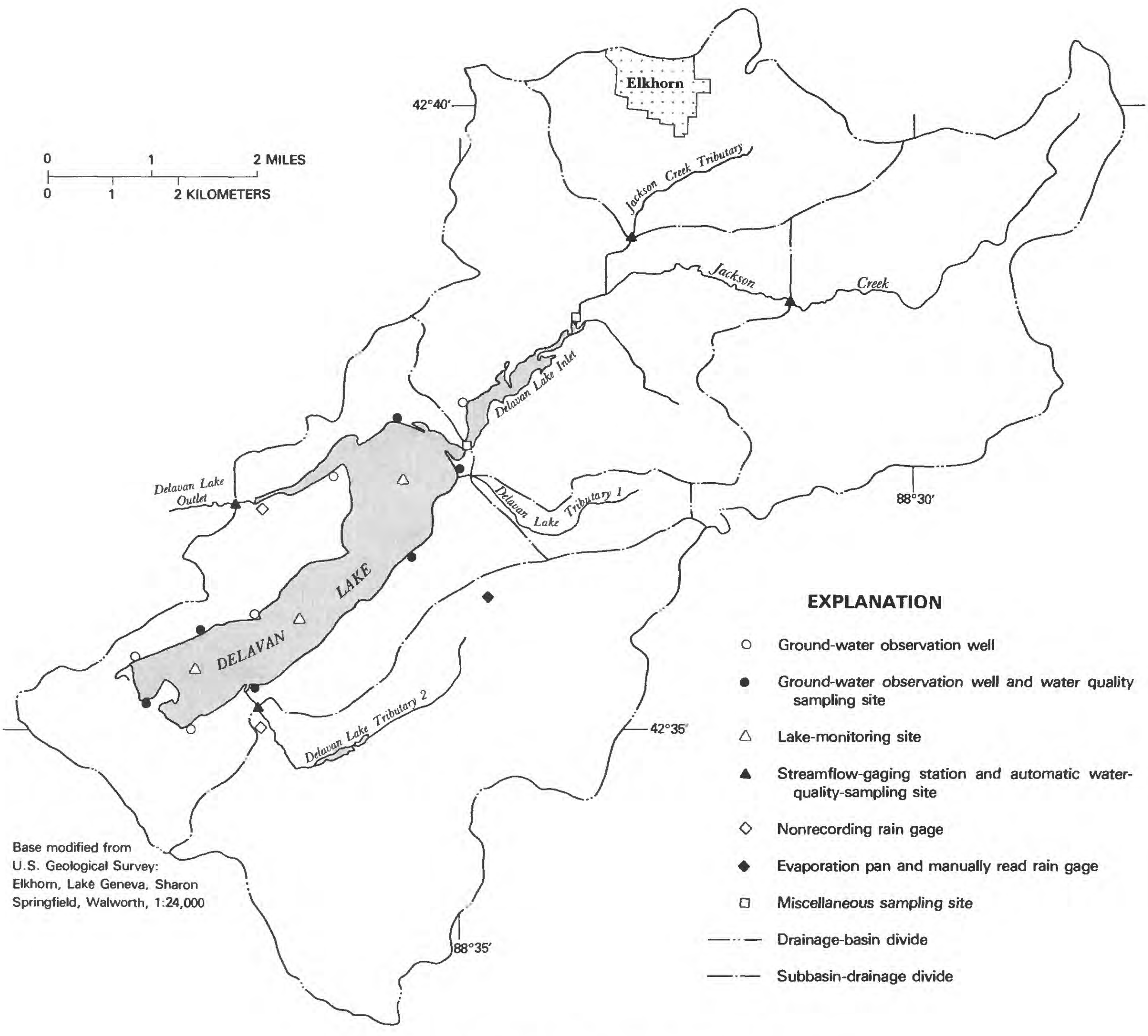


Figure 1. Delavan Lake drainage basin and monitoring sites.

Table 1. Characteristics of Delavan Lake

Parameter	Measurements	
Size		
Area of lake[1]	1,790 acres	2.8 mi^2
Area of total watershed	24,700 acres	38.6 mi^2
Volume	44,800 acre-ft	
Shape		
Maximum length of lake		3.9 mi
Length of shoreline		13.0 mi
Maximum width of lake		1.0 mi
Shoreline development factor[2]		2.19
Depth		
Area of lake less than 10 ft		29 percent
Area of lake 10 to 20 ft		14 percent
Area of lake 20 to 30 ft		15 percent
Area of lake 30 to 40 ft		17 percent
Area of lake 40 to 50 ft		22 percent
Area of lake more than 50 ft		3 percent
Mean		25 ft
Maximum		54 ft

[1]Area determined from U.S. Geological Survey topographic maps. This area does not include Delavan Lake inlet but does include the surface area of the lake to the dam outlet.

[2]The ratio of the length of the shoreline to the circumference of a circle equal to that of the lake (Wetzel, 1983).

Plano-Griswold (fig. 2). The Pella-Kendall-Elburn association consists of poorly drained and somewhat poorly drained soils that line a subsoil of silty clay loam. The Miami-McHenry association are well-drained soils that have a subsoil of clay loam and silty clay loam. The Plano-Griswold associations are well-drained soils that have a subsoil of silty clay loam and sandy clay loam.

Land Use

Agriculture is the principal land use in the Delavan Lake basin (table 2) (R. S. Grant, Southeastern Wisconsin Regional Planning Commission, written commun., 1985). The percentage of row crops, grain crops, and hay ranges from 50 percent in the shoreline drainage subbasin to 89 percent in the Jackson Creek subbasin (fig. 3). The percentage of woodland is low; 7 percent is the maximum amount in the Delavan Lake tributary No. 2 subbasin. Streets and highways are most dense in the Jackson Creek tributary basin (7 percent), which drains the city of Elkhorn. The largest amount of impervious area is found in the shoreline drainage around Delavan Lake (19 percent); the second largest amount (12 percent) is found in the Jackson Creek tributary subbasin. The largest amount of land used for retail, commercial, and manufacturing areas is found in the Jackson Creek tributary subbasin.

DATA COLLECTION AND METHODS OF ANALYSIS

Water-quality samples collected from Delavan Lake and its tributaries were analyzed by several means. Chemical analyses of water samples were performed by the U.S. Geological Survey central laboratory using standard analytical methods described by Fishman and Friedman (1985). Analyses for dissolved constituents were performed on samples that were filtered in the field through a .45 μm (micrometer) filter. Analyses for total or total recoverable constituents were performed on raw water samples. Preservation and shipment of samples followed standard protocols established by the laboratory. Suspended-sediment concentration analyses were performed by the U.S. Geological Survey sediment lab in Iowa City, Iowa.

STREAMFLOW

Water inflow to and outflow from the lake was measured at four locations (fig. 1). Inflow sites were Jackson Creek tributary near Elkhorn, Jackson Creek near Elkhorn, and Delavan Lake tributary 2 at South Shore Drive. The lake outflow was monitored 0.1 mi downstream from the dam.

At the major inflow site of Jackson Creek through Delavan Lake inlet at State Highway 50 it was not possible

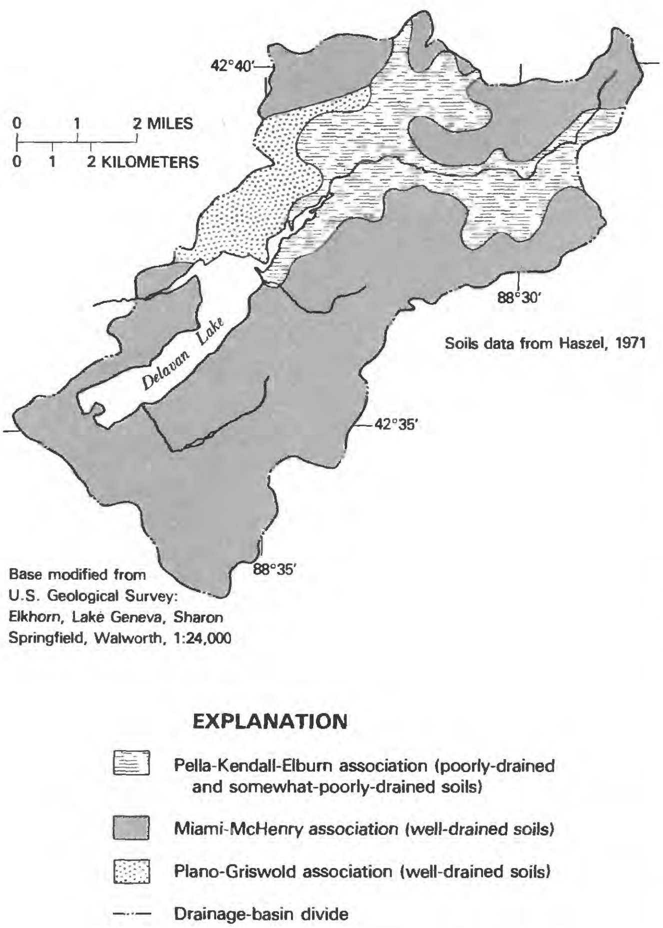


Figure 2. Soil associations.

to develop a stage-discharge relationship using conventional methods because of backwater from Delavan Lake. Discharge for this site was instead estimated by a drainage-area relationship with the upstream station of Jackson Creek near Elkhorn. The Jackson Creek near Elkhorn gaging station discharge was used because the land use in that basin is similar to that of the intervening area (see table 2).

Water samples were collected at all five sites for analysis of suspended-sediment concentration, and concentrations of nitrogen and phosphorus species. Three inflow stations were equipped with stage-activated, refrigerated, automatic Isco Model 1680[1] samplers to collect storm runoff samples. Flow-integrated samples were collected manually using the equal-width increment (EWI) method described by Guy and Norman (1970) at these and the other two sites. EWI samples collected at the times that samples were taken by the automatic samplers were used to develop coefficients to correct for concentration differences between point samples collected by the samplers and the more-representative flow-integrated samples. EWI samples were collected at low flow at all sites to estimate transport during low-flow periods. Nitrogen, phosphorus, and suspended-sediment loads at each monitoring station were computed using the integration method described by Porterfield (1972).

GROUND WATER

Thirteen shallow wells (average depth 10 ft) were drilled along the lakeshore for collection of quarterly water-level measurements and water samples for chemical analyses (fig. 1). Data were used to determine the direction of ground-water movement near the lake and to estimate the contribution of nutrients to the lake by ground water. Approximately 50 private wells in the basin also were used for quarterly water-level measurements to determine the direction of ground-water movement.

PRECIPITATION AND EVAPORATION

Precipitation quantity was monitored at three sites (fig. 1) during nonfreezing weather. Records from the National Weather Service station at Lake Geneva, 8 mi to the southeast, were used when these stations were not operating (U.S. Department of Commerce, 1983, 1984, and 1985). Precipitation samples for chemical analysis were collected from a bulk precipitation collector at the DLSD location during the 1985 water year. These data were used to estimate nutrient contribution to the lake from precipitation.

Evaporation from the lake's surface was estimated using data from an evaporation pan installed at the DLSD office (fig. 1). This was read daily by their personnel during ice-free periods.

LAKE SAMPLING

Chemical and Physical Characteristics

Three sites in the lake were sampled: one in the center of the lake at a depth of 54 ft, and the other two sites at a depth of 30 ft at each end of the lake (fig. 1). Water-quality samples were collected with an Alpha Type or Kemmerer sampler, monthly from November through March and twice a month from April through October. Discrete samples were collected 3 ft below the water surface and 2 ft above the lakebed. Two additional samples were collected at each site during thermal stratification. Samples were collected at the center site in mid-June, mid-July, and early September every 6 ft in the epilimnion and every 3 ft in the metalimnion and hypolimnion.

Depth profiles of water temperature, dissolved oxygen, and pH were determined at all three sites using the sampling frequency described above using an Ocean Data Equipment Corporation meter. The meter was calibrated with known standards prior to lake sampling; dissolved oxygen was calibrated by the Winkler calibration method.

Plankton

Samples for phytoplankton and zooplankton were collected monthly from November through March and twice

[1]Use of the trade names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

Table 2. Land use in Delavan Lake basin [1]
[Drainage subbasin (in percent of subbasin)]

Land use	Jackson Creek	Jackson Creek tributary	Delavan Lake inlet[2]	Delavan Lake tributary 2	Shoreline drainage	Delavan Lake tributary 1
Row crops	69	55	66	76	48	62
Grain crops	5	0	1	0	0	0
Hay	15	2	5	4	2	7
Woodland	3	0	4	4	1	7
Streets and highways	1	7	1	0	1	7
Residential impervious	0	12	3	2	19	8
Retail, commercial, utilities, manufacturing	0	7	2	1	0	1
Other	7	17	18	13	29	15
Subbasin total	100	100	100	100	100	100

[1]The data presented in this table were inventoried in 1975. In the other classification are: water, airfields, landfills and dumps, other recreational, and other open spaces.

[2]Intervening area--upstream of Highway 50 and downstream of Jackson Creek tributary gaging stations.

a month from April through October from the two ends of the lake (fig. 1). Samples for phytoplankton were collected from the upper 3-ft composite sample using a Kemmerer sampler and were preserved with 10 mL/L (milliliters per liter) of Lugols solution. These samples were sent to Susswasser, Jan Brockson, P.O. Box 1255, Paso Robles, Calif., 93447, who performed the analyses. Samples for zooplankton were collected by towing a Wisconsin Plankton net, mesh size 153 microns through the oxgenated zone; only a single haul per site was used. These samples were preserved with an equal volume of 5 percent formalin solution and were sent to the firm of Susswasser, which performed the analyses from October 7, 1983, to March 13, 1984, and to GZT Associates, 435 Mammoth Oaks Drive, Charlotte, N.C. 28226, for subsequent analyses.

Benthic Invertebrates

Benthic invertebrates were sampled in May and September during the 1984 and 1985 water years. Twelve sites in the lake were sampled (fig. 4) using a PONAR grab sampler; replicate samples were collected at most sites. Samples were preserved with an equal volume of 70 percent ethanol and identifications were made by Robert A. Lidwin, U.S. Geological Survey, Madison, Wisconsin.

BOTTOM SEDIMENTS

Bottom sediment cores were collected at the deep hole (54 ft deep) and in Delavan Lake inlet. Sediment cores were collected during winter using a freeze corer similar to one described by Walkotten (1976). The freeze corer is an aluminum tube approximately 5 ft long and 2 in. (inch) in diameter with a pointed lead plug at one end. The corer was weighted with lead and then filled with pelletized dry ice and ethanol. The corer was plugged at the top with a rubber stopper and dropped into the sediments. The corer remained in the sediment for approximately 5 minutes to allow the dry ice to freeze the sediment around the corer. The corer was raised to the surface and the frozen sediment around the outside of the corer was removed by emptying the dry ice from the tube and filling the tube with lake water. The water loosened the sediment around the tube until the sediment could slide over the end of the corer. The frozen sediment was wrapped in aluminum foil, labeled, and placed in a cooler with dry ice. The cores were then sliced with a steel band saw into individual cores for analyses.

The Delavan Lake inlet was surveyed to determine the depth of its soft sediment. The survey was conducted by applying the weight of one person [approximately 175 lb (pounds)] to a 1-in. diameter probe at 10 to 20 points in 21 cross sections.

HYDROLOGY

PRECIPITATION

Precipitation for the 1984 and 1985 water years is shown in table 3. Annual precipitation in the 1984 water year was

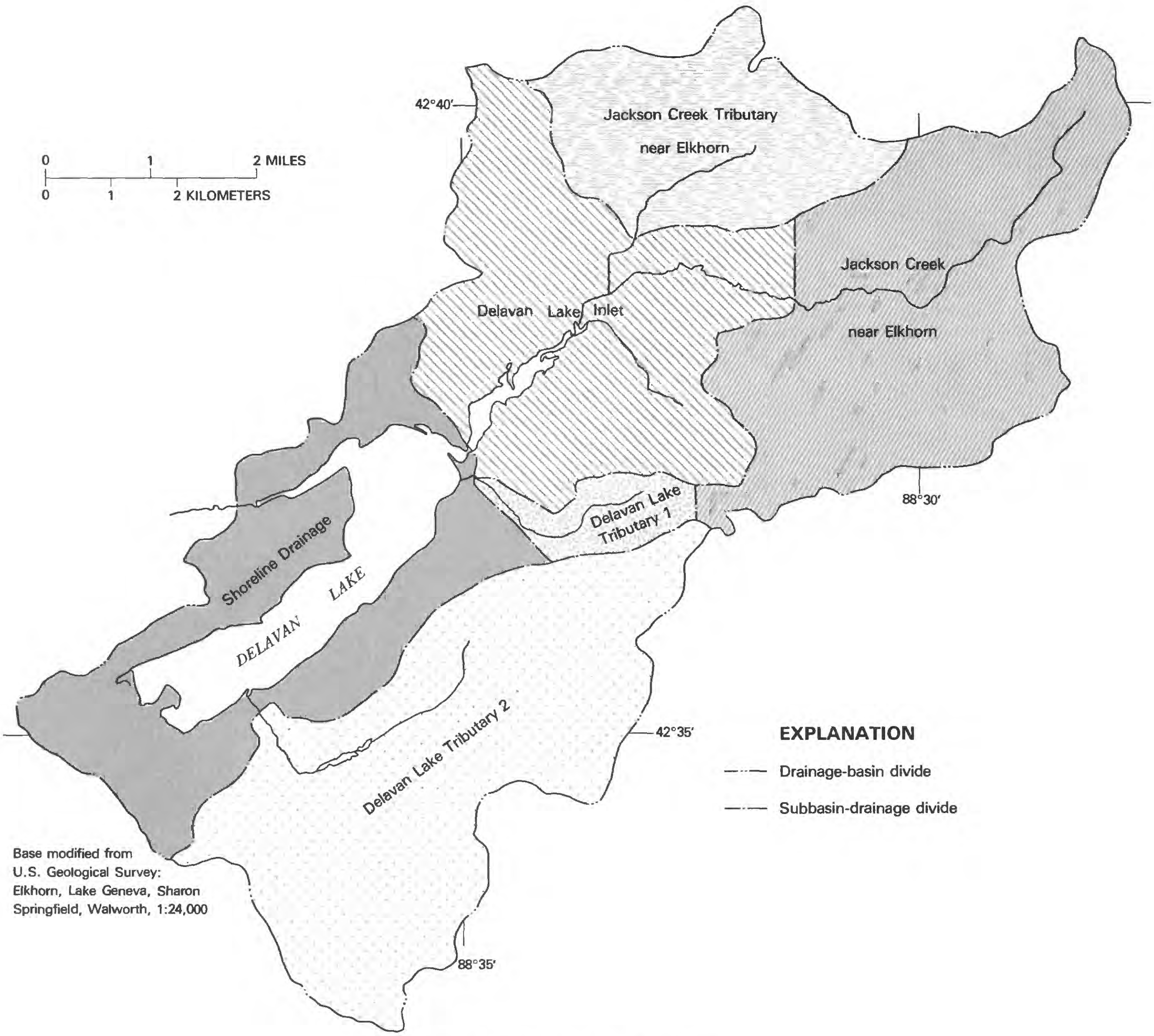


Figure 3. Delavan Lake subbasins.

32.0 in. and in the 1985 water year it was 38.9 in. based on data from the three nonrecording precipitation stations around the lake (fig. 1) during nonfreezing periods and the data from Lake Geneva during freezing periods. Average annual precipitation for Delavan Lake is 31.6 in. based on the long-term average from the National Weather Service station at Whitewater, 16 mi northwest of the lake.

EVAPORATION

Evaporation from the lake surface during the 1984 and 1985 water years was calculated as 27.45 and 32.98 in., based on evaporation pan data and the mass-transfer method (Dunne and Leopold, 1978; Winter, 1981). Monthly evaporation pan readings obtained by personnel from the sanitary district and evaporation pan data at the National Weather Service station located at Madison, 60 mi to the northwest of Delavan Lake, are shown in table 4. An annual pan coefficient of 0.77 was used to determine the evaporation from the lake surface (U.S. Department of Commerce, 1982). For those months (except October 1983) when evaporation pan data were unavailable, estimates were made using the mass-transfer method.

STREAMFLOW

Summaries of the streamflow characteristics for the Delavan Lake basin and Turtle Creek gaging stations are shown in table 5. Daily discharge data for these stations, excluding Delavan Lake inlet, are published in the U.S. Geological Survey annual data publication (Holmstrom and others, 1985, 1986).

The Turtle Creek gaging station is located 21 mi downstream from the Delavan Lake outlet. Its 45-year record was used to compare the streamflow data from the gaging stations in the Delavan Lake basin.

Table 3. Precipitation at Delavan Lake and Lake Geneva, 1984 and 1985 water years

	1984 water year		1985 water year	
	Delavan Lake	Lake Geneva	Delavan Lake	Lake Geneva
October	[1]3.31	3.31	6.37	5.51
November	2.96	3.73	3.72	3.55
December	[1]3.14	3.14	[1]3.16	3.16
January	[1]1.31	1.31	[1]2.52	2.52
February	[1]1.63	1.63	[1]1.67	1.67
March	1.28	2.12	[1]2.99	2.99
April	3.17	4.17	[1]1.38	1.38
May	4.85	5.09	3.22	3.29
June	3.78	3.36	1.85	2.49
July	2.14	2.86	5.08	5.57
August	1.15	1.37	3.72	3.20
September	3.29	4.30	3.19	2.94
	32.01	36.39	38.87	38.27

[1]Used Lake Geneva data.

Table 4. Evaporation data for Delavan Lake, 1984 and 1985 water years

	Evaporation pan data, 1984 water year (in inches)			Evaporation pan data, 1985 water year (in inches)		
	Delavan	Madison	Estimated[2]	Delavan	Madison	Estimated[2]
October	[1]2.52	2.77		3.35	2.14	
November			0.25			0.97
December			1.00			.43
January			.19			.54
February			.35			.39
March			.61			.65
April			.59	5.38		
May	3.42	5.62		7.30	8.67	
June	7.71	7.26		5.08	7.89	
July	7.38	7.31		8.42	8.61	
August	6.38	6.37		5.49	5.94	
September	4.36	5.02		3.94	3.78	
Total	31.77			38.96		
Pan coefficient	X 0.77			X 0.77		
Evaporation	24.46		2.99	30.00		2.98
Total annual evaporation	27.45			32.98		

[1]Estimate based on 9 percent reduction comparing Delavan evaporation pan data to Madison for those months when both months' data were available.

[2]Estimated using methods by Dunne and Leopold (1978) and Winter (1981).

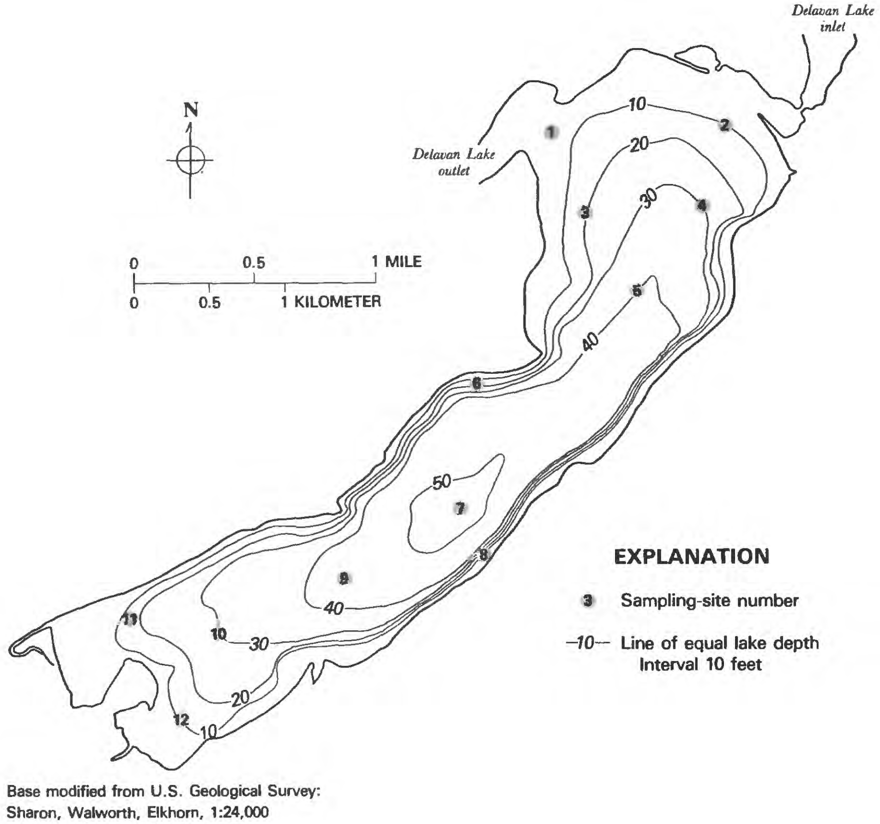


Figure 4. Bathymetric map of Delavan Lake showing benthic-macroinvertebrate sampling sites.

Table 5. Summary of streamflow characteristics for Delavan Lake basin and Turtle Creek at Clinton gaging stations

[mi^2, square miles; (ft^3/s)-d, cubic feet per second days; a dash indicates data unavailable]

Station name	Year	Drainage area (mi^2)	Total[1] discharge [(ft^3/s)-d]	Mean daily discharge (ft^3/s)	Maximum daily mean discharge (ft^3/s)	Maximum instantaneous discharge (ft^3/s)	Minimum daily mean discharge (ft^3/s)	Mean discharge [(ft^3/s)/mi^2]	Runoff (inches)
Jackson Creek	1984	8.96	1,600	4.36	135	177	0.07	0.49	6.62
	1985		1,600	4.39	80	103	.10	.49	6.66
Jackson Creek tributary	1984	4.34	1,100	2.99	56	108	.39	.69	9.40
	1985		1,500	4.11	60	129	.25	.95	12.9
Delavan Lake inlet	1984	21.8	4,230	11.6	310	--	.53	.53	7.23
	1985		4,630	12.7	216	--	.46	.58	7.91
Delavan Lake tributary 2	1984	9.99	597	1.63	17	18	.23	.21	2.90
	1985		509	1.40	15	22	.15	.18	2.47
Delavan Lake outlet	1984	42.1	7,690	21.0	128	134	.41	.53	7.19
	1985		9,050	24.8	88	163	.18	.62	8.47
Turtle Creek at Clinton	1984	199	54,200	148	1,110	1,190	62	.74	10.2
	1985		58,700	161	960	1,100	60	.81	11.1
Turtle Creek at Clinton	Period of record			122		16,500			8.33

[1]Total discharge is the sum of the daily mean discharges for the entire year.

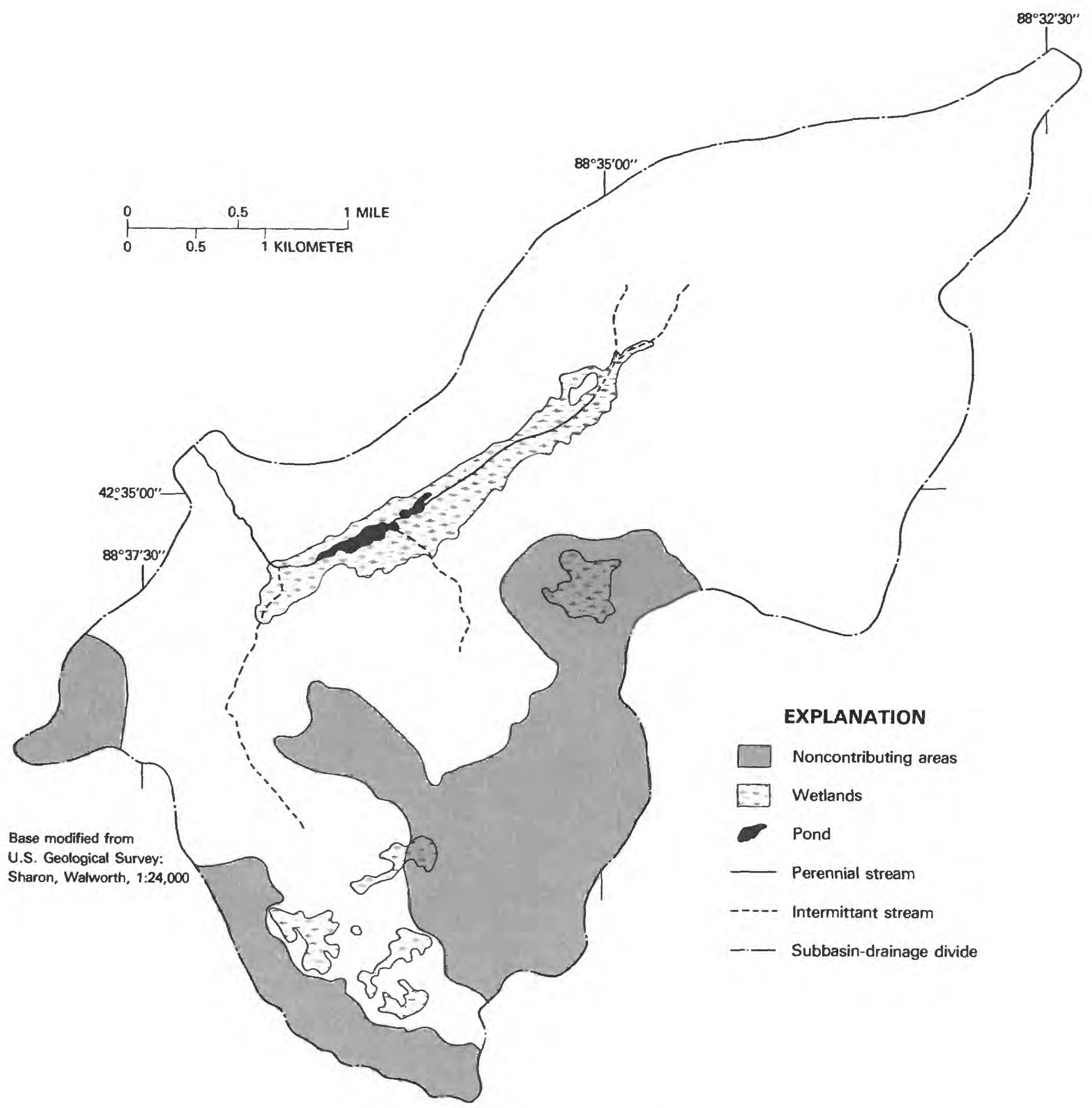


Figure 5. Delavan Lake tributary 2 basin.

Annual streamflow in the Delavan Lake basin, based on the Turtle Creek gaging station records for the 1984 water year, was 21 percent greater than average; in the 1985 water year it was 32 percent greater. The greater than average discharges in 1985 can be explained by the 7.2 in. greater than average precipitation and higher than average ground-water levels for the past several years (see fig. 9 in the section "Ground Water"). Greater than average precipitation can result in greater than average runoff. High ground-water levels increase the base flow of streams and thus increase the total streamflow for the year. These greater than normal ground-water levels may also have caused the above-normal stream discharges in the 1984 water year despite normal precipitation for the year.

Streamflow maximums for both years were not excessively high as indicated by the maximum instantaneous discharge at Turtle Creek shown in table 5. The mean annual flood for Turtle Creek is 2,160 ft^3/s (cubic feet per second) (Conger, 1981). The maximum instantaneous streamflow in the 1984 water year was about 50 percent of the mean annual flood calculated for this station whereas the 1985 water year maximum was only slightly greater than the mean annual flood.

It is important to note the amount of variation in runoff (table 5) between the various subbasins of the Delavan Lake basin. Runoff, in inches, indicates the depth of water that would cover a drainage area if all streamflow for a given time period were uniformly distributed. The average runoff for the Delavan Lake basin is 8.33 in. using the long-term average of the Turtle Creek gaging station record as an index. Runoff is lowest in the Delavan Lake tributary 2 basin, averaging 2.68 in. for the 2-year period and highest in the Jackson Creek tributary basin, averaging 11.1 in.

The low annual runoff from the Delavan Lake tributary 2 basin is indirectly caused by the basin's topography and vegetative cover. The southern part of the basin is end moraine material with a rolling to hummocky surface with several noncontributing areas (fig. 5). Noncontributing areas

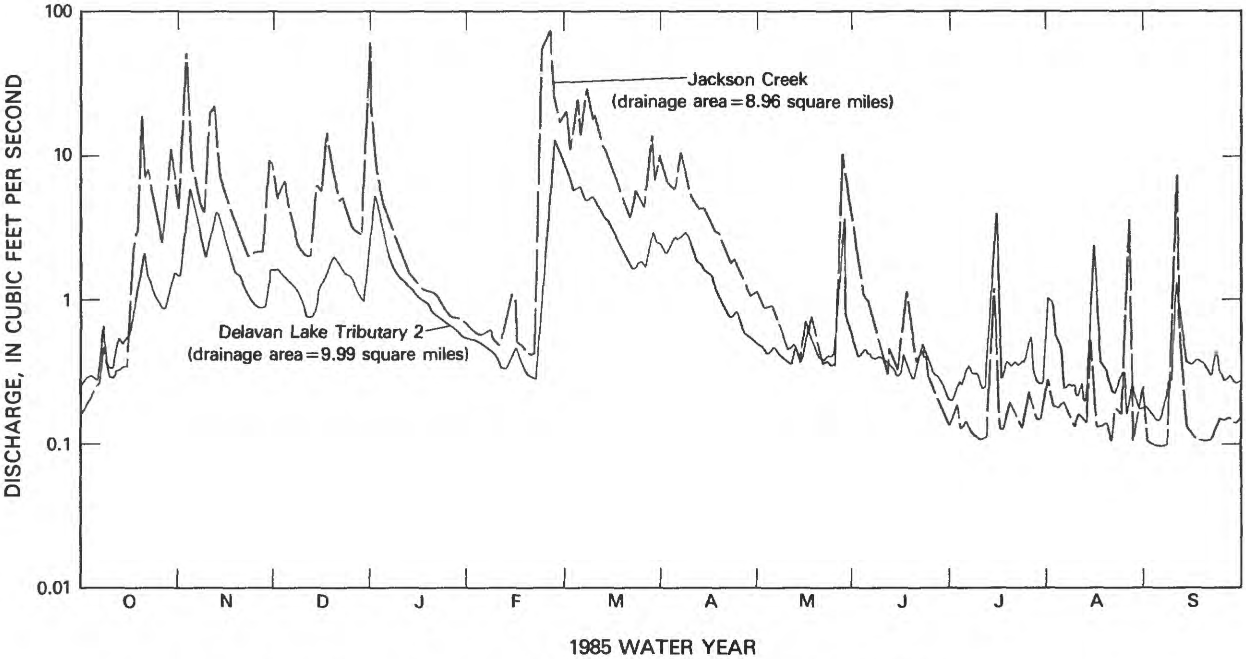


Figure 6. Discharge of Delavan Lake tributary 2 and Jackson Creek, 1985 water year.

are internally drained and do not contribute to surface runoff. Noncontributing areas in this basin compose 2.33 mi², or 23 percent of the basin. The basin also contains numerous wetland areas; a large wetland about 2 mi long and 0.25 mi wide near the downstream end of the basin drains most of the surface runoff. It is likely that much evapotranspiration occurs from these wetlands.

The effect of the topography and wetlands on the reduction in surface runoff is illustrated in figure 6 by comparing the 1985 water year hydrographs of Delavan Lake tributary 2 (drainage area = 9.99 mi²) and Jackson Creek (drainage area = 8.96 mi²). The Jackson Creek gaging station records much higher peak flows than that of the Delavan Lake tributary station.

The basin with the highest annual runoff is the Jackson Creek tributary basin. This basin drains the city of Elkhorn and contains the greatest percentage of streets and highways (7 percent) and impervious residential areas (12 percent) of the three inflow monitoring sites. These impervious areas cause greater runoff.

GROUND WATER

Occurrence

Ground water occurs in saturated sediment deposits that range in thickness from 100 ft in the northeastern part of the basin to 400 ft in the southwestern part of the basin (Borman, 1976). Depth to the water table varies from 0 to 10 ft near the wetlands and lakes to 125 ft below the hills.

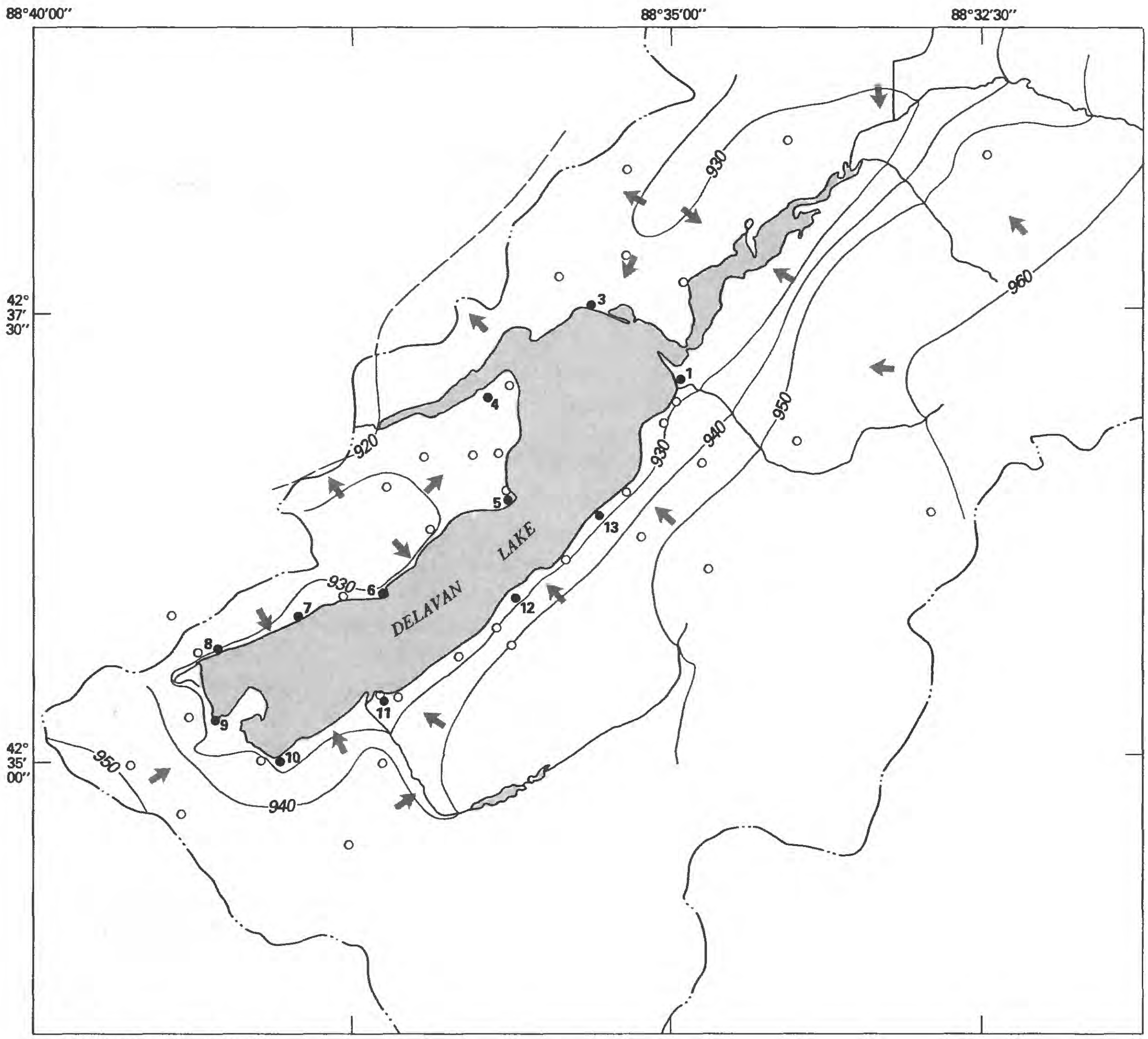
Movement

Ground water moves from areas of recharge to areas of discharge. The rate at which ground water is replenished depends on the amount and intensity of precipitation, the infiltration capacity of the soil, and the permeability of the underlying materials. The regional gradient of the ground-water table in the Delavan Lake basin, although complex, is generally from the southeast to northwest (fig. 7). The contour lines in figure 7 were drawn based on the data from the 13 ground-water sampling wells close to the lake and 50 private wells scattered throughout the basin.

The 13 shallow ground-water wells near the lake's edge were used to determine the direction of ground-water movement around Delavan Lake (fig. 7). The relationship between the water surface in these wells to the lake surface elevation is shown in figure 8. The datum for these wells and lake surface in the illustration is at 922.92 ft above mean sea level. Well numbers 1 and 7–11 all show generally positive gradients or ground-water movement toward Delavan Lake (fig. 8, upper graph). Water levels in some wells were at or below the lake surface (fig. 8, lower graph). Well number 5 is the only well that shows nearly consistent movement away from the lake. The water depths for well numbers 4 in April 1984 and 6 in November 1984 may be anomalous data.

Water-level fluctuations in wells in and near the Delavan Lake basin are shown in figure 9. Well number Ww-9 is located about 7 mi northwest of Delavan Lake and is a drilled artesian well in Galena dolomite of Silurian age 287 ft deep. Figure 9 shows that ground-water levels during the 2-year study period were above the normal for the 40-year long-term record. Water-level fluctuations in the wells in the Delavan Lake basin show about a 4-ft fluctuation during the 2-year study period.

Ground-water discharge to the lake was based on periods when the lake was ice covered and evaporation was minimal. Recharge to the ground-water system from the lake was considered negligible because most of the shallow ground-water



Base modified from U.S. Geological Survey: Elkhorn, Geneva, Sharon Springfield, Walworth, 1:24,000

0 0.5 1 MILE

0 0.5 1 KILOMETER

EXPLANATION

—930— Water-table contour—Shows altitude of water table on January 5 and 6, 1984. Contour interval 10 feet. Datum is sea level

(arrow) Direction of ground-water flow

●2 USGS observation well and number

○ Domestic observation well

—··— Drainage-basin divide

Figure 7. Generalized regional water-table configuration and ground-water movement.

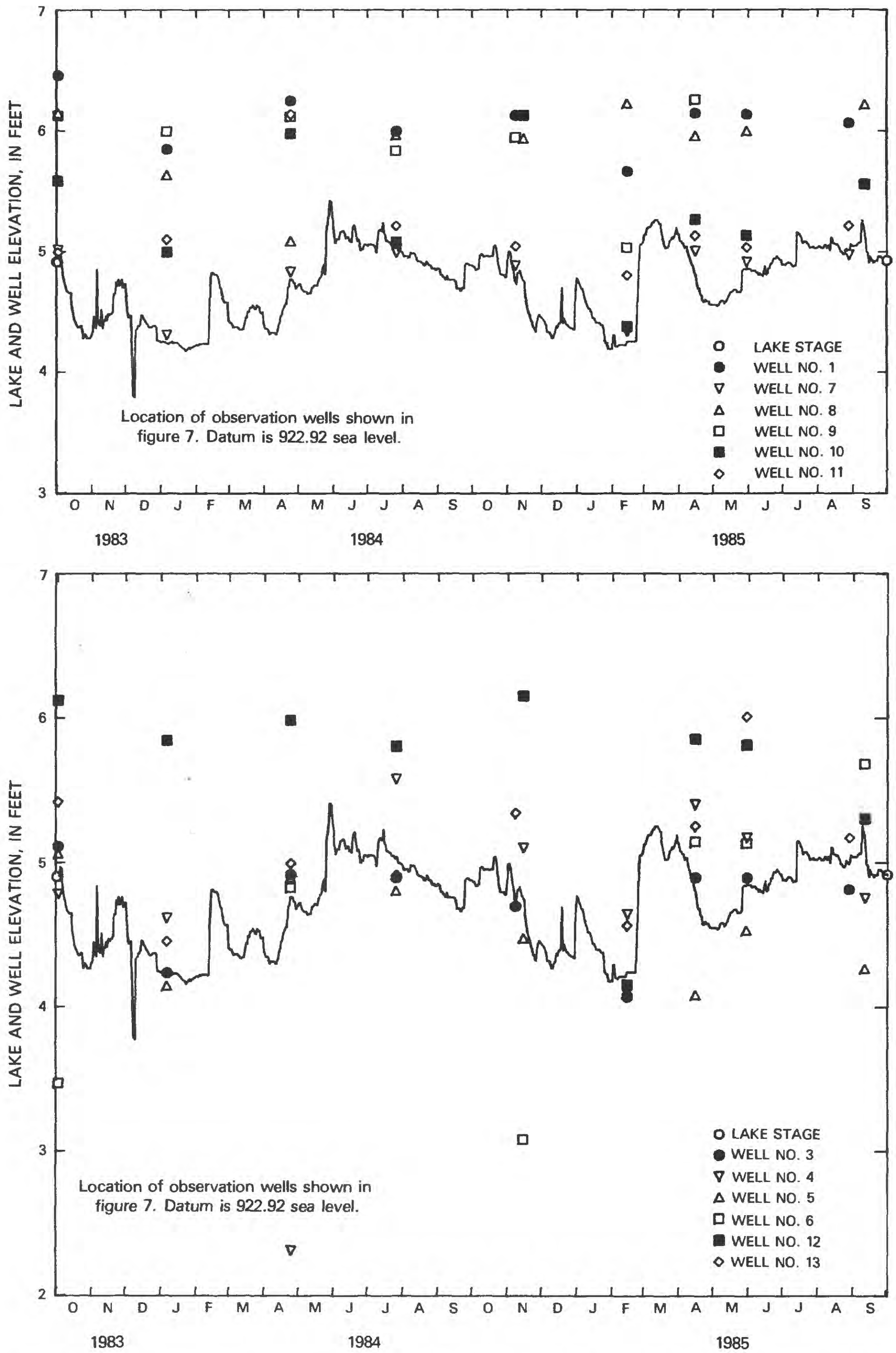


Figure 8. Relation between water level in wells within 10 feet of Delavan Lake's shoreline and the lake's water surface.

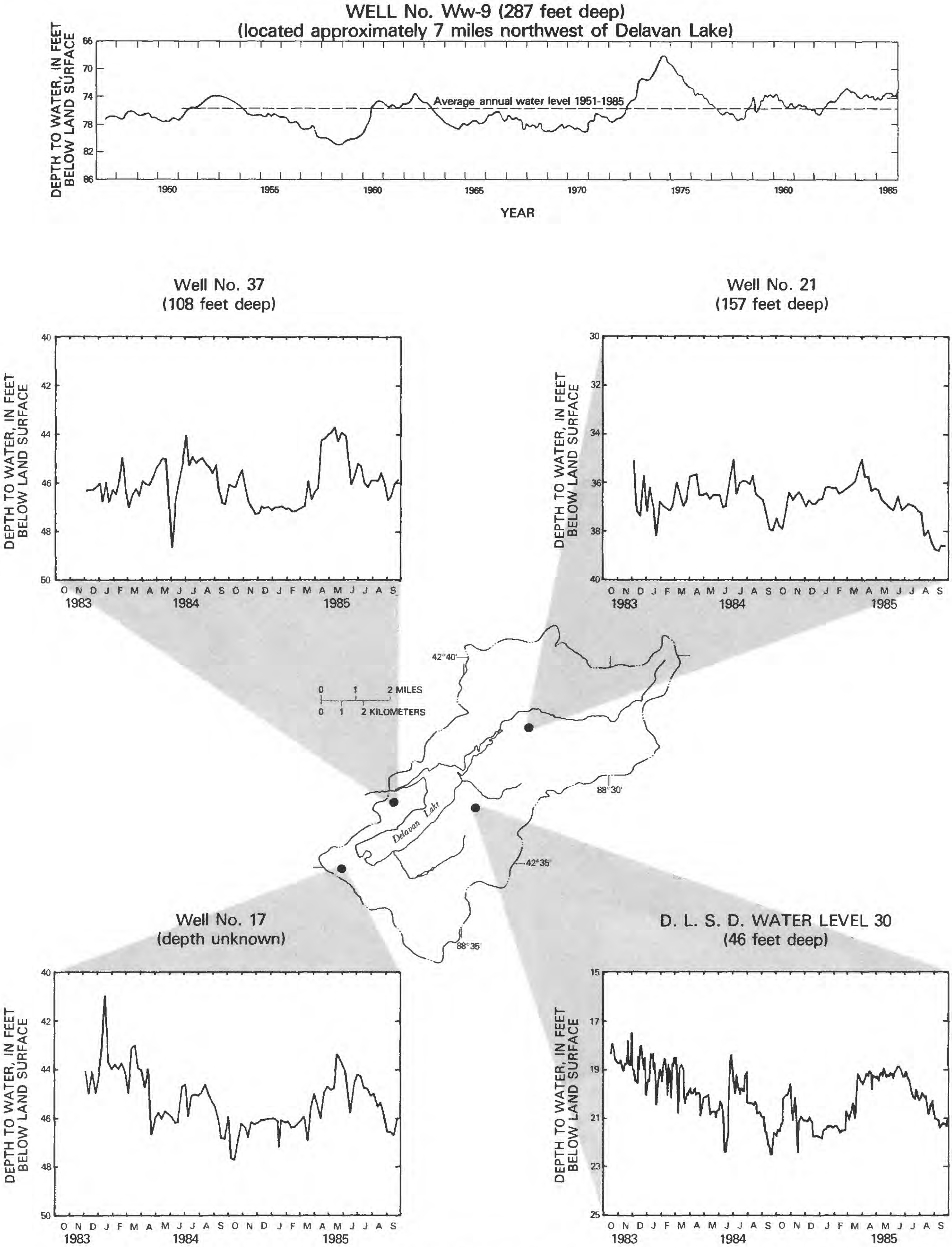


Figure 9. Water-level fluctuations in ground-water wells in and near Delavan Lake basin.

wells near the lake's edge show that ground water discharges to the lake.

Ground-water discharge to the lake was estimated using the following equation:

Ground-water discharge = change in lake storage − precipitation + (streamflow out − streamflow in)

Ground-water discharge to the lake in the 1984 water year was computed based on the period January 22 to February 8 and averaged 5.0 ft^3/s. In the 1985 water year it was computed based on the period February 1–8 and was averaged 7.9 ft^3/s. During these periods the streamflow was determined by streamflow measurements and discharge records at the gaging stations.

LAKE STAGE

Water-level fluctuations of lake stage were shown previously in figure 8; the datum of the gage is 922.92 ft above sea level. Minimum levels occur in late fall or early winter when water levels are drawn down to prevent ice damage to shoreline structures during winter. Drawdown of the lake level is started about October and the lake is raised to pre-October levels starting in May (K. L. MacKinnon, DLSD, oral commun., 1985). In the 1984 water year the lake stage minimum was 3.78 ft on December 9; in 1985 water year it was 4.18 ft January 29–31 (table 6). The maximum lake stage in 1984 water year was 5.42 ft on May 29; in the 1985 water year it was 5.26 ft on March 11–13.

HYDROLOGIC BUDGET

The annual hydrologic budget for Delavan Lake is conceptualized as follows:

change in storage = inflow − outflow

The budget can be rewritten as

change in storage − inflow + outflow = 0

The various terms considered are:

$$\text{Change in storage} = \Delta S$$
$$\text{Inflow} = P + Qi + G$$
$$\text{Outflow} = Qo + E$$

where

ΔS = change in volume of stored water,

P = volume of precipitation falling directly on the lake, in acre-feet,

Qi = surface-water inflow, in acre-feet,

Qo = surface-water outflow, in acre-feet,

G = net ground-water flow, in acre-feet, and

E = volume of water evaporation from the lake, in acre-feet.

Therefore the hydrologic budget for Delavan Lake is written as

$$\Delta S - P - Qi - G + Qo + E = 0$$

A water budget was calculated for the 1984 and 1985 water years using the data collected at the monitoring network previously described. Each term in the hydrologic budget was either measured or estimated. The budgets are shown in table 7. An estimate of runoff from the unmonitored area was made because the streamflow gaging stations do not monitor the total surface-water inflow to Delavan Lake. The larger of the unmonitored areas (5.78 mi^2)—the shoreline drainage that drains directly into Delavan Lake—is an urban area and runoff was calculated using the runoff from Jackson Creek tributary, also an urban area. The runoff yield from Jackson Creek basin was used to calculate runoff for Delavan Lake tributary 1 basin because the basins' land use and topography are similar.

Measurement and interpretation errors are associated with each term in the hydrologic budget equation. To aid in evaluating these errors, the hydrologic budget can be written as:

$$\Delta S - P - Qi - G + Qo + E - r = 0$$

where r is a net residual term. Rewriting the hydrologic budget in terms of the net residual (r) results in

$$r = \Delta S - (P + Qi + G) + (Qo + E)$$

The net residual associated with the 1984 water year was 5 percent of the total inflow to the lake and in the 1985 water year it was 9 percent. Errors associated with individual components may be greater than or less than these figures; the net residual term is simply a reflection of the overall integrity of the hydrologic budget.

The hydrologic budget shows that streamflow is the dominant component of the input budget; streamflow composes 59 percent and 54 percent, respectively, of the 1984 and 1985 water years' budgets. Precipitation is the next largest component (23 percent). Ground water is the smallest component; it composes 18 percent and 23 percent of the hydrologic budget for the 1984 and 1985 water years.

Streamflow also dominates the losses in the hydrologic budget; it comprises 78 percent for both water years. Evapotranspiration from the lake's surface makes up the remainder of the loss (22 percent).

HYDRAULIC RESIDENCE TIME

The hydraulic residence time for Delavan Lake is the time period required for the full volume of the lake, 44,806 acre-ft (acre-feet), to be replaced by inflowing waters. This is important for determining the expected response time of the lake to increased or reduced nutrient loadings. The smaller the lake volume and/or greater streamflow input, the shorter the residence time. Based on the hydrologic budget of total inflow to Delavan Lake of 20,288 acre-ft for the 1984 water year and 24,913 acre-ft for the 1985 water year, the calculated hydraulic residence times were 2.2 years and 1.80 years, respectively. However, these calculations were based on the assumption that the lake mixes completely, which is not the situation in Delavan Lake because of short circuiting (discussed in the section "Nutrient and Sediment Sources and Loading"). The true hydraulic residence time is likely greater than these calculated values. In comparison, Fowler Lake in Waukesha County in 1984, which has a small volume and a large streamflow input, had a hydrologic residence time of 7 days (P. E. Hughes, U.S. Geological Survey, written commun., 1986).

WATER QUALITY

PHYSICAL AND CHEMICAL CHARACTERISTICS OF THE LAKE WATER COLUMN

The characteristics of water allow for the formation of a stratified environment that controls the chemical and biological properties of lakes. Water temperature and

Table 6. Lake stage of Delavan Lake, 1984 and 1985 water years
[A dash indicates data unavailable; gage height in feet above datum of 922.92 feet]

	Mean Values											
DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	1984 Water Year (October 1983 - September 1984)											
1	---	4.31	4.73	4.24	4.22	4.41	4.38	4.72	5.24	5.04	4.97	4.86
2	4.91	4.33	4.63	4.24	4.22	4.40	4.35	4.73	5.12	5.06	4.95	4.85
3	4.92	4.46	4.50	4.25	4.21	4.40	4.35	4.73	5.06	5.05	4.96	4.84
4	4.98	4.38	4.44	4.24	4.23	4.38	4.35	4.68	5.10	5.06	4.96	4.80
5	4.96	4.35	4.46	4.24	4.22	4.36	4.33	4.67	5.10	5.05	4.96	4.80
6	---	4.85	4.46	4.23	4.23	4.37	4.30	4.66	5.10	5.05	4.94	4.78
7	4.79	4.40	4.18	4.23	---	4.37	4.32	4.66	5.16	5.04	4.95	4.78
8	---	4.38	3.80	4.22	4.23	4.37	4.32	4.66	5.16	5.02	4.99	4.76
9	---	4.38	3.78	4.24	4.23	4.36	4.32	4.64	5.17	4.98	4.98	4.80
10	4.67	4.52	4.34	4.24	4.23	4.35	4.32	4.65	5.17	5.09	4.98	4.76
11	---	4.35	4.35	4.25	4.22	4.34	4.30	4.65	5.14	5.17	4.98	4.76
12	4.65	4.42	4.38	4.23	4.23	4.34	4.30	4.65	5.10	5.18	4.96	4.76
13	4.65	4.42	4.38	4.24	4.56	4.35	4.34	4.70	5.12	5.16	4.94	4.76
14	4.65	4.46	4.40	4.24	4.78	4.35	4.39	4.70	5.12	5.16	4.92	4.76
15	4.52	4.42	4.47	4.24	4.82	4.40	4.42	4.72	5.08	5.24	4.91	4.76
16	4.48	4.48	4.46	4.23	4.82	4.45	4.46	4.72	5.08	5.14	4.91	4.75
17	4.42	4.46	4.43	4.22	4.80	4.44	4.48	4.71	5.07	5.12	4.91	4.74
18	4.40	4.48	4.42	4.21	4.80	4.50	4.52	4.71	5.20	5.08	4.90	4.68
19	4.38	4.48	4.40	4.20	4.80	4.49	4.54	4.76	5.22	5.08	4.90	4.69
20	4.36	4.50	4.39	4.19	4.78	4.53	4.56	4.78	5.20	5.07	4.88	4.69
21	4.36	4.65	4.37	---	4.75	4.53	4.56	4.79	5.14	5.07	4.88	4.66
22	4.38	4.65	4.36	4.18	4.70	4.55	4.70	4.82	5.08	5.05	4.92	4.69
23	4.38	4.75	4.36	4.16	4.68	4.53	4.71	4.86	5.10	5.05	4.90	4.70
24	4.33	4.71	4.37	4.18	4.64	4.51	4.77	4.89	5.06	5.05	4.88	4.69
25	4.27	4.77	4.38	4.19	4.60	4.51	4.77	4.80	5.00	5.03	4.88	4.89
26	4.31	4.71	4.38	4.20	4.57	4.55	4.76	5.15	5.02	5.05	4.88	4.90
27	4.29	4.73	4.38	4.18	4.57	4.53	4.73	5.22	5.02	5.04	4.85	4.90
28	4.27	4.77	4.36	4.20	4.57	4.53	4.73	5.29	5.06	5.00	4.85	4.89
29	4.27	4.69	4.25	4.20	4.57	4.48	4.68	5.42	5.06	5.00	4.86	4.88
30	4.27	4.73	4.25	4.21	---	4.48	---	5.40	5.05	---	4.84	4.88
31	4.27	---	4.25	4.21	---	4.49	---	5.30	---	4.99	4.84	---

dissolved oxygen are two properties that will be discussed in detail and pH will be discussed briefly. Water temperatures, dissolved oxygen, and pH profiles for the center site are shown in figures 10 and 11. The other two sites at the opposite ends of the lake are not shown but the data are available at the U.S. Geological Survey office in Madison, Wis.

Water Temperature

Many climatic factors affect the water temperatures throughout Delavan Lake. Complete mixing of the lake is restricted by thermal stratification in the summer and by ice cover in the winter. Thermal stratification of lake water is a result of differential heating, water-temperature density, and wind-driven mixing. Water is unique among liquids because it reaches its maximum density (weight per unit volume) at about 4° C.

As summer begins, the lake surface absorbs the sun's energy and the upper layer of water is heated. Wind action and, to some extent, internal heat transfer transmit this energy to underlying water. A density "barrier" begins to form between the warmer surface water and the lower, heavier, colder water. This barrier is marked by a sharp temperature

Table 6. Lake stage of Delavan Lake, 1984 and 1985 water years—Continued

[a dash indicates data unavailable; gage height in feet above datum of 922.92 feet]

	Mean Values											
DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	1985 Water Year (October 1984 - September 1985)											
1	4.88	4.88	---	4.78	4.18	5.10	5.14	4.55	4.85	4.88	5.03	5.04
2	4.87	5.00	---	---	4.30	5.14	5.08	4.55	4.85	4.89	5.04	5.04
3	4.87	5.00	4.42	---	4.30	5.14	5.08	---	4.85	4.88	5.04	5.04
4	4.84	4.96	4.40	---	4.20	5.18	5.06	4.55	4.83	4.88	5.02	5.04
5	4.84	4.90	4.38	4.68	4.20	5.20	5.06	4.54	4.84	4.90	5.02	5.06
6	4.85	4.86	4.32	4.68	4.20	5.20	5.02	4.55	4.84	4.91	5.02	5.07
7	4.86	4.81	4.32	4.64	4.22	5.20	5.04	4.58	4.84	4.90	5.05	5.07
8	4.97	4.74	4.32	4.60	4.22	5.22	5.04	4.59	4.82	4.90	5.05	5.08
9	4.98	4.72	4.30	4.57	4.22	5.24	4.98	4.59	4.82	4.89	5.02	5.26
10	4.97	4.82	4.27	4.55	4.22	5.24	4.95	4.58	4.80	4.87	5.05	5.22
11	4.95	4.82	4.27	4.52	4.22	5.26	4.92	4.56	4.82	4.87	5.04	5.18
12	4.96	4.84	4.31	4.52	4.22	5.26	4.90	4.58	4.80	4.88	5.00	5.10
13	4.96	4.80	4.33	4.50	4.22	5.26	4.88	4.60	4.80	4.88	5.12	4.99
14	4.96	4.77	4.38	4.48	4.25	5.24	4.86	4.62	4.79	5.16	5.10	4.98
15	4.96	4.75	4.36	4.44	4.25	5.22	4.81	4.64	4.84	5.15	5.06	4.90
16	4.95	4.74	4.40	4.44	4.25	5.22	4.80	4.66	4.88	5.14	5.06	4.96
17	4.96	4.62	4.40	4.42	4.25	5.14	4.73	4.66	4.80	5.12	5.05	4.92
18	4.96	4.58	4.42	4.40	4.25	5.10	4.68	4.67	4.82	5.10	5.06	4.92
19	4.96	4.52	4.70	4.40	4.25	5.05	4.69	4.68	4.86	5.06	---	4.90
20	5.04	4.48	4.39	4.40	4.25	5.02	4.64	4.68	4.86	5.08	5.02	4.92
21	5.05	4.46	4.44	4.40	4.25	5.03	4.62	4.68	4.90	5.08	4.99	4.92
22	5.02	4.42	4.40	4.38	4.25	5.03	4.58	4.65	4.90	5.08	4.99	4.92
23	4.96	4.40	4.38	4.38	4.44	5.05	4.57	4.66	4.94	5.06	4.97	4.96
24	4.90	4.36	4.38	4.38	4.71	5.09	4.60	4.66	4.94	5.05	4.97	4.95
25	4.85	4.35	4.36	---	4.99	5.10	4.58	4.66	4.94	5.02	4.99	4.96
26	4.80	4.32	4.36	4.24	5.06	5.12	4.58	4.68	4.96	5.03	5.02	4.94
27	4.80	4.40	4.35	4.23	5.06	5.10	4.58	4.84	4.94	5.03	5.00	4.94
28	4.80	4.45	4.35	4.23	5.07	5.13	4.56	4.85	4.93	5.04	4.99	4.92
29	4.80	4.47	4.34	4.18	---	5.15	4.55	4.85	4.92	5.02	5.01	4.92
30	4.78	4.45	4.34	4.18	---	5.20	4.55	4.85	4.92	5.02	5.06	4.92
31	4.78	---	4.68	4.18	---	5.14	---	4.86	---	5.02	5.04	---

gradient known as the thermocline or metalimnion; it separates the warmer, less dense, upper layer of water called the epilimnion, from the cooler, more dense, lower layer called the hypolimnion. Once stratification begins the temperature of the hypolimnetic water changes little throughout the summer stratification period.

Delavan Lake is only weakly, thermally, stratified throughout the summer stratification period (fig. 10). This thermocline is not a barrier to fish migration but it inhibits the exchange of water between the two layers and has a great impact on both the chemical and biological activity in the lake. The development of the thermocline begins in early summer, reaches its maximum in late summer, and disappears in the fall (fig. 10). This stratification period lasts until the fall, when air temperatures cool the surface water and wind action results in the erosion of the thermocline.

As water cools, it becomes more dense, sinking and displacing the warmer water below. The colder water sinks and mixes because of wind action until the entire column of water is a uniform temperature. This lake season, which follows summer stratification, is known as fall turnover. When the water temperature drops below 4° C, the water again becomes less dense and "floats" near the surface. Eventually the surface of the water is cooled until at 0° C ice forms and covers the surface of the lake, isolating the lake's liquid water from the atmosphere for 3 to 4 months. During the study period, ice cover existed from December 19, 1983, through April 4, 1984, and from January 4 to March 27, 1985.

Winter stratification occurs as the colder, less dense water and ice remain at the surface, again separated from the relatively warmer, more dense water near the bottom of the lake. Spring brings a reversal to the process. As the ice thaws and the upper layer of water warms, it becomes denser and begins to approach the temperature of the warmer, deeper water until the entire water column reaches the same temperature. This lake season, which follows winter stratification, is referred to as spring turnover and usually

Table 7. Hydrologic budget for Delavan Lake, 1984 and 1985 water years

	1984 water year		1985 water year	
	Total cubic feet per second days	Acre-feet	Total cubic feet per second days	Acre-feet
Inputs				
Delavan Lake inlet	4,215	8,360	4,628	9,180
Delavan Lake tributary	597	1,184	509	1,010
Delavan Lake tributary 1	190	378	191	380
Shoreline drainage around Delavan Lake	1,026	2,035	1,421	2,819
Total surface runoff	6,028	11,957	6,749	13,389
Precipitation on lake surface	2,376	4,713	2,926	5,804
Net ground water (estimated)	1,824	3,618	2,884	5,720
Total inputs	10,228	20,288	12,559	24,913
Losses				
Delavan Lake outlet[1]	7,575	15,025	8,938	17,728
Evaporation	2,067	4,100	2,483	4,925
Lake volume increase	36	71	36	71
Total losses	9,678	19,196	11,457	22,724

[1]Adjusted for 0.65 mi^2 between dam outlet and gaging station using runoff yield from Jackson Creek.

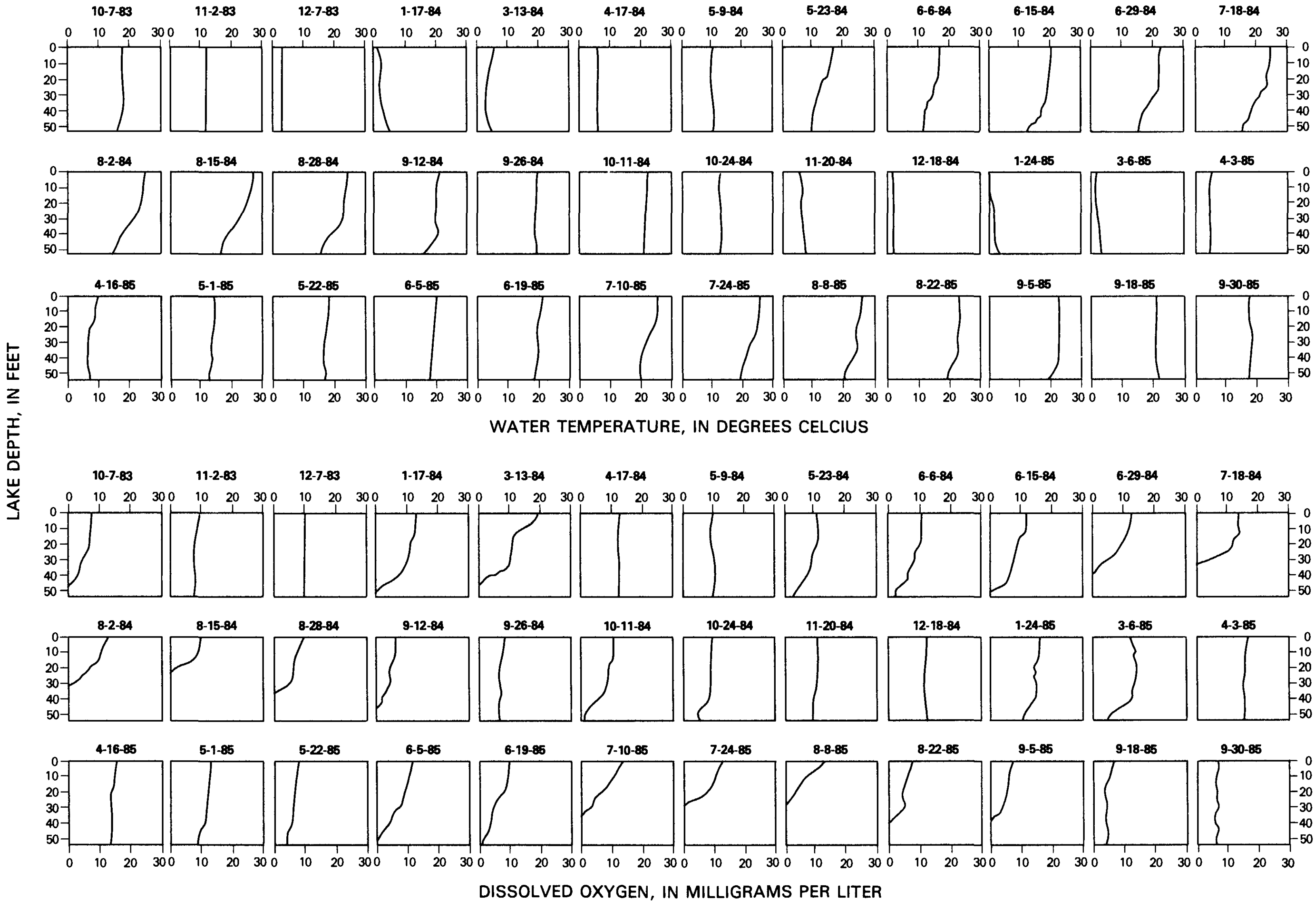


Figure 10. Depth profiles of water temperature and dissolved oxygen in Delavan Lake, 1984 and 1985 water years.

occurs within weeks after the ice melts. After this period, the water at the surface warms, again becoming less dense, and floats above the colder water. Wind and resulting waves carry some of the energy of the warmer, lighter water to lower depths, but only to a limited extent. Thus begins the formation of the thermocline and another summer thermal stratification.

Dissolved Oxygen

Dissolved-oxygen levels are one of the most critical factors affecting a lake ecosystem and they are essential to the metabolism of all aquatic organisms that require oxygen. Dissolved-oxygen depth profiles at the center site monitored in Delavan Lake are shown in figure 10. Anoxia (no dissolved oxygen) occurred in the bottom waters in the winter of 1984 (fig. 10). Oxygen was present throughout the entire water column during the winter of 1985. Dissolved-oxygen levels were adequate for the support of fish throughout the winter for depths less than 40 ft (fig. 10).

In early summer, as the thermocline develops, the upper, warmer layer (epilimnion) cuts off the surface supply of dissolved oxygen to the lower, colder layer (hypolimnion). The hypolimnion thus becomes isolated from the atmosphere. Large populations of planktonic algae are produced because the waters of Delavan Lake are nutrient-rich. These organisms die, fall to the bottom of the lake, and decompose. A large oxygen demand from this decaying material depletes the oxygen content of the water beginning at the lake bottom. The oxygen depletion then progresses upward and, because Delavan Lake is only weakly stratified, migrates through the metalimnion to the top of the thermocline by mid-summer.

Anoxia during summer stratification was first noted in 1984 on June 15. The zone reached a maximum by August 15 when depths greater than 23 ft were devoid of oxygen. Anoxia was last noted on September 12. Fall turnover was noted on September 26 and oxygen was circulated throughout the entire lake. Anoxia was estimated to have lasted 102 days, from June 10 to September 20.

Summer anoxia was first noted in 1985 on July 10, reached a maximum zone from July 24 to August 8 when depths greater than 27 ft were anoxic, and was last noted on September 5. Fall turnover was noted on September 18. Anoxia was estimated to have lasted 81 days, from June 25 to September 14.

These anoxic conditions are typical of eutrophic lakes and anoxia, in varying degrees, is common in many of the eutrophic lakes in southeastern Wisconsin. However, when oxygen does disappear from the bottom water, oxygen-reducing processes can cause phosphorus (if in large enough quantities in the lake sediments) to be released from the bottom sediments.

Delavan Lake has been treated with copper sulfate to kill algae and it is important to realize the ramifications of this treatment. Dissolved oxygen levels in lakes have been shown to be severely depressed after copper sulfate application (Hanson, 1981; Whitaker and others, 1978). A copper sulfate treatment killed a large quantity of algae in Budd Lake on June 29, 1978. The decomposition of these algal cells utilized large quantities of oxygen during the breakdown process. Dissolved-oxygen concentrations at the top of the lake dropped from 15 mg/L (milligrams per liter) to less than 4 mg/L during a 4-day period.

No effort was made during the study of Delavan Lake to continuously monitor the effects of declining oxygen concentrations due to the oxygen demand from decomposing algal cells killed by the chelated copper application. Chelated copper was applied to Delavan Lake 14 times from June through September during 1984; it was applied 14 times from June through August during 1985 (K. L. MacKinnon, DLSD, written commun., 1985). The cumulative copper chelate applications during 1984 amounted to 915 gal (gallon); 508 gal were applied during 1985.

pH

The photosynthetic and respiration processes of planktonic (free-floating) algae can have a significant effect on the pH of waters. These plants give off oxygen and consume carbon dioxide as they photosynthesize during daytime; they consume oxygen and give off carbon dioxide when they respire at night. When carbon-dioxide concentrations decrease, pH increases; when carbon-dioxide concentrations increase, pH decreases.

The large phytoplankton population in Delavan Lake uses much of the available carbon dioxide as they photosynthesize during the daytime and thereby cause the water near the lake surface to become highly alkaline, at times in excess of a pH of 9.0 (fig. 11). Natural water that has pH above 9.0 is unusual (Hem, 1985). However, because there are no living phytoplankton cells near the lake bottom, photosynthesis does not take place and a nearly neutral pH is maintained near the lake bottom during summer stratification.

Nutrient and Chemical Analyses

SPRING TURNOVER

The water mixes throughout the entire lake when spring turnover occurs. Concentrations of many constituents are most uniform at that time. Spring water-chemistry samples collected April 17, 1984, and April 3, 1985, are shown in table 8. Delavan Lake is a hard water, calcareous, eutrophic lake with alkalinity values averaging 181 mg/L as calcium carbonate (table 8). Total phosphorus concentrations are very large; the mean concentration was 0.143 mg/L as phosphorus on April 17, 1984 and 0.138 mg/L as phosphorus on April 3, 1985. These concentrations are seven times greater than 0.02 mg/L, or the level where the eutrophic classification begins (Gerloff, G.C., University of Wisconsin, written commun., 1984; Wisconsin Department of Natural Resources, 1981 and 1983).

PHOSPHORUS

The general environmental requirements for the growth of green plants, including algae, are: light, water, essential minerals, suitable temperatures, oxygen, absence of toxic conditions, vitamins, ammino acids, and energy (Gerloff, G.C., University of Wisconsin, written commun., 1984). Phosphorus and nitrogen, two of the essential minerals, when in abundant supply can cause excessive algal blooms. Phosphorus is generally the nutrient that limits biological productivity (Wetzel, 1983). Nitrogen, however, often becomes the nutrient limiting plant growth as phosphorus loading to fresh waters increases. Excessive loading of these nutrients permits increased plant growth until other nutrients or light availability become the limiting growth factors.

Phosphorus concentrations have substantially increased in Delavan Lake since 1943 (Limnetics, Incorporated, 1969) (fig. 12). Much of this increase was likely due to high phosphorus loading from sewage effluent (see "Background"). A lake is classified eutrophic[2] when surface phosphorus concentrations exceed 0.02 mg/L (20 μg/L) of total phosphorus (Gerloff, G.C., University of Wisconsin, written commun., 1984; Wisconsin Department of Natural Resources, 1981 and 1983). Figure 13 shows that monthly average concentrations at the surface of the lake are well above this threshold.

Large fluctuations in the average in-lake total phosphorus concentrations occurred during the 2-year study period. A maximum of 0.184 mg/L was calculated on January 17, 1984; a minimum of 0.054 mg/L was calculated on May 1, 1985.

Phosphorus fluctuations at the bottom and top of Delavan Lake are shown in figures 13 and 14. Concentrations fluctuate significantly. The large increase in concentration at the bottom of the lake is primarily due to the large amounts of phosphorus that are released during anoxic periods from the sediments that are high in phosphorus. The chemical analyses of a sediment core collected August 1, 1984, at the center of the lake (54 ft depth) are shown in table 9 and reveal high phosphorus concentrations. According to a classification of the Great Lakes Harbor sediments (Environmental Protection Agency, 1977), phosphorus concentrations greater than 650 mg/kg (milligrams per kilogram) are indicative of "heavily polluted" water. Numerous laboratory studies have shown that phosphorus can be released from lake sediments when the overlying water is anoxic (Mortimer, 1941 and 1942; Theis and McCabe, 1978; Holdren and Armstrong, 1980).

Phosphorus concentrations above the sediments of Delavan Lake increased dramatically due to anoxic phosphorus release during the anoxic periods noted January 17 to March 13, 1984, June 15 to September 12, 1984, and July 10 to September 5, 1985. The dissolved-oxygen concentration 4 ft above the lake bottom was 2.5 mg/L on March 6, 1985, although no anoxia was noted. It is likely that at the sediment-water interface the dissolved-oxygen concen-

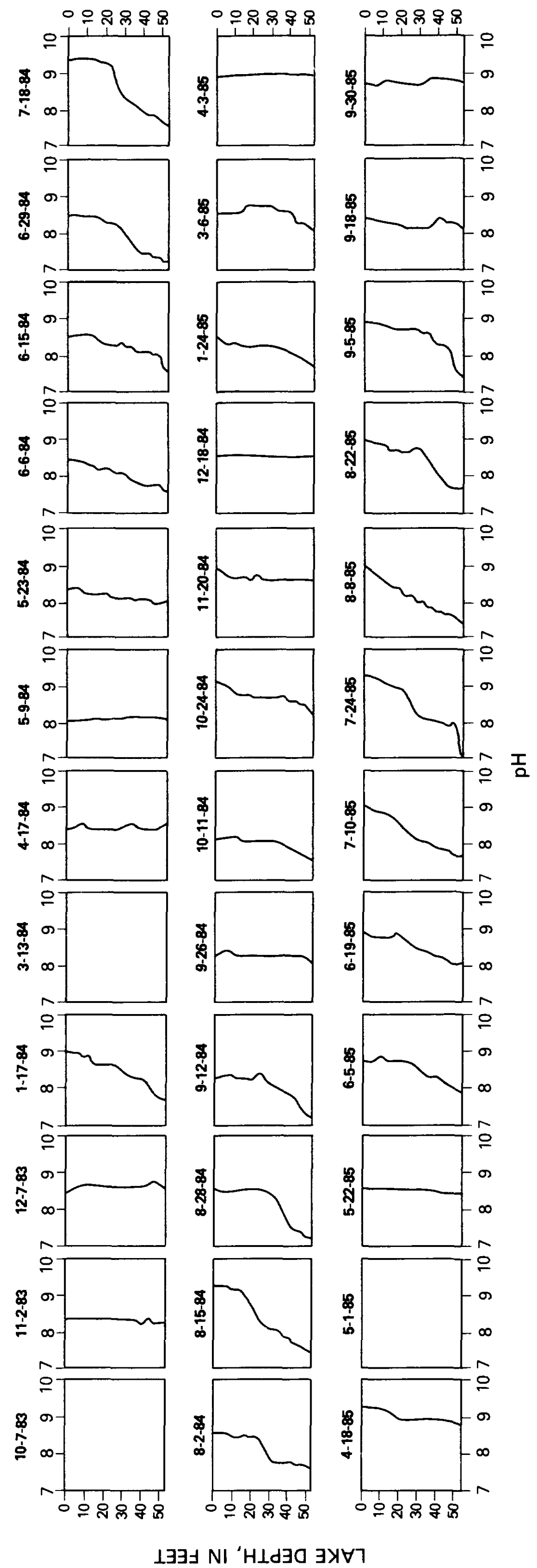


Figure 11. Depth profiles of pH in Delavan Lake, 1984 and 1985 water years.

[2] See discussion on eutrophic lakes in section "Carlson's Trophic-State Index".

Table 8. Spring water chemistry, April 17, 1984, and April 3, 1985, Delavan Lake

[All units in milligrams per liter unless otherwise indicated; µg/L, micrograms per liter; µS/cm, microsiemens per centimeter; a dash indicates data unavailable]

	April 17, 1984					
	Southwest		Center		Northeast	
	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2
Depth of sample (feet)	3	30	3	52	3	30
Dissolved silica (SiO_2)	.6	.6	.6	.6	.7	.7
Dissolved iron (Fe) (ug/L)	3	7	5	--	3	5
Dissolved manganese (Mn) (µg/L)	1	1	1	--	<1	<1
Dissolved calcium (Ca)	41	41	40	--	41	41
Dissolved magnesium (Mg)	31	31	30	--	31	31
Dissolved sodium (Na)	20	19	19	--	20	20
Dissolved potassium (K)	2.9	2.9	3	--	2.9	2.9
Alkalinity as $CaCO_3$	180	182	181	182	182	182
Hardness, as $CaCO_3$	230	230	220	--	230	230
Dissolved solids	328	316	338	--	324	327
Dissolved sulfate (SO_4)	27	27	26	--	27	27
Dissolved chloride (Cl)	45	45	45	--	46	45
Total nitrite + nitrate nitrogen (as N)	.50	.50	.50	.50	.50	.50
Total ammonia + organic nitrogen (as N)	1.4	1.4	1.5	2.0	1.4	1.8
Total phosphorus (as P)	.16	.12	.15	.13	.16	.12
Dissolved orthophosphate phosphorus (as P)	.06	.06	.07	.07	.07	.07
Secchi-disk reading (meter)	-- 1.5 --		-- 1.5 --		-- 1.5 --	
Chlorophyll *a* (µg/L)	21.0	--	24.0	--	21.0	--
Chlorophyll *b* (µg/L)	6.50	--	<.100	--	<.100	--
Water temperature (°C)	5.9	5.9	5.9	5.8	5.8	5.7
Dissolved oxygen	12.6	12.4	12.8	12.1	12.7	12.1
pH (pH units)	8.5	8.5	8.4	8.5	8.3	8.4
Specific conductance (µS/cm)	493	492	493	490	495	496

Table 9. Phosphorus, iron, manganese, arsenic, and moisture content of bed material at maximum depth (54 feet) in Delavan Lake

[mg/kg, milligrams per kilogram; µg/kg, micrograms per kilogram; µg/g, micrograms per gram]

Sediment core depth (in feet)	Phosphorus as P (mg/kg)	Iron (µg/kg)	Manganese (µg/kg)	Arsenic (µg/gm)	Moisture content (percent)
0 - 0.33	1,200	4,600	490	3	84.5
0.33 - 0.83				6	
0.83 - 1.33				5	
0.33 - 1.33	1,100	2,800	630		83.1
1.33 - 1.83				4	
1.33 - 2.33	1,100	2,300	490		64.9
1.83 - 2.33				5	
2.33 - 2.88	840	2,400	560	4	73.8

Table 8. Spring water chemistry, April 17, 1984, and April 3, 1985, Delavan Lake—Continued
[All units in milligrams per liter unless otherwise indicated; µg/L, micrograms per liter; µS/cm, microsiemens per centimeter; a dash indicates data unavailable]

	April 3, 1985					
	Southwest		Center		Northeast	
	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2
Depth of sample (ft)	3	30	3	50	3	30
Dissolved silica (SiO_2)	<.1	<.1	<.1	<.1	<.1	<.1
Dissolved iron (Fe) (µg/L)	<3	3	3	<3	5	7
Dissolved manganese (Mn) (µg/L)	1	2	2	2	2	1
Dissolved calcium (Ca)	41	40	41	41	43	43
Dissolved magnesium (Mg)	32	31	32	33	32	32
Dissolved sodium (Na)	19	19	19	19	19	19
Dissolved potassium (K)	2.7	2.5	2.6	2.7	2.6	2.6
Alkalinity as $CaCO_3$	180	180	180	178	180	180
Hardness, as $CaCO_3$	230	230	230	240	240	240
Dissolved solids	316	328	320	315	320	328
Dissolved sulfate (SO_4)	27	27	27	27	27	27
Dissolved chloride (Cl)	45	45	46	45	47	46
Total nitrite + nitrate nitrogen (as N)	1.1	1.1	1.1	1.1	1.2	1.2
Total ammonia + organic nitrogen (as N)	.27	.26	.26	.22	.10	.26
Total phosphorus (as P)	.13	.14	.15	.18	.13	.23
Dissolved orthophosphate phosphorus (as P)	.06	.06	.06	.08	.07	<.01
Secchi-disk reading (meter)	-- 1.5	--	-- 1.1	--	-- 2.0	--
Chlorophyll a (µg/L)	8.10	--	15.0	--	17.0	--
Chlorophyll b (µg/L)	<.10	--	<.100	--	<.100	--
Water temperature (°C)	4.0	4.4	4.4	4.3	4.6	4.4
Dissolved oxygen	15.8	15.8	15.7	15.6	15.9	15.8
pH (pH units)	8.8	8.8	8.8	8.8	8.8	8.8
Specific conductance (µS/cm)	494	500	500	500	490	500

tration was zero, which allowed the sediments to release phosphorus.

Phosphorus is released from the sediments in the dissolved form. The dissolved orthophosphate phosphorus and total phosphorus concentrations were nearly identical during the 1984 water year.[3] Simple linear regressions of total phosphorus and dissolved orthophosphate phosphorus from June 6 to September 12, show slopes of the regression lines to be 6.4 and 6.7 (µg/L)/d (micrograms per liter per day), respectively, or nearly identical. It is unlikely that the dissolved orthophosphate phosphorus accumulation was the result of decomposing algal cells that contain phosphorus. Gachter and Mares (1985) found in a phosphorus-limiting lake, Lake Lucerne in Switzerland, that dead algal cells settling to the lake bottom accumulated dissolved reactive phosphorus by sorption rather than by releasing phosphorus.

The dissolved orthophosphate phosphorus and total phosphorus concentrations during the 1985 water year were similar except during the period July 10 to September 5 (fig. 14). The reason for this large deviation of total phosphorus from the dissolved orthophosphate phosphorus is that the total phosphorus concentration trend for this period probably reflects the phosphorus concentration in the settling dead algal cells (fig. 14). The upper graph of this illustration shows that the total phosphorus concentration trend duplicates the algal population trend except for a 2-week lag. Total phosphorus may not have followed the algal population trends in 1984 water year (fig. 14) because water circulation patterns in the lake differed from those in 1985,

[3] Dissolved orthophosphate phosphorus was greater than total phosphorus, on two occasions during 1984, either because of sample error, analytical error, or rounding error.

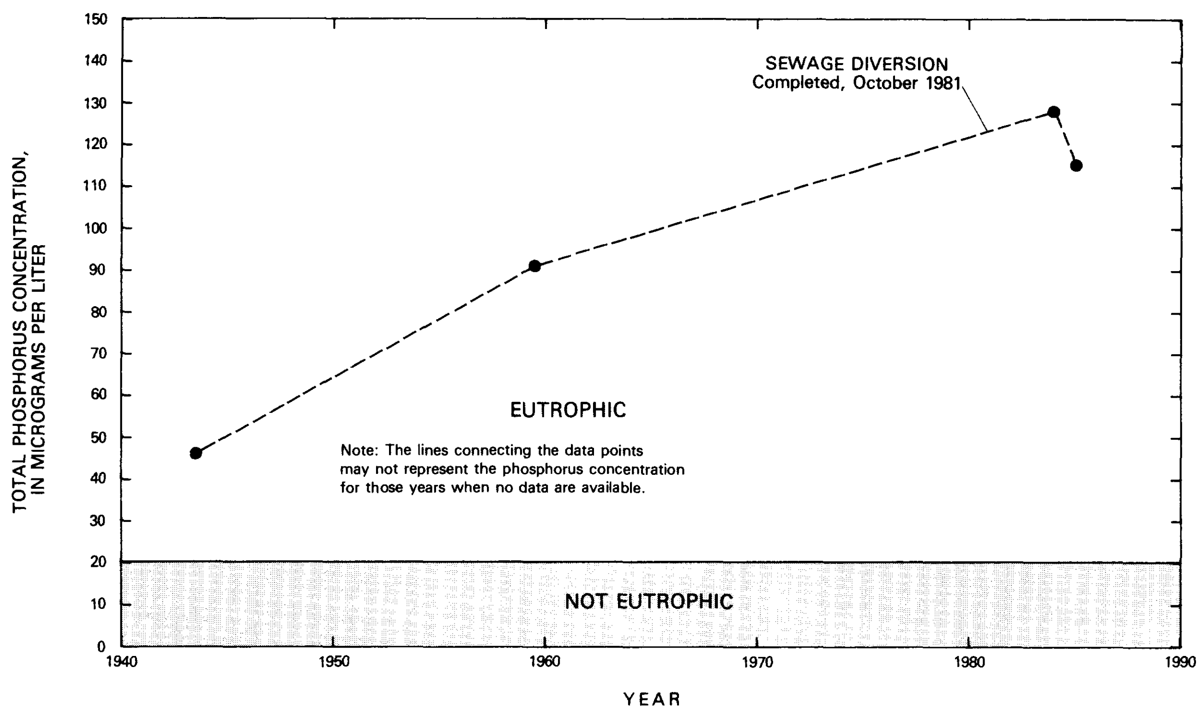


Figure 12. Trends in total phosphorus concentration in Delavan Lake, 12-month, average surface concentration, center site.

thereby the dead algal cells were deposited in a different part of the lake. A simple linear regression of the dissolved orthophosphate phosphorus from June 19 to August 22, 1985, shows that the slope of the regression line is 7.4 (μg/L)/d. A regression of total phosphorus was not done because it reflected the phosphorus in the dead algal cells.

The phosphorus accumulation rates above the lake bottom in Delavan Lake are great and are almost twice those found in eutrophic Lake Mendota in Madison, Wis., by Sonzogni (1974). He found the accumulation rates for total phosphorus and dissolved reactive phosphorus[4] were identical, but were different for 1971 and 1972, 3.9 and 3.1 (μg/L)/d, respectively.

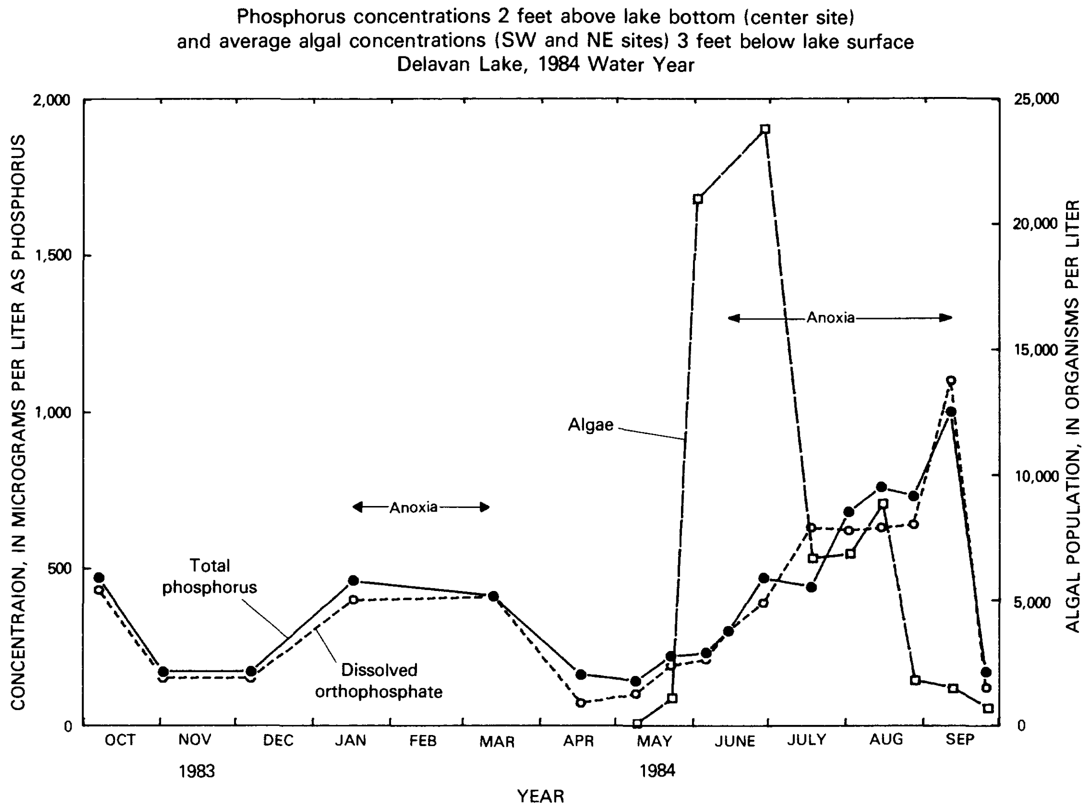
Phosphorus concentrations at the top of Delavan Lake also fluctuate considerably. They are generally greatest during fall turnover when large amounts of phosphorus, that are released from the bottom sediments during anoxia, are mixed throughout the lake. They are least in midsummer when algal cells use the phosphorus.

Algal cells use dissolved orthophosphate phosphorus to grow and they incorporate this phosphorus in their cell walls thereby becoming total phosphorus. Algal cells are short-lived organisms and when they die they settle to the lake bottom, carrying with them the phosphorus they utilized in their growth. Therefore, this growth and death of the algal cells in the top layer of water causes some of the change in the total phosphorus and dissolved orthophosphate concentrations. Also, because Delavan Lake is only weakly stratified, dissolved orthophosphate phosphorus that has been released from the bottom sediments during summer anoxic periods, migrates through the metalimnion into the epilimnion where it is almost immediately used by the algal cells. Stauffer (1974), in his study of Delavan Lake, found that cold fronts accompanied by high winds caused vertical migration of dissolved orthophosphate phosphorus from the hypolimnion into the epilimnion. Figure 14 shows that the total phosphorus concentrations increased 3 ft below the water surface from June 8 to August 22, 1985. This was a period when external loading was very low (fig. 15, total phosphorus input) and was due to the phosphorus being released from the anoxic sediments and migrating from the hypolimnion to the epilimnion.

[4] Because the laboratory procedures for dissolved reactive phosphorus and dissolved orthophosphate phosphorus are the same, the analyses are considered comparable.

NITROGEN

Nitrogen, like phosphorus, when in abundant supply can cause excessive algal blooms although phosphorus commonly limits algal biomass in freshwater systems. The algal biomass in Delavan Lake at times appears to be nitrogen limited. Lakes with a total nitrogen to total phosphorus ratio greater than 15:1 are considered phosphorus limited; ratios between 10–15:1 are indicative of a transition situation; and ratio values less than 10:1 are generally indicative of nitrogen limitation (Lillie and Mason, 1983). The statistical summaries of the nitrogen-to-phosphorus ratios for the open-water periods from samples collected 3 ft below the lake surface of Delavan Lake for the 1984 and 1985 water years are listed (p.28).



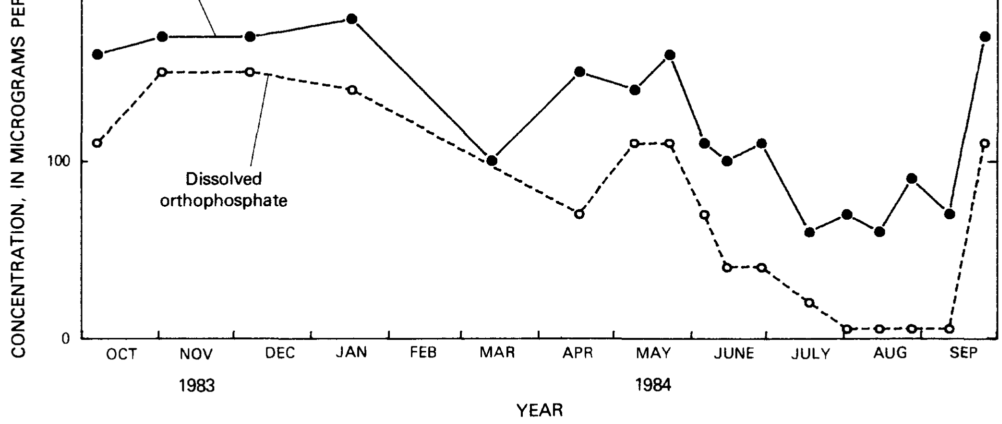


Figure 13. Phosphorus and algal concentrations in the bottom and top water layers of Delavan Lake, 1984 water year.

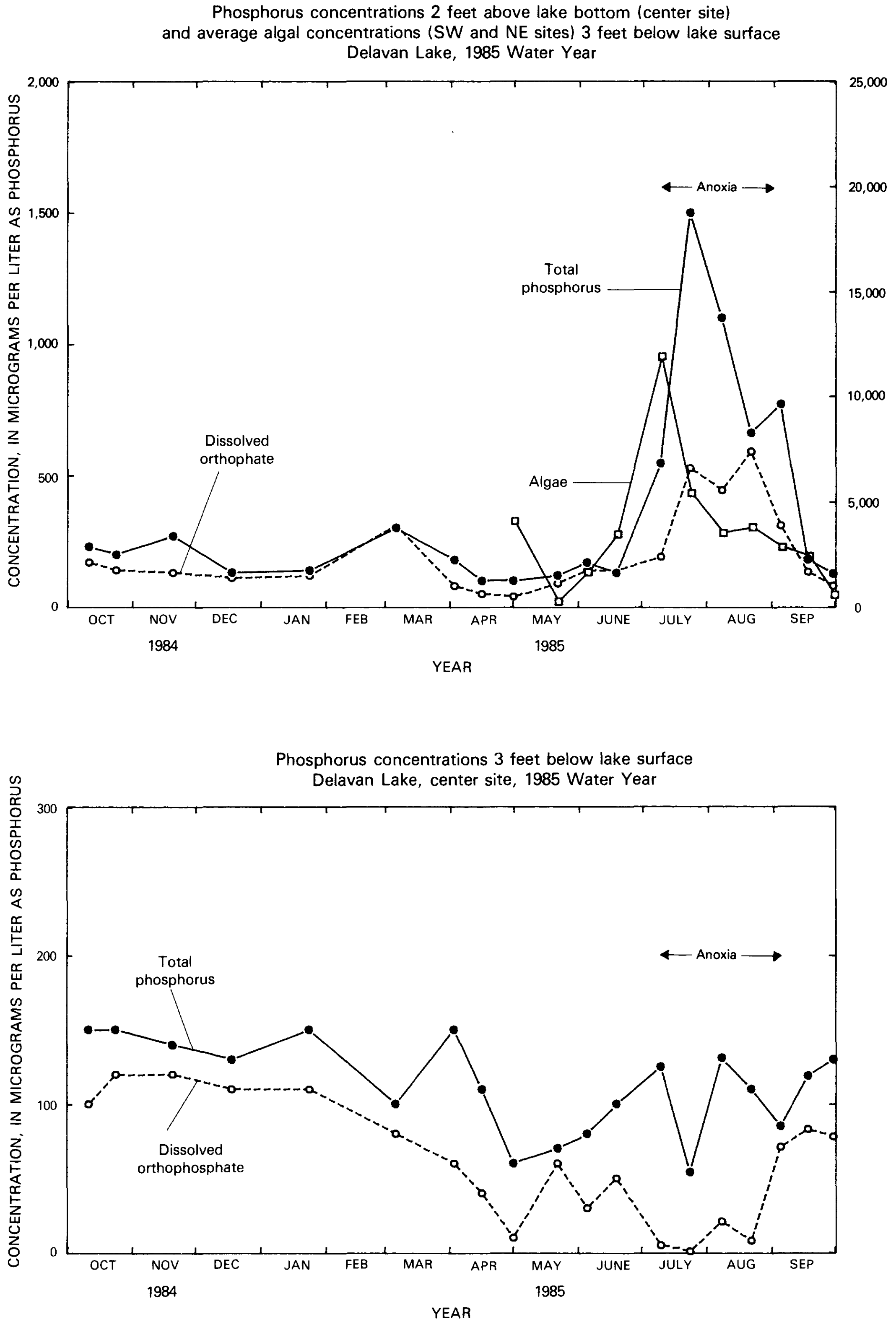


Figure 14. Phosphorus and algal concentrations in the bottom and top water layers of Delavan Lake, 1985 water year.

Total phosphorus mass balance for Delavan Lake

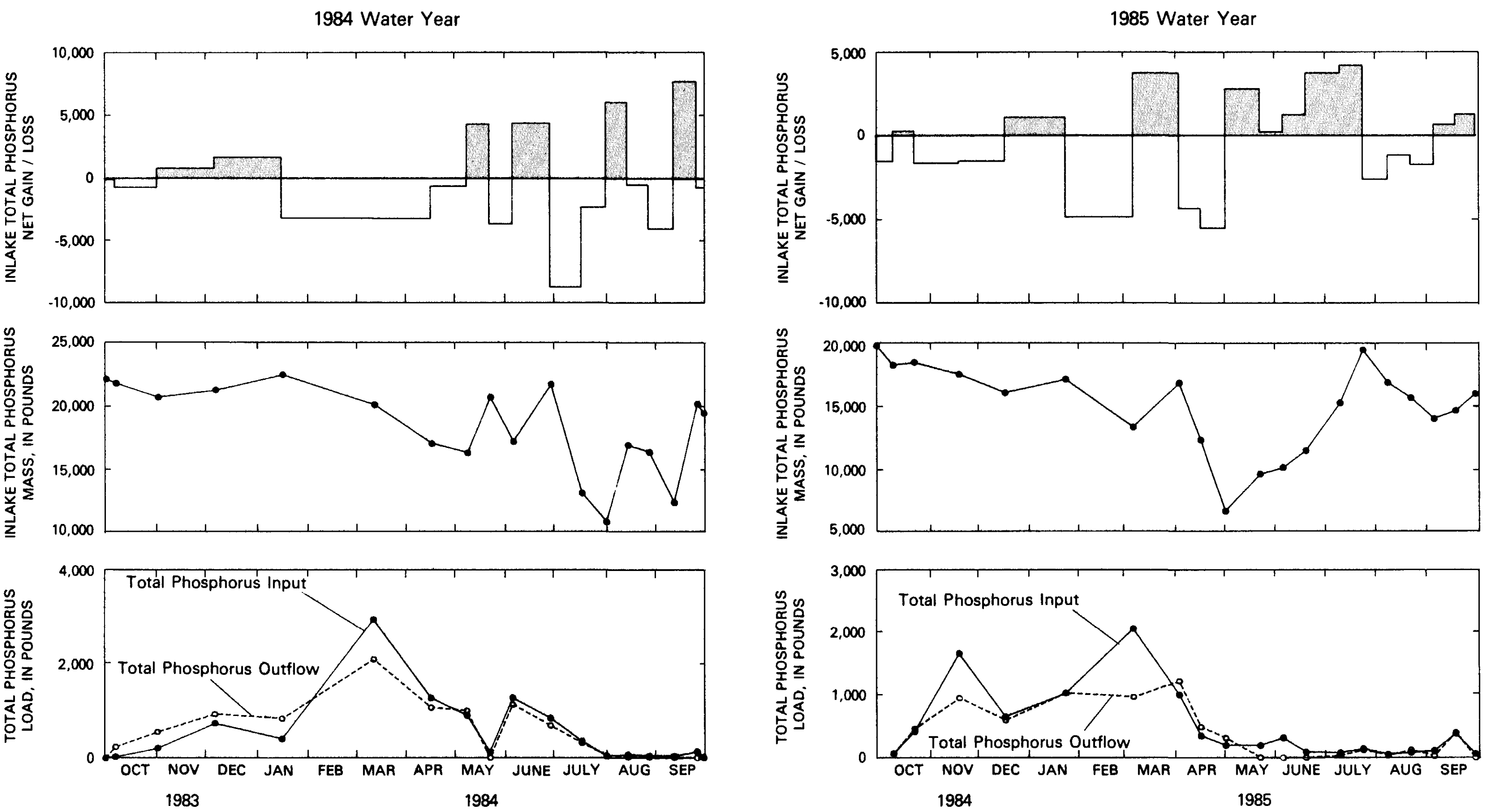


Figure 15. Total phosphorus mass balance for Delavan Lake, 1984 and 1985 water years.

	Southwestern end	Center	Northeastern end
		1984 Water Year	
Number	14	14	14
Range	8.8-60	9.4-28	8.4-330
Median	16	17	17
		1985 Water Year	
Number	15	17	16
Range	7.3-27	8.6-32	10-50
Median	15	16	18

The spring turnover samples are included in the summaries above. The ratios for spring turnover samples were 12 at the two ends of the lake and 13 at the center site during the 1984 water year; the ratios were 14 at the center site, 15 at the southwest site, and 18 at the northeastern site during the 1985 water year.

Nitrogen limitation in Delavan Lake is hypothesized in the National Eutrophication 1972 Survey (Environmental Protection Agency, 1974). An algal assay of *Selenastrum capricornutum* during that survey showed that the species was nitrogen limited. Concentrations of nitrogen and phosphorus determined during EPA's study suggest nitrogen limitation because the nitrogen/phosphorus ratios were less than 10:1.

Nitrogen occurs in freshwater in various forms: "sources of nitrogen include: (a) precipitation falling directly onto the lake surface, (b) nitrogen fixation both in the water and the sediments, and (c) inputs from surface and groundwater drainage. Losses of nitrogen occur by (a) effluent outflow from the basin, (b) reduction of NO_3^- to N_2 by bacterial denitrification with subsequent return of N_2 to the atmosphere, and (c) permanent sedimentation loss of inorganic and organic nitrogen-containing compounds to the sediment" (Wetzel, 1983, p. 223).

Filamentous blue-green algae (except Oscillatoriaceae) also possess heterocysts (specialized cells within the algae) with which they obtain nitrogen from the atmosphere (nitrogen fixation).

Nitrogen undergoes various seasonal changes in the top and bottom layers of Delavan Lake (fig. 16).[5] The changes in the top layers of the water are mostly influenced by changes in algal populations. The changes in the bottom layers of the water are largely caused when oxygen disappears (reduction) and reappears (oxidation).

In the top layer of the lake, where most of the algal population grows, ammonia nitrogen (NH_4N) and nitrite plus nitrate nitrogen ((NO_2+NO_3)[6] are greatest during the winter when algal populations are lowest. They are least during midsummer when algal populations peak by utilizing the nitrate nitrogen and ammonia nitrogen to grow and then sink to the bottom. The data in figure 16 are consistent with this idea and suggest that during the spring and summer the ammonia nitrogen is used by the algae in preference to the nitrate nitrogen. This is normal because the energy necessary to assimilate ammonia nitrogen is least and increases for nitrate nitrogen. Nitrogen fixation by blue-green algae increases when ammonia nitrogen and nitrite plus nitrate nitrogen decrease in the summer (Wetzel, 1983).

The oxidation-reduction reaction at the bottom of the lake greatly changes the nitrate nitrogen and ammonia nitrogen concentrations. Most of the nitrogen is in the oxidized form (nitrate nitrogen) when oxygen is present. The nitrate nitrogen concentrations are greatest during spring and least during summer anoxia when the nitrate nitrogen undergoes denitrification.

"Denitrification by bacteria is the biochemical reduction of oxidized nitrogen anions, NO_3-N and NO_2-N, with concomitant oxidation of organic matter" (Wetzel, 1983, p. 237). Nitrate nitrogen is thus converted to ammonia nitrogen under anoxic conditions. Ammonia nitrogen is least during the spring and fall but increases dramatically as anoxia occurs due to the decomposition of the decaying algal cells in the hypolimnion, denitrification, and the release of ammonia nitrogen from the sediments.

SILICA

Silica is important to the growth of diatomaceous algae. The major source of silica is from the degradation of aluminosilicate materials. Silica concentrations in the trophogenic zone (that upper layer where photosynthesis takes place) of eutrophic lakes are commonly near analytical undetectability (Wetzel, 1983). In lakes where silica concentrations are low, progressive long-term enrichment with phosphorus and nitrogen can lead to rapid biogenic reduction in silica levels so that diatoms cannot effectively compete and they are replaced by nonsiliceous phytoplankton (Kilham, 1971). Seasonal dissolved silica fluctuations at the top and bottom of Delavan Lake are shown in figure 17. The maximum silica concentration in the surface layer 3 ft from the lake surface was 2.1 mg/L; the minimum was at analytical undetectability (<0.1 mg/L). Diatoms use the silica in the surface layer of the lake and as they die they fall to the lake bottom. Decomposition of these diatoms increases the silica content of the bottom waters of Delavan Lake during summer and winter periods of stratification; maximum concentrations commonly reach 4 to 7 mg/L. The large increases in dissolved silica concentrations during summer and winter anoxia also suggest that because silica sorbs to the iron hydroxides (as anoxia occurs) dissolved silica is released with the iron into the water column as the iron is released.

Water Clarity

The range of depths within which photosynthetic activity occurs depends largely on the transparency of the water. Sec-

[5] Nitrogen analyses were not determined in 1984 for all months.

[6] Most of the NO_2+NO_3N is NO_3N. "Nitrite (NO_2^-) is readily oxidized and rarely accumulates except in the metalimnion, upper hypolimnion, or interstitial water of sediments of eutrophic lakes. Concentrations are usually very low (less than 100 μg/L) unless organic pollution is high" (Wetzel, 1983, p. 253). Therefore, when nitrate nitrogen is mentioned it is implied that nitrite nitrogen is included.

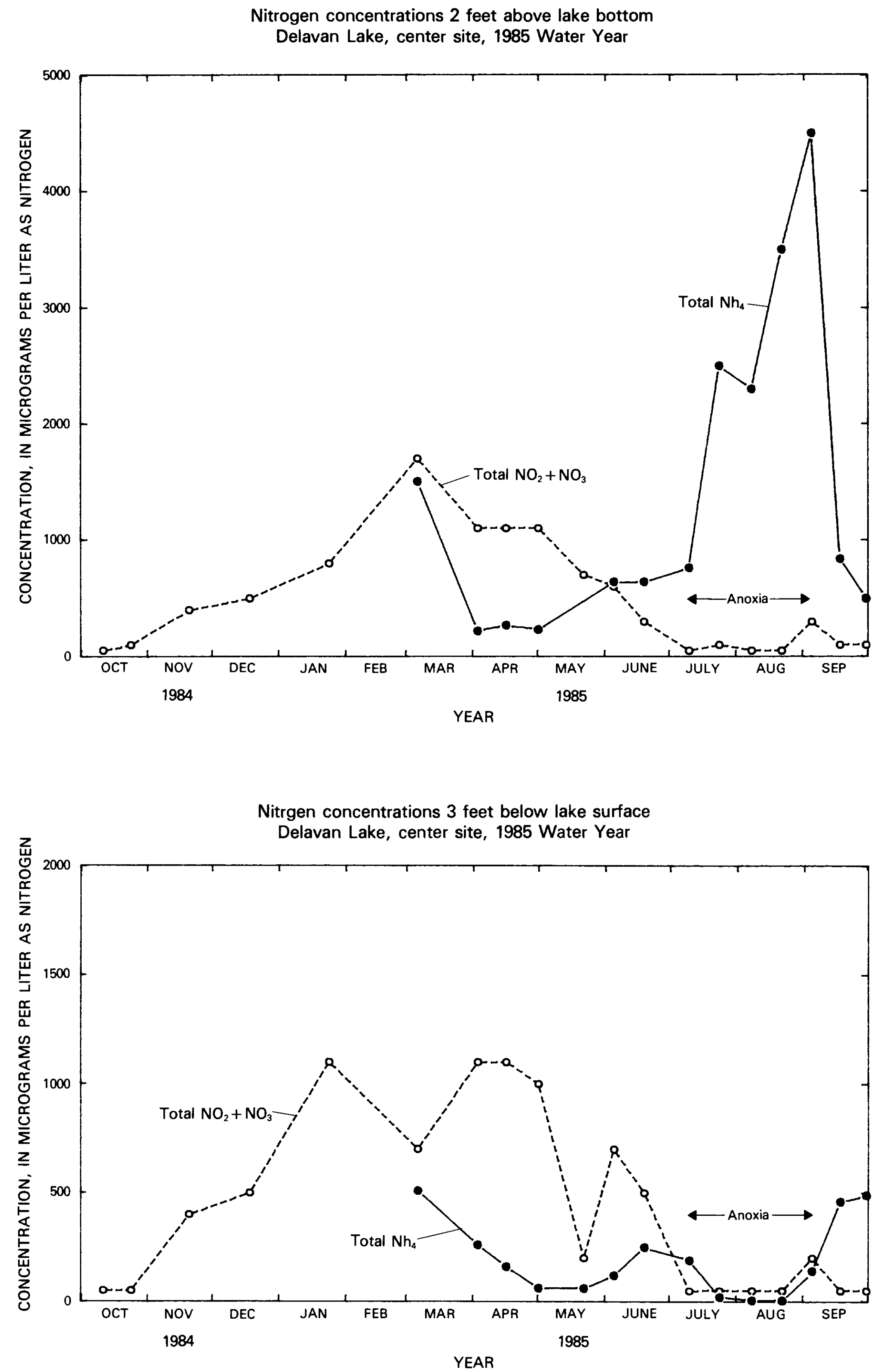
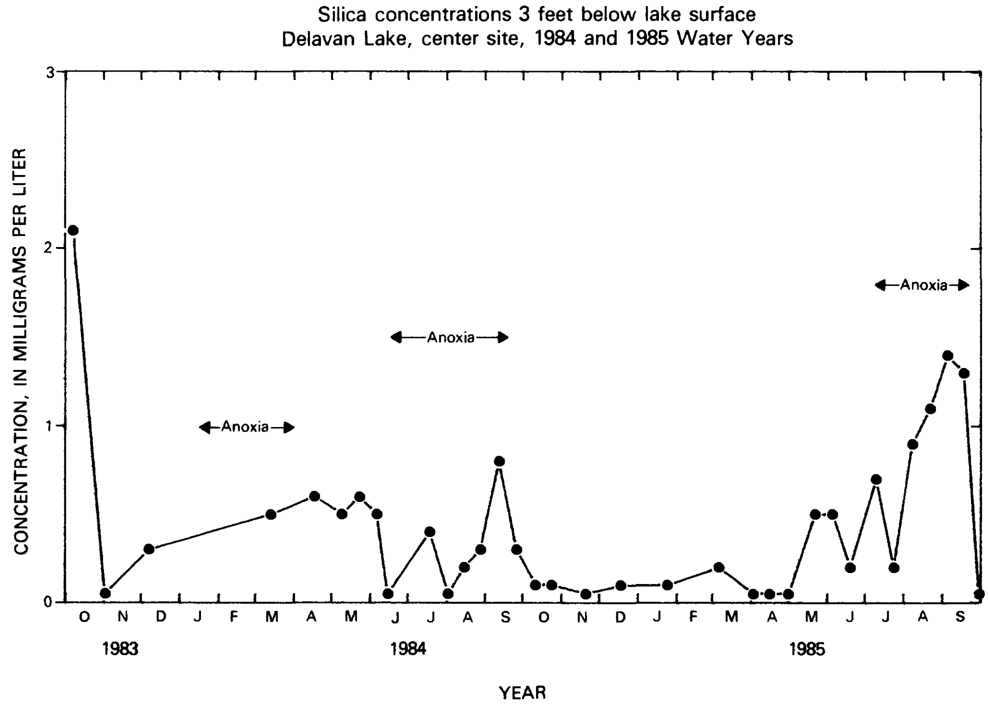


Figure 16. Nitrogen concentrations in the bottom and top water layers of Delavan Lake, 1985 water year.



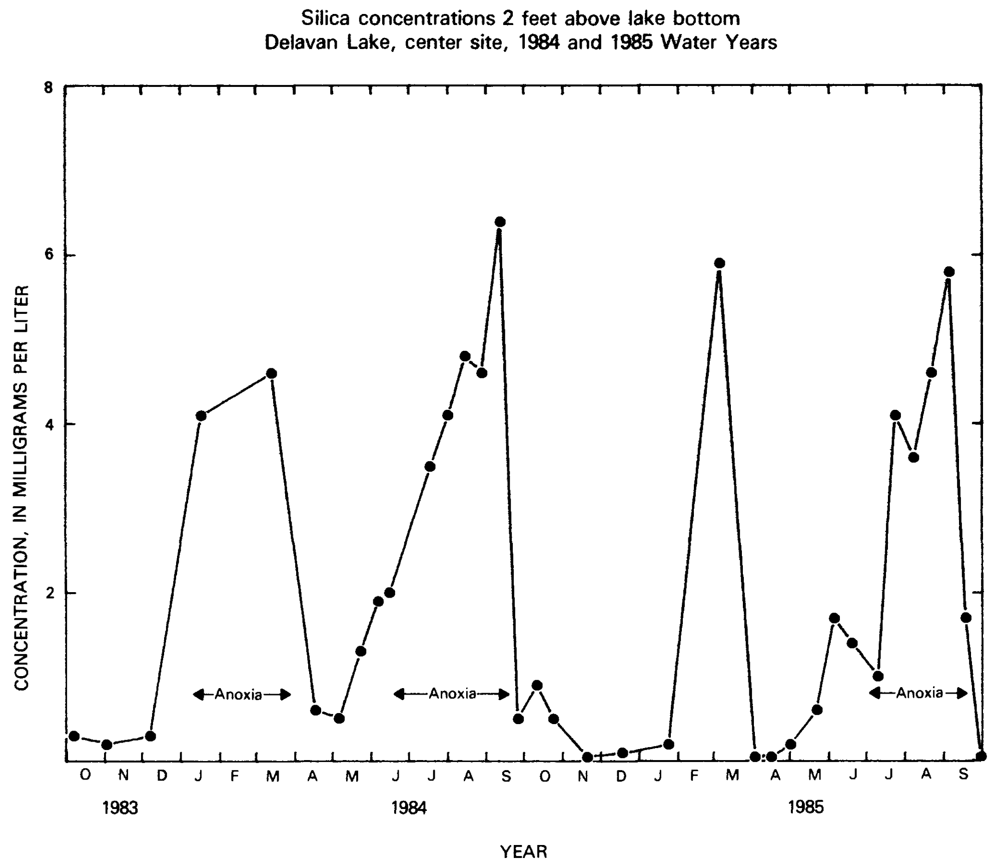


Figure 17. Dissolved silica concentrations, top and bottom water layers of Delavan Lake, 1984 and 1985 water years.

chi disc measurements provide a measurement of this transparency or water clarity. A Secchi disc is an 8-in. black and white disc lowered to a depth at which it is no longer visible from the water surface. Factors that reduce water clarity are algae, zooplankton, water color, and suspended sediment. Algae is the most dominant factor in Delavan Lake, and therefore Secchi disc transparency is significantly correlated with the algal population. Secchi disc transparency is least during summer because algal populations are largest during this time. A minimum Secchi disc transparency of 1.6 ft was measured July 10 and August 8, 1985. A maximum Secchi disc transparency of 21 ft was measured January 24, 1985, during winter when algal populations are lowest. The Secchi disc transparency values are affected when the DLSD sprays chelated copper to kill algal populations; as the algal cells die and settle to the bottom the water clarity increases and Secchi transparencies are increased.

Chlorophyll *a*

Chlorophyll *a* is the primary photosynthetic pigment of all oxygen-evolving photosynthetic organisms and is present in all algae (Wetzel, 1983). It is therefore an indicator of algal biomass. Chlorophyll *a* concentrations are least during winter when algal populations are lowest and are greatest during summer when algal populations are highest. The chlorophyll *a* concentrations at the three sites monitored in Delavan Lake are shown in the illustrations with Secchi disc transparency (fig. 18) to illustrate how the algal populations affect the Secchi disc transparency. As the chlorophyll *a* concentrations increase, reflecting an increase in the algal population, the Secchi disc transparency decreases; as the chlorophyll *a* concentrations decrease, the Secchi disc transparency increases. Chlorophyll *a* concentrations reached a maximum of 87 μg/L on July 10, 1985, and a minimum of 0.1 μg/L on December 18, 1984, and March 6, 1985.

Plankton

ALGAE

Algae are small, generally microscopic plants that are found in all lakes and streams. They occur in a wide variety of forms, in single cells or colonies, and can be either attached (periphytic) or free floating (planktonic). Algae are primary producers that form the base of the aquatic food chain. They convert energy and nutrients into the compounds necessary to support life in the aquatic system through photosynthesis. Oxygen, which is vital to higher forms of life in a lake, is also produced in the photosynthetic process.

Blue-green algae (Cyanophyta) are not ordinarily used as food by zooplankton (microscopic animals) or fish populations and may become overabundant and out of balance with the organisms that feed on them. Population explosions (blooms) of blue-green algae can occur when nitrogen-limiting conditions occur (that is, nitrogen-phosphorus ratios are low), optimum sunlight and temperature conditions exist, and there is a lack of competition from other species.

Algal blooms may reach nuisance proportions in fertile or eutrophic lakes and cause surface scum or slime. Heavy concentrations of wind-blown algae may accumulate on shorelines, where they die and decompose, causing noxious odors and unsightly conditions. The decay process consumes oxygen; decay sometimes depletes available oxygen supplies and results in fish kills. Certain species of decomposing blue-green algae release toxic materials into the water.

The algal succession in Delavan Lake proceeds as in other eutrophic, temperate, waters. A spring algal bloom occurs as light conditions improve after the ice melts; the bloom consists mostly of diatoms (Bacillariophyta) and cryptophytes (Croptophyta). Silica concentrations in the surface waters decrease as diatoms utilize the silica in their growth (fig. 17). As water temperatures increase, summer populations of green algae flourish until concentrations of ammonia nitrogen and nitrite plus nitrate nitrogen decrease. Blue-green algae have a competitive advantage over other species because they have heterocysts in their cell walls that enable them to utilize atmospheric nitrogen and proliferate when nitrogen levels are reduced to very low levels ($<$0.10 mg/L).

Total algal populations at the southwestern and northeastern ends of the lake are shown in figure 19. These populations are from a top 3-ft composite water sample of the lake. June 1984 had the largest summer algal populations of the 2-year study period, averaging 22.4 million organisms per liter. This was almost twice as large as the maximum summer peak of 11.9 million organisms per liter during the 1985 water year. Blue-green algae (Cyanophyta) were the numerically dominant group during the 1984 water year, when algal populations were greatest in June, July, and August. They made up 98, 95, and 84 percent, respectively, of the total population (fig. 19). The most abundant species was *Synechocystis* sp. The cells of this algae are spherical and may be solitary or aggregated in colonies of a few cells (Smith, 1950).

Blue-green algae again numerically dominated the maximum algal bloom during the summer months of 1985. However, the blue-green population, as a percentage of the total population, declined from the high percentages in 1984 to (monthly averages) 43 percent in June, 76 percent in July, and 71 percent in August. *Synechocystis* sp. declined from being the numerically dominant blue-green species in the summer months of 1984 to being codominant with *Anabena circinalis* in June 1985. In July 1985, *Aphanizomenon flos-aqua* was the numerically dominant species and *Synechocystis* sp. ranked as the second largest population. *Aphanizomenon flos-aqua* was the sole numerically dominant species in August.

Anabena occurs in filaments either singly or in floccose colonies and free floating as in a delicate mucous stratum (Smith, 1950). *Aphanizomenon* are laterally joined to one another in small, macroscopic, free-floating, feathery, or scale-like colonies. Smith (1950) states "*A. flos-aqua* is widely distributed but rarely found in abundance"; on August 22, 1985, at the northeastern end of Delavan Lake,

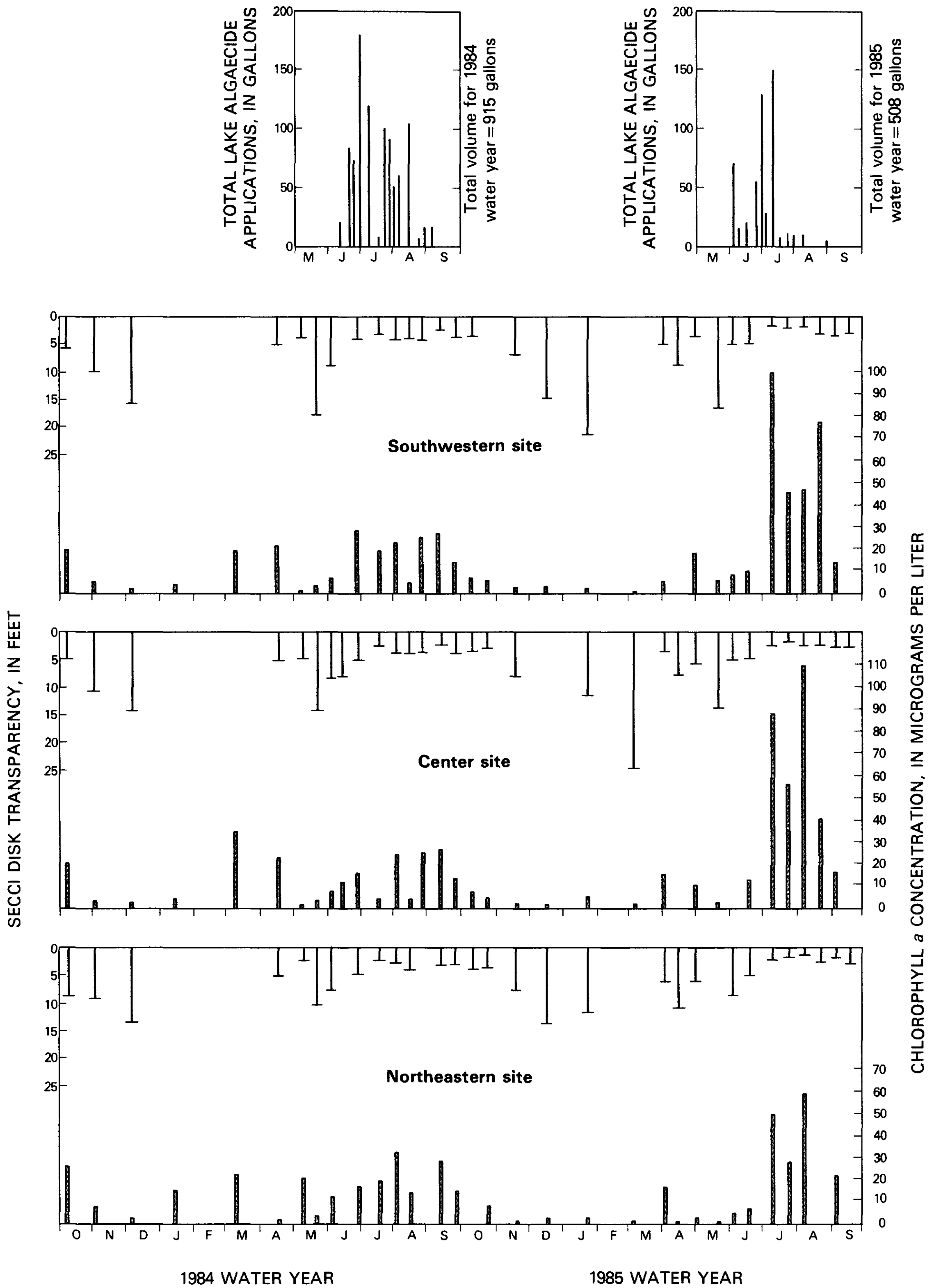


Figure 18. Secchi disc transparencies, chlorophyll *a* concentrations, and chelated copper application for Delavan Lake, 1984 and 1985 water years.

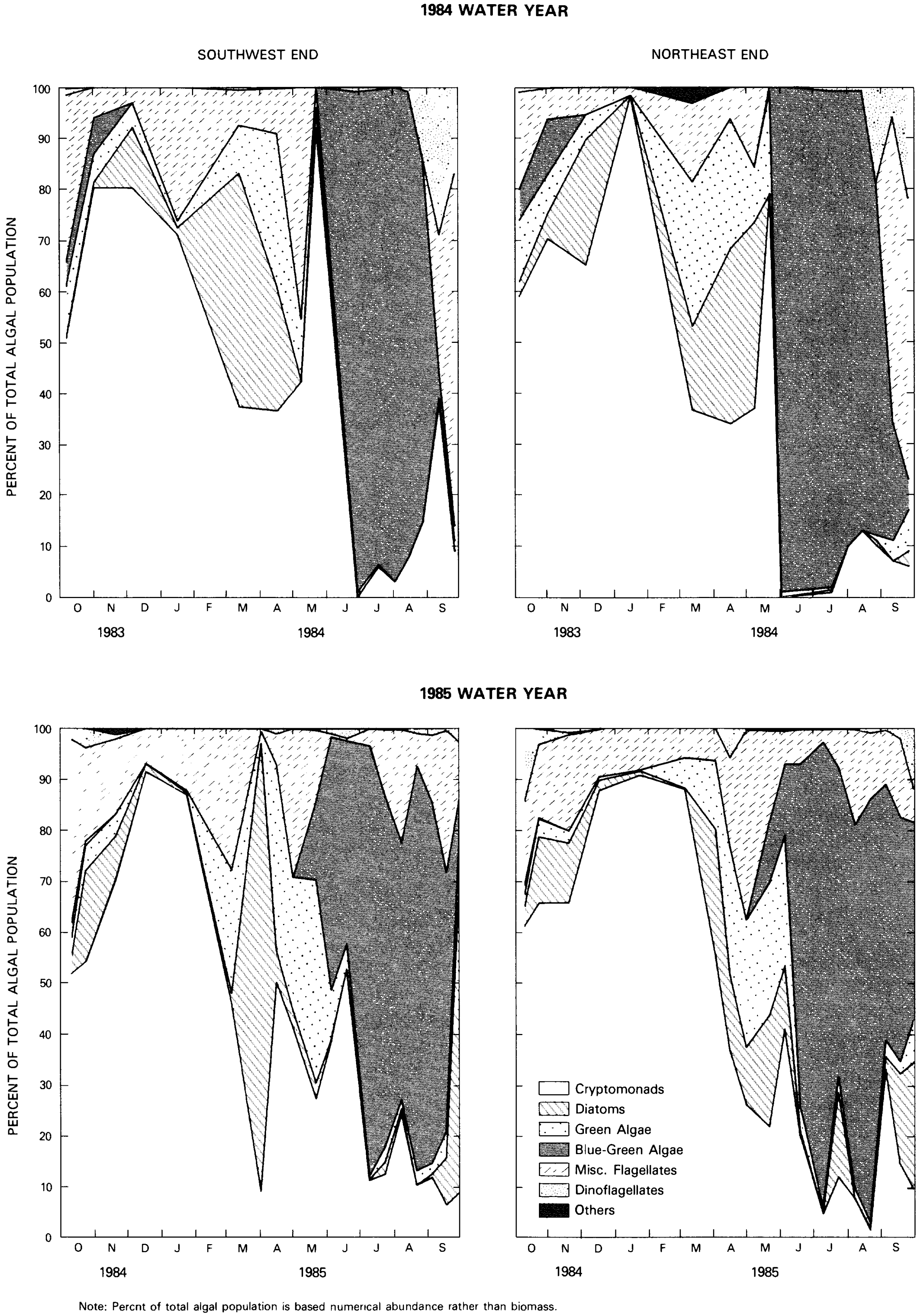


Figure 19. Types of algae in Delavan Lake, 1984 and 1985 water years.

Aphanizomenon flos-aqua dominated 78 percent of the total algal population.

Undesirable blue-green algae numerically dominate the large algal bloom in Delavan Lake during summer months because of the low nitrogen/phosphorus ratios. High phosphorus concentrations cause nitrogen/phosphorus ratios (by weight) to be low. Smith (1983) found in analysis of 17 lakes throughout the world that blue-green algae tend to be rare when the nitrogen/phosphorus ratio exceeds 29 to 1, but he also found a dramatic tendency for blue-green algal blooms to occur when the nitrogen-phosphorus ratios fall below 29 to 1. Smith concluded that blue-green algae are better nitrogen competitors during times of nitrate deficiency because of the heterocysts in the cell walls, but are poorer phosphorus competitors than other groups of algae.

The Cryptomonads (Cryptophyta) make up a significant part of the total population during the colder months of both study years. All members of these groups are small and little is known about their ecology or physiology (Wetzel, 1983). Algal growth in Delavan Lake during the winter months is limited to groups (Cryptophyta) that are adapted to low water temperatures and low light irradiance. As the ice cover melts in the spring and the season progresses, circulation of the water column results in mixing of the nutrient-laden water from lower depths with the top layer. Increasing light in the spring is the dominant factor contributing to spring algal blooms (Wetzel, 1983).

A minor algal peak occurred in the spring of both water years in Delavan Lake. The green algae (Chlorophyta) and the diatoms (Bacillariophyta) are codominant with the Cryptomonads in this algal bloom. The numerically dominant green alga was *Chlamydomons flagellate* and the numerically dominant diatoms included *Cyclotella* sp., *Nitzschia acicularis*, and *Stephanodiscus tenius*. *S. tenius* accounted for 88 percent of the large algal population peak on April 2, 1985, at the southwestern end of the lake (fig. 19).

ZOOPLANKTON

Zooplankton are microscopic animals that inhabit the same environments as phytoplankton. Zooplankton are an important link in the aquatic food chain. They feed on algae and, in turn, provide a food source for fish. During the 1984 and 1985 water years, 28 species of zooplankton were found in Delavan Lake in varying degrees of abundance, as shown in figures 20 and 21. The total populations of all zooplankton and phytoplankton are shown in figure 22. *Cydorus sphaericus* is by far the most dominant species in the zooplankton community. Other lesser dominant species include: *Daphnia* spp. (immature), *Enbosomina coregoni*, and immature copepods. Two other less populous species, *Daphnia galeata mendotae* and *Diaptomus sicilodes*, also were found in almost all samplings.

The rotifers *Conochiloides* spp. and *Synchaeta spp.* are the dominant spring species. Most rotifers are nonpredatory and feed on bacteria, small algae, and particulate organic matter; most food particles eaten are small—less than 0.47×10^{-3} in. (12 micrometers) in diameter (Wetzel, 1983). Immature copepods then dominate the zooplankton population from late April through May. The copepods are divided into three major groups: the Calanoida, Cyclopoda, and the Harpacticoida. The calanoid copepods almost exclusively feed on algae. *Cyclops bicuspidatus thomasi* and *Mesocyclops edax* are predators of other zooplankton (Cole, 1979). Diaptomus is essentially a filter feeder, straining out algal cells (Cole, 1979). The cladoceran, *Chydorus sphaericus* then becomes the dominant species from middle to late summer. *Chydorus* (and *Bosmina* genera) are microfiltrators; they ingest on the average of 5 to 15 percent algae, 10 to 20 percent detritus, and 70 to 80 percent bacteria (Kerfoot, 1980). *Chydous sphaericus* is typically found in very productive lakes.

Blue-green algae are generally unpalatable to zooplankton because they give off toxins (Wetzel, 1983). However, Schindler (1971) found that some blue-greens can be used as a food source. The zooplankton population increased and peaked in September of the 1984 water year after the blue-green population declined significantly, likely because more palatable alga (miscellaneous flagellates, dinoflagelletes, and cryptomonads) were present. However, the zooplankton population peaked in late July of the 1985 water year, probably because the blue-green algal populations did not represent almost the entire algal populations in summer and other palatable species were present. It is possible, however, that the zooplankton peaks may have been partly due to lack of predation by vertebrates on invertebrates.

Macrophytes

By Robert Wakeman, Wisconsin Department of Natural Resources

An aquatic macrophyte survey of Delavan Lake was conducted from June 12 to August 21, 1984. The survey consisted of weekly boat trips around the lake. Aquatic macrophytes were sampled, identified, and their growth and distribution were evaluated. Curly Leaf Pondweed (*Potomogeton crispus*) was the dominant macrophyte present during the survey period. Its distribution on June 12 and July 10 is shown in figure 23. The most significant growth occurred along the south shore and was limited to water less than 10 ft deep. The plants had developed seed heads and looked healthy by June 20. Its maximum distribution was noted on June 26. The plants had deteriorated noticeably by July 10 and had completely died off by August 14. Natural die off of Curly Leaf Pondweed commonly occurs by mid-August.

Two other types of aquatic macrophytes were present during the survey period, White Water Lily (*Nymphaea spp.*) and an unidentified pondweed (*Potomogeton spp.*). Neither plant was a significant component of the macrophyte population. The water lilies were confined to the shallow bay at the southwestern end of the lake and the unidentified pondweed was found at the northern edge (see fig. 23 for distributions).

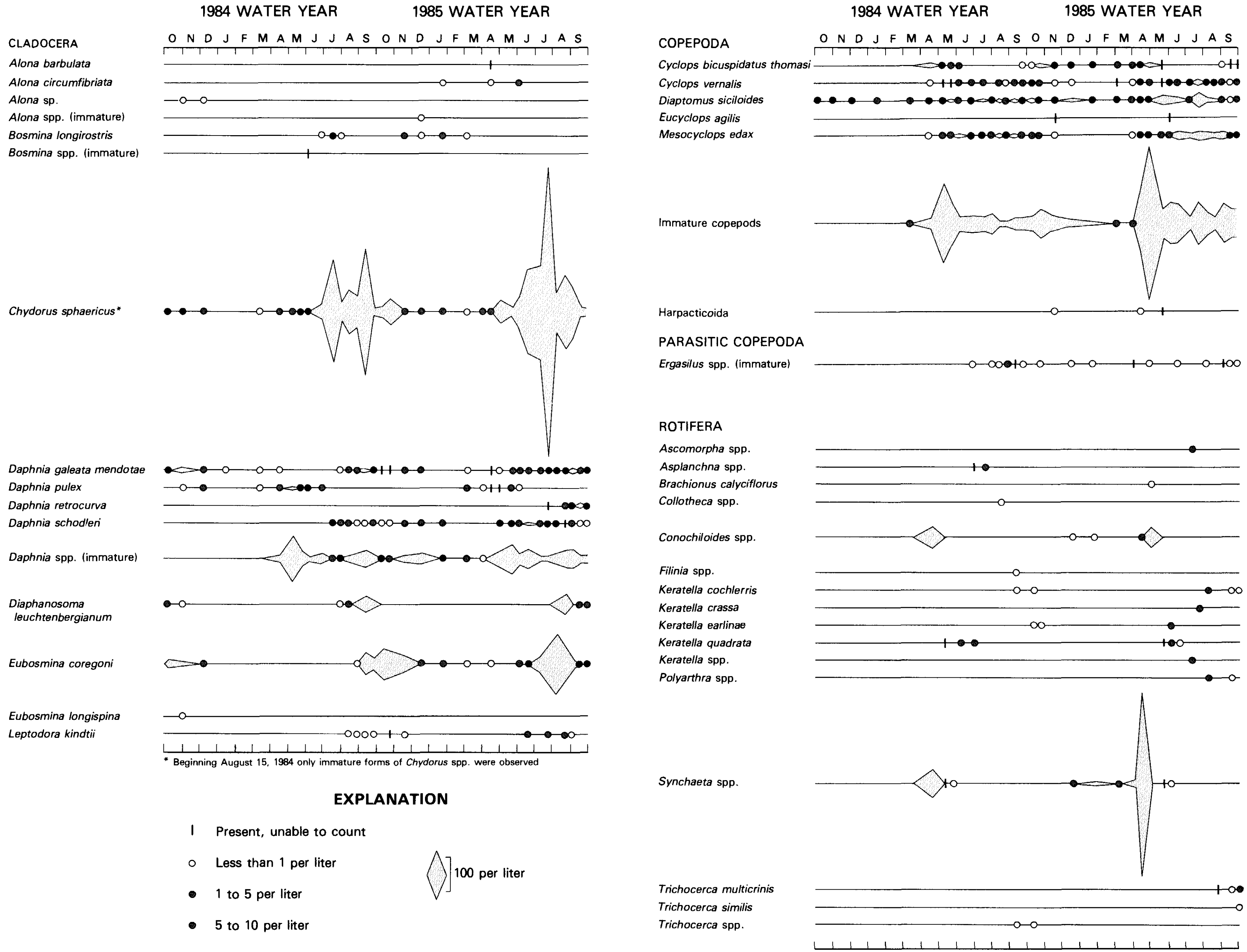


Figure 20. Zooplankton species, southwestern end of Delavan Lake, 1984 and 1985 water years.

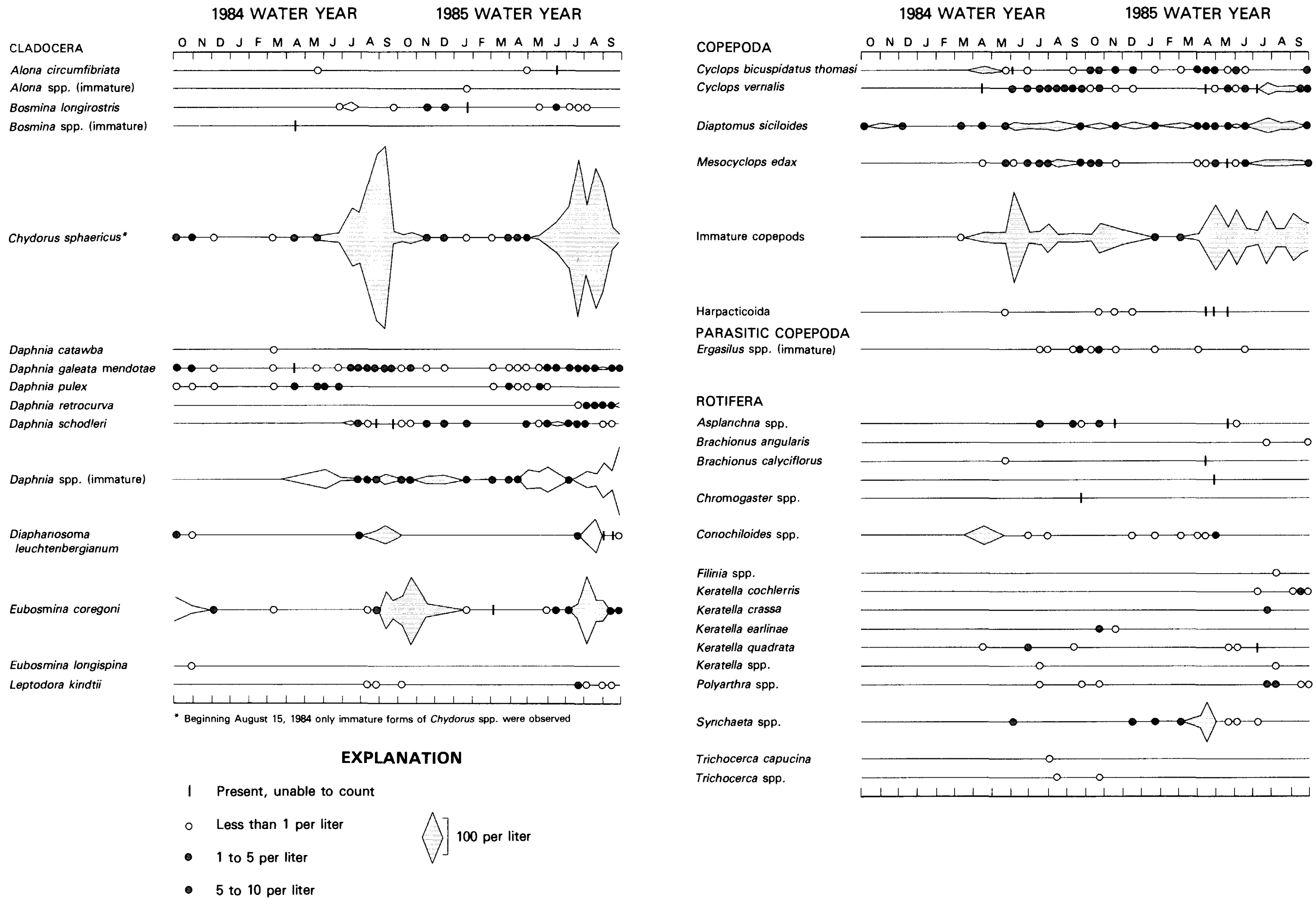
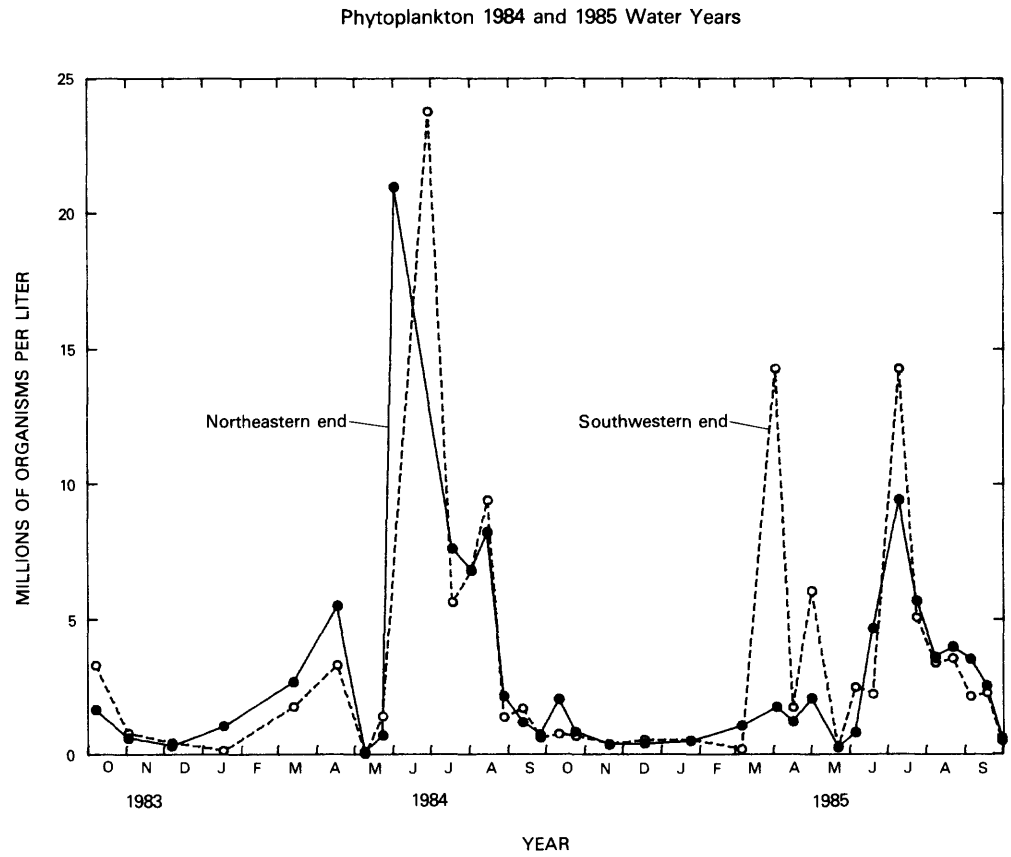


Figure 21. Zooplankton species, northeastern end of Delavan Lake, 1984 and 1985 water years.



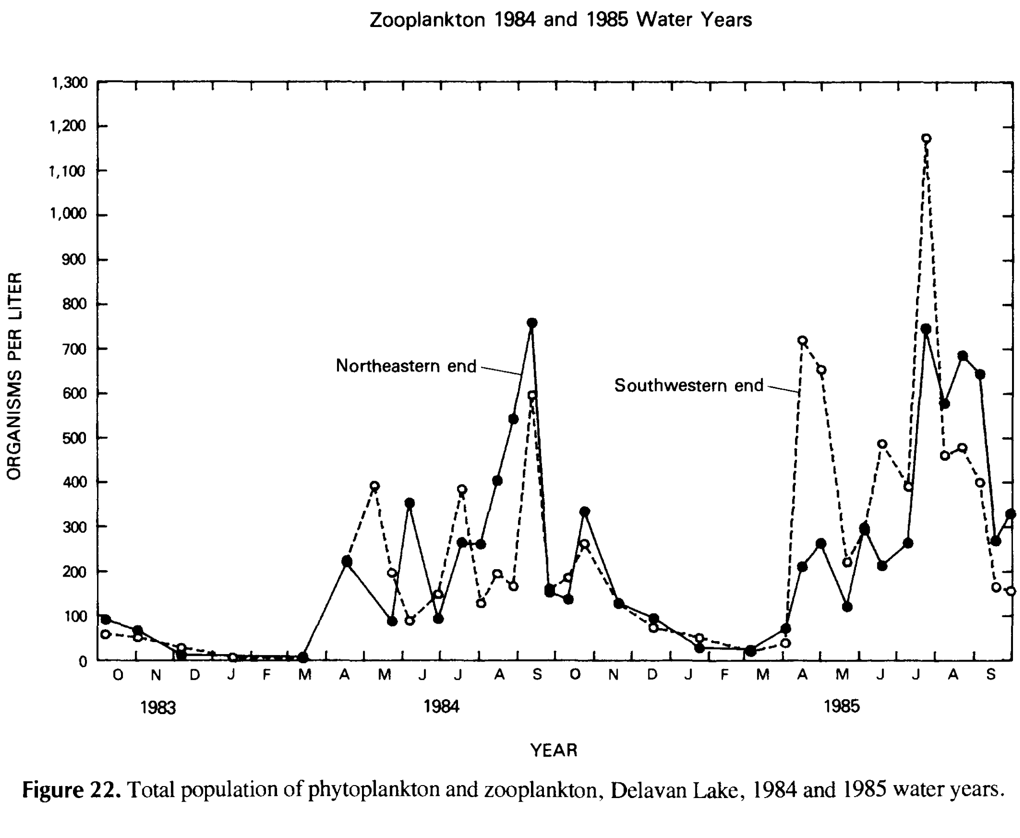


Figure 22. Total population of phytoplankton and zooplankton, Delavan Lake, 1984 and 1985 water years.

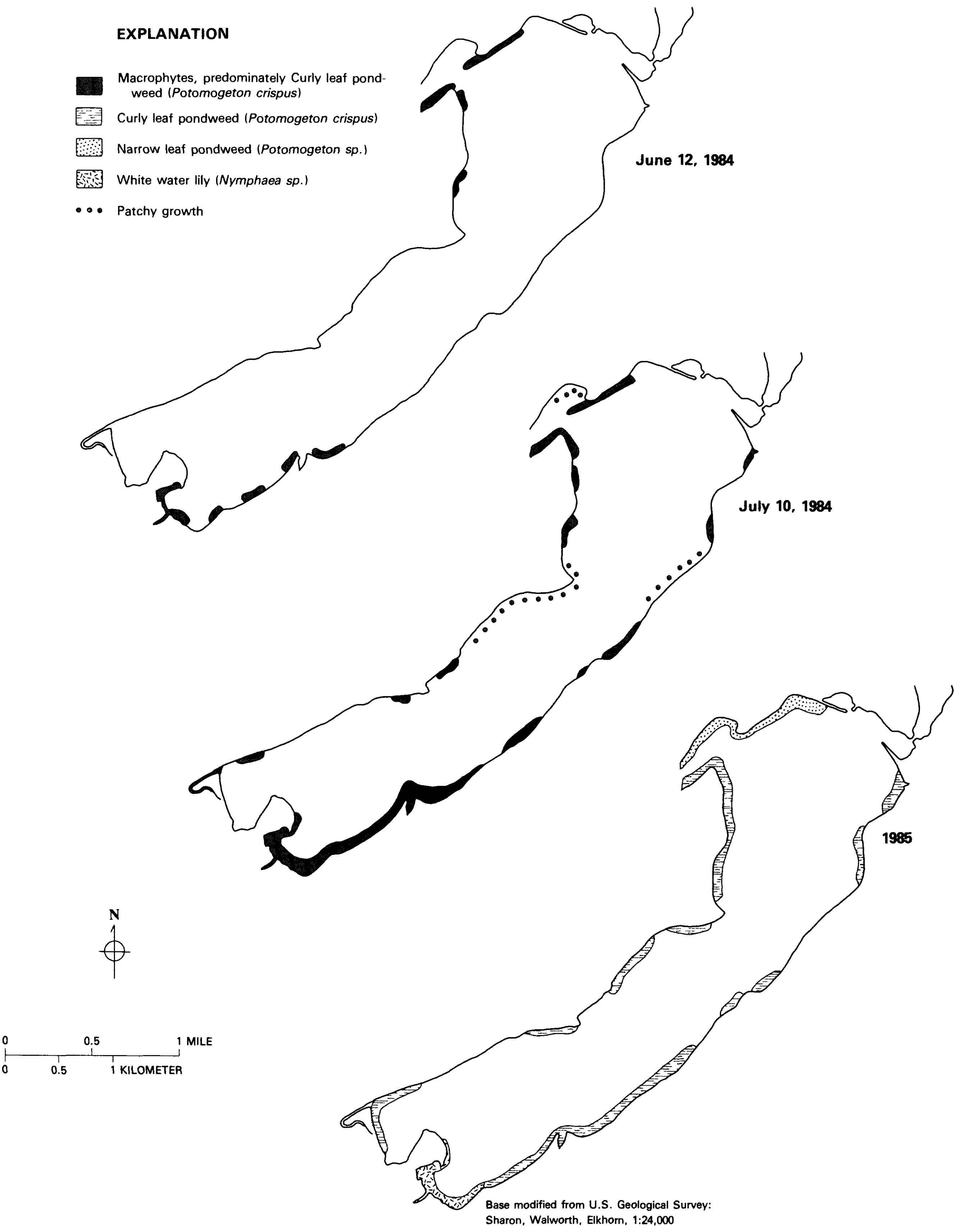


Figure 23. Distribution of macrophytes, June 12 and July 10, 1984, and 1985.

The presence of aquatic macrophytes represents an important change in the primary production of Delavan Lake. Since the late 1950's the lake has been virtually devoid of aquatic macrophytes due to intense shading by planktonic algae.

A second aquatic macrophyte survey of Delavan Lake was conducted from May 21 to August 27, 1985. Aquatic macrophytes were observed during weekly trips around the lake. This survey was limited at times by severe planktonic algae blooms that made visual observation impossible.

Figure 23 shows the aquatic macrophyte species distribution in Delavan Lake. Comparison of the 1985 distribution to the 1984 results shows similar species composition and distribution. The dominant species during 1985 was still *Potomogeton crispus*; it was found intermittently along the north and south shores. The densest growth occurred at the west end and in the channels. The unidentified pondweed (*Potomogeton sp.*) was more difficult to evaluate during 1985 due to its less prominent stature. This narrow leafed pondweed was found at the inlet and in the northern bay at the northern end of the lake. White water lily (*Nymphaea sp.*) was found in the extreme southwestern corner of the lake. Although elodea was not found in Delavan Lake, it has been reported present in the shallow bay at the southwestern end of Delavan Lake.

The continued success of *Potomogeton crispus* is contingent on good water clarity in the spring. This species grows quickly under the ice during late winter and continues in the spring. The plant dies by late July or August. The water clarity is limiting during July and August and is likely to limit other aquatic macrophytes that are more adapted to growth during this time of year.

Bottom Sediments

BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrates are the organisms that live in and on the bottom sediments. The sampling sites are shown in figure 4 and the total number of organisms is shown in table 10.

The number of organisms found in the bottom sediments of Delavan Lake is low compared to other lakes in the area. Hanson and Stefan (1984) summarized benthic macroinvertebrate data of other researchers that is a valuable comparison for the Delavan Lake data. Delavan Lake averaged 707 organisms per square meter compared to 7,567 for Lake Mendota, 1,109 for Lake Monona, 1,979 for Nagawicka Lake, and 1,623 for Pewaukee Lake. Lakes Mendota and Monona are in Madison about 60 mi northwest of Delavan Lake, and Nagawicka and Pewaukee Lakes are near Waukesha about 35 mi northeast of Delavan Lake.

The reason for the very low benthic macroinvertebrate population of Delavan Lake is not apparent but does not appear to be caused by copper accumulations in the Delavan Lake sediments from the spraying of the chelated copper to control algae. Wakeman (1985), in his survey of the Delavan Lake sediments in 1982 and 1984, found that the top 8 in. of sediment contained less than 100 mg/kg copper. By com-

Table 10. Benthic macroinvertebrate count, Delavan Lake, 1984 and 1985 water years

Delavan Lake benthic macroinvertebrate samples

Total count per sample (organisms per square meter)

Sampling site number	1984 May 15	1984 September 13	1985 May 23	1985 September 26	Average for each site
1	1,940	344-344	215-129	258-258	678
2	990	43-431	474-344	129-215	452
3	732	215-172	215-129	431-129	344
4	431	775-517	301-387	215-215	409
5	602	1,080-732	215-301	1,080-732	667
6	4,180	1,080- 43	689-818	1,120-732	1,604
7	947	1,210-603	603-861	1,250-947	920
8	5,120	689-904	215-344	129-344	1,610
9	387	1,030-172	560-344	517-388	474
10	388	646-560	86-172	172-258	334
11	1,680	129-258	43-43	301-215	543
12	1,210	172- 86	86-258	473-129	452
Range	387-5,120	43-1,210	43-816	129-1,250	
Mean	1,550	509	326	443	707
Median	969	474	280	280	

parison Lake Monona contained a mean concentration of 420 mg/kg of copper in the bottom sediments and Fairmont Lake in 1964 in Minnesota contained copper in the sediments as high as 5,600 mg/kg. Fairmont Lake was almost completely devoid of bottom organisms.

The only group of benthic fauna in any appreciable quantities in Delavan Lake are the aquatic insects—the Diptera order or flies. "As hypolimnetic strata of hypereutrophic waters undergo extreme eutrophicational or pollutional loading of organic matter essentially all of the aquatic insects may be eliminated. Practically the only group of benthic fauna adapted to conditions of extremely high organic loading is the oligochaete annelids." (Wetzel, 1983, p. 647). Oligochaetes were present in some of the samples but not in sufficient numbers to count. Of the Diptera, the Chironomidae are the only dominant group in the Delavan Lake muds and they show few density changes with water-column depth. Chironomid larvae possess a type of hemoglobin in their blood that functions efficiently at low oxygen concentrations (Wetzel, 1983).

SEDIMENTS AT DELAVAN LAKE INLET

The sediments at Delavan Lake inlet were surveyed to determine the quantity of soft sediments and their phosphorus, iron, manganese, and moisture content to evaluate the effectiveness of sediment dredging in the inlet to improve the lake's water quality. The Delavan Lake inlet upstream of State Highway 50 is very shallow and is less than 2 ft deep. Depths of the soft sediments range from a mean of 1.4 to 4.4 ft. Phosphorus concentrations of the sediments are very high and well above those concentrations of 650 mg/kg considered by EPA to be indicative of "heavily polluted" water (U.S. Environmental Protection Agency, 1977). The total volume of soft sediments in the inlet (sections 1-21) is 947,000 yd^3 (cubic yards). The sample sections, section volumes and cross-section numbers, are shown in table 11. The concentration data are shown in table 12.

NUTRIENT AND SEDIMENT SOURCES AND LOADINGS

External Loading

STREAMFLOW

Annual nutrient and suspended-sediment loads and yields in the Delavan Lake basin are shown in tables 13 and 14. The yields from the basins upstream of the gaging stations varied significantly, and all parameters except nitrite plus nitrate nitrogen, generally showed a reduction for the 1985 water year compared to the 1984 water year.

Of the phosphorus species only total phosphorus loads were calculated. If other phosphorus species (that is, particulate phosphorus, dissolved orthophosphate phosphorus, dissolved phosphorus) had been analyzed and loads calculated, the relationship of these species loads to those foı total phosphorus may have varied considerably between basins (Elder, 1985).

Jackson Creek tributary near Elkhorn

The Jackson Creek tributary basin (fig. 3) had the greatest phosphorus, Kjeldahl nitrogen, and suspended-sediment yields of the four inflow monitoring basins. The high yields were partly caused by greater runoff (table 5) from this partly urbanized area relative to the other stations. However, they were primarily caused by the high concentrations of phosphorus, Kjeldahl nitrogen, and suspended sediments during storm runoff periods. The statistical summaries of the concentration data for the four inflow gaging stations are shown in table 15.

Drainage area size is an important factor for the total sediment yield from a watershed. The rate of sediment delivery decreases as the size of the drainage area increases and in accordance with streamflow (Chow, 1964, section 17, p. 12). The steeper watershed slopes for smaller tributaries increases runoff and flow velocity, thereby increasing erosion. Jackson Creek tributary is the smallest of the gaged basins and has the greatest slope. Therefore sediment yields from this basin should be greater than from the other basins.

A good correlation exists between phosphorus and sediment yields because phosphorus sorbs to the sediment particle. It follows that phosphorus yields may, as sediment yields do, also be partially dependent on drainage-area size, and on watershed slope. The close association of phosphorus with sediment has been demonstrated in the Steiner Branch basin (Field and Lidwin, 1982), as well as in other basins (Verhoff and others, 1979, and Sharpley and others, 1971). This is the direct result of the transport mechanisms involved in delivering phosphorus to the stream.

Phosphorus is quickly adsorbed to the surface of soil particles, especially on the silt and clay fractions. These small particles have a greater surface area-to-volume ratio than larger diameter particles and are, thus, more efficient transporters of phosphorus. When soil is eroded during a rain storm, the sorbed phosphorus is transported to the stream with soil particles. The relation of phosphorus and sediment yields at the four inflow gaging stations compared to those yields for stations, in nonpoint pollution studies in the southern half of Wisconsin are shown in figure 24 (Field and Lidwin, 1982; Field, 1984, 1985, and 1986). The phosphorus yields at Jackson Creek tributary plot considerably above the regression line and indicate that the higher phosphorus yields are likely not related to the sediment yields in the basin. There are, point sources of pollution within the city of Elkhorn that may cause elevated phosphorus yields in this basin (N. T. O'Reilly, Wisconsin Department of Natural Resources, oral commun., 1986).

Kjeldahl nitrogen is composed of ammonia nitrogen and organic nitrogen. Although no separate analyses were obtained for the individual components of ammonia nitrogen and organic nitrogen, other Wisconsin studies by the author in the Onion River basin, Sheboygan County (Field, 1984), Elk Creek basin, Trempealeau County (Field, 1985), and the Steiner Branch basin, Lafayette County (Field and Lidwin, 1982) have shown that organic nitrogen is the major

Table 11. Results and sites of sediment survey of Delavan Lake inlet

Section	Mean sediment depth[1] (feet)	Area (thousands of square feet)	Volume (thousands of cubic feet)
1	1.38	154	213
2	1.83	461	843
3	3.61	50	2,060
4	3.19	488	1,560
5	2.87	602	1,730
6	2.52	717	1,810
7	1.84	596	1,100
8	3.53	623	2,220
9	3.52	169	593
10	4.21	281	1,180
11	3.66	386	1,410
12	3.09	542	1,670
13	3.87	790	3,060
14	2.85	303	862
15	4.44	512	2,270
16	3.48	178	618
17	3.02	113	341
18	3.70	151	559
19	3.20	95	304
20	3.70	133	493
21	3.75	180	674
			25,570

Total volume of soft sediments: 947,000 cubic yards

[1]Mean depth of cross section across channel.

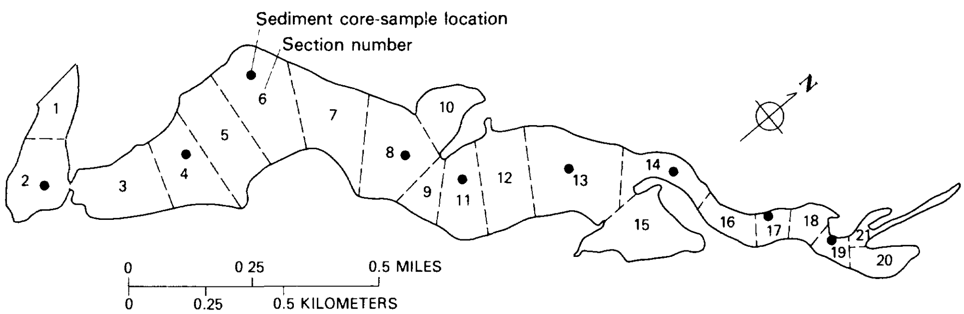


Table 12. Delavan Lake inlet sediment characteristics

[mg/kg, milligrams per kilogram; µg/kg, micrograms per kiligram; a double dash indicates data unavailable]

1984	Cross section number	Distance upstream from State Highway 50 (in feet)	Distance from left bank (LB) or right bank (RB)[1] (in feet)	Core depth interval (feet)	Phosphorus concentration (mg/kg)	Iron concentration (µg/g)	Manganese concentration (µg/g)	Moisture content (percent)
				0-1	1,500	11,000		
August 1	2	400	345 (RB)	1-2	510	8,600		
		(downstream)		2-3	380	6,900		
August 1	6	2,000	340 (RB)	0-1	1,900	1,100		
				1-2	1,300	14,000		
August 1	8	3,700	Channel	0-1	2,300	8,000		
			center	1-1.8	1,700	5,200		
August 1	13	5,500	Channel	0-1	1,200	13,000		
			center	1-2	1,300	18,000		
August 2	14	6,400	120 (RB)	0-1	1,700	10,000		
				1-2	710	7,900		
August 2	19	8,300	40 (RB)	0-1	2,200	6,800		
				1-1.4	1,900	9,500		
August 1,2	4	1,200	360 (LB)	--	--	--		
	11	4,400	350 (RB)	--	--	--		
	17	7,700	40 (RB)	--	--	--		
August 1,2	Composite 4,11,17			0-1	990	7,000	200	60
August 1,2	Composite 4,11,17			1-2	620	4,000	110	40
August 1,2	Composite 4,11			2-3	1,200	6,500	220	73

[1]Right bank and left bank are determined looking downstream.

component of Kjeldahl nitrogen. This is also assumed to be the same with the organic nitrogen component of Kjeldahl nitrogen in the Delavan Lake inflow basins. The transport mechanisms for organic nitrogen may be similar to those for phosphorus and as a result the Kjeldahl nitrogen yields are high.

Nitrate yields in the Jackson Creek tributary basin are comparable to those in the Jackson Creek basin. Nitrate concentrations generally are highest during base flow and decrease with increasing discharge. Nitrate nitrogen is a readily soluble form of nitrogen. It can leach through the soil profile with precipitation, percolate to the ground-water reservoir, and eventually discharge to a surface-water body. Therefore, it is expected that most of the nitrate nitrogen would be contributed by base flow. Field and Lidwin (1982) found that 75 percent of the nitrate nitrogen load was associated with base flow.

Jackson Creek at Petrie Road near Elkhorn

The basin upstream of Jackson Creek at Petrie Road near Elkhorn contains the greatest density of livestock of the basins monitored. Despite this potential source of nutrients, phosphorus and Kjeldahl nitrogen yields were lower than those from the Jackson Creek tributary basin. Nitrate yields were comparable to those in the Jackson Creek tributary basin.

Delavan Lake Inlet

The total phosphorus yield of 323 lb/mi^2 in the 1984 water year and 309 lb/mi^2 in the 1985 water year at Jackson Creek at the Delavan Lake inlet may be somewhat in error but the yields appear reasonable compared to the yields

Table 13. Nutrient and suspended-sediment loads and yields in the Delavan Lake drainage basin, 1984 water year

[mi^2, square miles; lbs, pounds; lbs/mi^2, pounds per square mile; $tons/mi^2$, tons per square mile; mg/L, milligrams per liter; ft^3/s-d, cubic feet per second per day; a double dash indicates data unavailable]

Item	Drainage area (mi^2)	Total phosphorus Load (lbs)	Total phosphorus Yield (lbs/mi^2)	Nitrite + nitrate nitrogen Load (lbs)	Nitrite + nitrate nitrogen Yield (lbs/mi^2)	Kjeldahl nitrogen Load (lbs)	Kjeldahl nitrogen Yield (lbs/mi^2)	Suspended sediment Load (tons)	Suspended sediment Yield ($tons/mi^2$)
1 - Jackson Creek gaging station	8.96	2,590	289	56,600	6,320	12,200	1,370	305	34.0
2 - Jackson Creek tributary gaging station	4.34	3,800	876	21,000	4,830	16,300	3,760	227	52.3
3 - Delavan Lake inlet	21.78	7,040	323	64,300	2,950	57,500	2,640	1,076	49.4
4 - Delavan Lake tributary 1	1.07	309	[1]289	6,760	[1]6,320	1,460	[1]1,370	--	--
5 - Delavan Lake tributary 2 gaging station	7.66	591	59.2	3,810	497	5,220	681	44	5.74
6 - Delavan Lake shoreline drainage	5.78	1,160	[2]200	3,930	[2]680	8,180	[2]1,420	--	--
7 - Delavan Lake precipitation[3]	2.80	[a]207		[b]6,100		[c]8,934			
8 - Ground water[4]		[d]197		[e]23,600		[f]6,210			
TOTAL 3-8	39.09	9,504		108,500		87,500			
Below-dam drainage area	.65	188	[1]289	4,110	[1]6,320	888	[1]1,370	--	--
Delavan Lake outlet gaging station	39.74	8,970	226	32,600	821	88,800	2,230	679	17.1

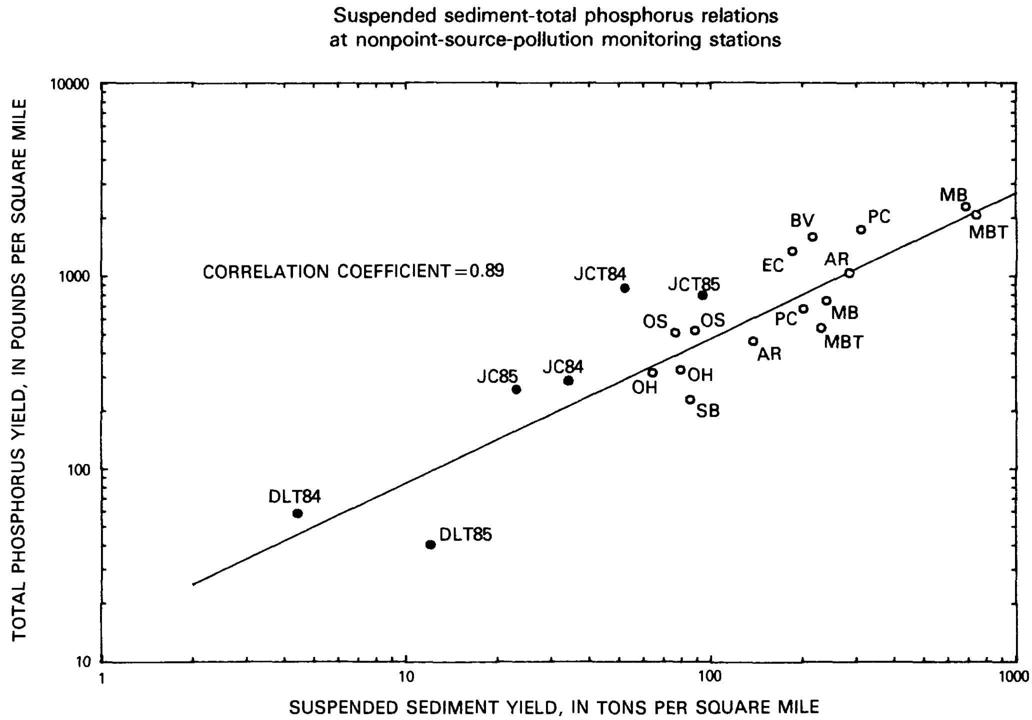
[1]Based on Jackson Creek.
[2]Reckhow, 1980; Much and Kemp, 1978.
[3]Based on precipitation of 31.56 inches.
[a]Phosphorus mean concentration of 0.02 mg/L (1985 water year data).
[b]Based on seasonal nitrite + nitrate nitrogen concentration (1985 water year data).
[c]Based on seasonal Kjeldahl nitrogen concentration (1985 water year data).
[4]Based on ground-water contribution of 1,824 [(ft^3/s)-d].
[d]Phosphorus mean concentration of 0.02 mg/L.
[e]Nitrite + nitrate nitrogen mean concentration of 2.4 mg/L.
[f]Kjeldahl nitrogen mean concentration of 0.63 mg/L.

Table 14. Nutrient and suspended-sediment loads and yields in the Delavan Lake drainage basin, 1985 water year

[mi^2, square miles; lbs, pounds; lbs/mi^2, pounds per square mile; tons/mi^2, tons per square mile; mg/L, milligrams per liter; ft^3/s-d, cubic feet per second per day; a double dash indicates data unavailable]

Item	Drainage area (mi^2)	Total phosphorus		Nitrite + nitrate nitrogen		Kjeldahl nitrogen		Suspended sediment	
		Load (lbs)	Yield (lbs/mi^2)	Load (lbs)	Yield (lbs/mi^2)	Load (lbs)	Yield (lbs/mi^2)	Load (tons)	Yield (tons/mi^2)
1 - Jackson Creek gaging station	8.96	2,340	261	51,500	5,750	10,600	1,180	206	23.0
2 - Jackson Creek tributary gaging station	4.34	3,480	801	25,100	5,780	14,900	3,430	407	93.7
3 - Delavan Lake inlet	21.78	6,730	309	85,400	3,920	45,500	2,090	2,002	91.9
4 - Delavan Lake tributary 1	1.07	279	[1]261	6,150	[1]5,750	1,260	[1]1,180	--	--
5 - Delavan Lake tributary 2 gaging station	7.66	407	53.1	4,120	538	3,210	419	120	15.7
6 - Delavan Lake shoreline drainage	5.78	1,010	[2]174	3,900	[2]675	6,930	[2]1,200	--	--
7 - Delavan Lake precipitation[3]	2.80	243		7,340		10,100			
8 - Ground water[4]		[a]311		[b]40,500		[c]13,100			
TOTAL 3-8	39.09	8,980		147,410		80,100			
Below-dam drainage area	.65	170	261	3,740	5,750	767	1,180	--	--
Delavan Lake outlet gaging station	39.74	7,330	185	42,100	1,060	71,500	1,800	1,530	38.5

[1]Based on Jackson Creek.
[2]Reckhow, 1980; Much and Kemp, 1978.
[3]Based on precipitation of 38.87 inches.
[4]Based on ground-water contribution of 2,884 [(ft^3/s)-d].
[a]Phosphorus mean concentration of 0.02 mg/L.
[b]Nitrite + nitrate nitrogen mean concentration of 2.6 mg/L.
[c]Kjeldahl nitrogen mean concentration of 0.84 mg/L.



EXPLANATION

●	Annual yield - Delavan study	MB	Madden Branch
o	Annual yield - Other studies	MBT	Madden Branch tributary
DLT	Delavan Lake tributary	OH	Onion River, Hingham
JC	Jackson Creek	OS	Onion River, Sheboygan Falls
JCT	Jackson Creek tributary	PC	Pats Creek
AR	Apple River	SB	Steiner Branch
BV	Bruce Valley		
EC	Elk Creek	85	Study year

Figure 24. Suspended sediment-total phosphorus relations at nonpoint-source-pollution monitoring stations.

upstream. Estimated discharges at this site may have increased the error in load calculations (see section "Data Collection and Methods of Analysis—Streamflow"). Also, phosphorus sedimentation during surface runoff occurring in the 1.7-mi long, ponded Delavan Lake inlet upstream of State Highway 50 would have reduced the yields from those upstream. Maximum observed total phosphorus concentration during storm runoff at this site was 3.8 mg/L. Minimum total phosphorus concentrations during low-flow periods were very high; they ranged from 0.08 to 0.86 mg/L; the median was 0.29 mg/L. Dissolved orthophosphate phosphorus ranged from 0.01 to 0.18 mg/L and the median was 0.05 mg/L. These high total phosphorus concentrations during low-flow periods were probably caused by resuspension of the bottom particulate material by carp and big-mouthed buffalo activity in this shallow inlet.

Nitrate nitrogen and Kjeldahl nitrogen yields in the inlet differed significantly from those yields of the basin upstream. Dense algal populations in the ponded inlet assimilate the nitrate nitrogen and ammonia nitrogen and convert it to organic nitrogen.

Suspended-sediment yields were less than those yields from upstream because sedimentation occurs in the ponded inlet.

Considerable short circuiting of the total phosphorus inflow from Delavan Lake inlet may occur considering the proximity of the outlet to Delavan Lake inlet, through which 75 percent of the external total phosphorus input flows. Short circuiting has been demonstrated on other lakes where the outlet is also in close proximity to the inlet (Englert and Stewart, 1983). The total phosphorus output in figure 15 closely follows the total phosphorus input and generally the in-lake total phosphorus mass responds only slightly to external phosphorus inputs (see March 13, June 6, and November 20, 1984, data points). K. L. MacKinnon (Delavan Lake Sanitary District, oral commun., 1985) has also noted that during storm-runoff periods that a line of turbid dark brown water extends from Delavan Lake inlet along the north shore of the lake to the outlet. Figure 25 also illustrates this short circuiting. The peak temporal concentration patterns at both stations are similar although the concentrations of total phosphorus are reduced at the outlet.

Table 15. Statistical summaries of nutrient and suspended-sediment concentrations in runoff at the four Delavan Lake inflow gaging stations

[Concentrations in milligrams per liter]

Water-quality characteristic	Number of samples	Maximum	Minimum	Median	Mean	Standard deviation
			JACKSON CREEK TRIBUTARY			
			1984 water year			
Total phosphorus	138	8.2	<0.01	0.77	1.1	1.3
Nitrite + nitrate nitrogen	132	13	.10	3.2	3.4	2.2
Kjeldahl nitrogen	132	37	.40	2.6	3.5	3.8
Suspended sediment	246	5,520	1	84	274	618
			1985 water year			
Total phosphorus	128	4.1	.20	.66	.86	.66
Nitrite + nitrate nitrogen	128	6.1	.50	2.7	2.8	1.3
Kjeldahl nitrogen	128	13	.70	2.5	3.0	2.0
Suspended sediment	273	2,456	4	111	229	320
			JACKSON CREEK			
			1984 water year			
Total phosphorus	97	1.4	.04	.31	.34	.22
Nitrite + nitrate nitrogen	97	17	.05	5.3	5.7	3.3
Kjeldahl nitrogen	97	5.6	.40	1.7	1.9	1.1
Suspended sediment	155	802	1	36	80	124
			1985 water year			
Total phosphorus	85	1.1	.05	.44	.46	.21
Nitrite + nitrate nitrogen	85	14	.50	5.0	5.4	2.3
Kjeldahl nitrogen	85	9.4	.80	1.8	2.0	1.2
Suspended sediment	181	449	5	52	85	85

Delavan Lake Tributary 2

All nutrient and sediment yields from this basin were extremely low (fig. 24). This was primarily due to the significantly reduced annual runoff from this basin (2.90 in. in the 1984 water year and 2.47 in. in the 1985 water year) but was partly due to the slightly lower concentrations than coming from the other basins. Mean and median concentrations of total phosphorus and Kjeldahl nitrogen are generally only slightly less than those from the Jackson Creek basin. The low runoff is likely due to storage and evapotranspiration in the large pond and wetland in the basin.

GROUND WATER

Ground-water nutrient loads account for only a small part of the nutrient input from all external sources because total phosphorus and Kjeldahl nitrogen concentrations in ground water are low and ground-water discharge to the lake is low. For the 1984 water year, phosphorus load was calculated using a mean concentration of 0.02 mg/L phosphorus and ground-water discharge of 1,820 (ft^3/s)-d (cubic feet per second days); values of 0.02 mg/L phosphorus and 2,884 (ft^3/s)-d discharge were used for water year 1985. The same ground-water discharges were used to calculate the Kjeldahl nitrogen loads. A mean concentration of 0.63 mg/L in the 1984 water year was used and 0.84 mg/L in the 1985 water year was used.

Nitrite plus nitrate concentrations are high in ground water compared to those concentrations found in surface runoff; nitrite plus nitrate loads from ground water therefore contribute significantly to total nitrite plus nitrate nitrogen input to Delavan Lake. A mean concentration of 2.4 mg/L was used in the 1984 water year to calculate the ground-water load from nitrite plus nitrate nitrogen; in the 1985 water year a mean concentration of 2.6 mg/L was used.

Table 15. Statistical summaries of nutrient and suspended-sediment concentrations in runoff at the four Delavan Lake inflow gaging stations—Continued

[Concentrations in milligrams per liter]

Water-quality characteristic	Number of samples	Maximum	Minimum	Median	Mean	Standard deviation
		DELAVAN LAKE INLET				
		1984 water year				
Total phosphorus	97	.80	.08	.27	.29	.27
Nitrite + nitrate nitrogen	97	4.8	.05	2.1	2.3	1.9
Kjeldahl nitrogen	97	3.8	.20	2.1	2.1	2.1
Suspended sediment						
		1985 water year				
Total phosphorus	71	3.8	.12	.26	.34	.44
Nitrite + nitrate nitrogen	65	10	.05	2.9	3.0	2.5
Kjeldahl nitrogen	65	10	.80	2.3	2.7	2.0
Suspended sediment						
		DELAVAN LAKE TRIBUTARY				
		1984 water year				
Total phosphorus	54	.87	.05	.21	.27	.21
Nitrite + nitrate nitrogen	52	1.7	.20	.85	.93	.46
Kjeldahl nitrogen	52	13	.40	1.4	2.2	2.3
Suspended sediment	98	4,990	1	22	225	778
		1985 water year				
Total phosphorus		1.2	.03	.30	.37	.24
Nitrite + nitrate nitrogen		1.4	.40	.80	.78	.28
Kjeldahl nitrogen		7.8	.60	1.7	2.2	1.6
Suspended sediment		7,720	3	84	394	1,034

PRECIPITATION

Concentrations of nutrients in precipitation are low and therefore they account for only a minor part of the external nutrient input to the lake. Data collected during the 1985 water year in the bulk precipitation collector at the DLSD show that total phosphorus concentrations ranged between <0.01 and 0.06 mg/L, nitrite plus nitrate nitrogen concentrations ranged from <0.10 to 0.70 mg/L, and Kjeldahl nitrogen ranged from 0.10 to 1.3 mg/L.

Nutrient Budget

A nutrient budget for Delavan Lake for phosphorus and nitrogen, 1984 and 1985 water years, is shown in table 16. For the 2-year average, most of the phosphorus load (75 percent), nitrite plus nitrate nitrogen load (58 percent), and Kjeldahl nitrogen load (62 percent) entered Delavan Lake through Delavan Lake inlet via Jackson Creek. Phosphorus retention in the lake is small; the 1984 water year showed a phosphorus retention of 8 percent of the incoming load and the 1985 water year showed a phosphorus retention of 20 percent. In contrast nitrite plus nitrate nitrogen loads discharging from the lake in both water years showed a 74 percent reduction from the total input; much of this reduction is due to nitrate nitrogen assimilation by the algal cells. Kjeldahl nitrogen loads show only a slight reduction from the incoming load.

Trophic Condition

The trophic status of Delavan Lake was evaluated by the application of two commonly used methods: Carlson's Trophic State Index and the Vollenweider model. Carlson's Trophic State Index evaluates the in-lake conditions and Vollenweider's model evaluates the nitrogen and phosphorus loadings to a lake.

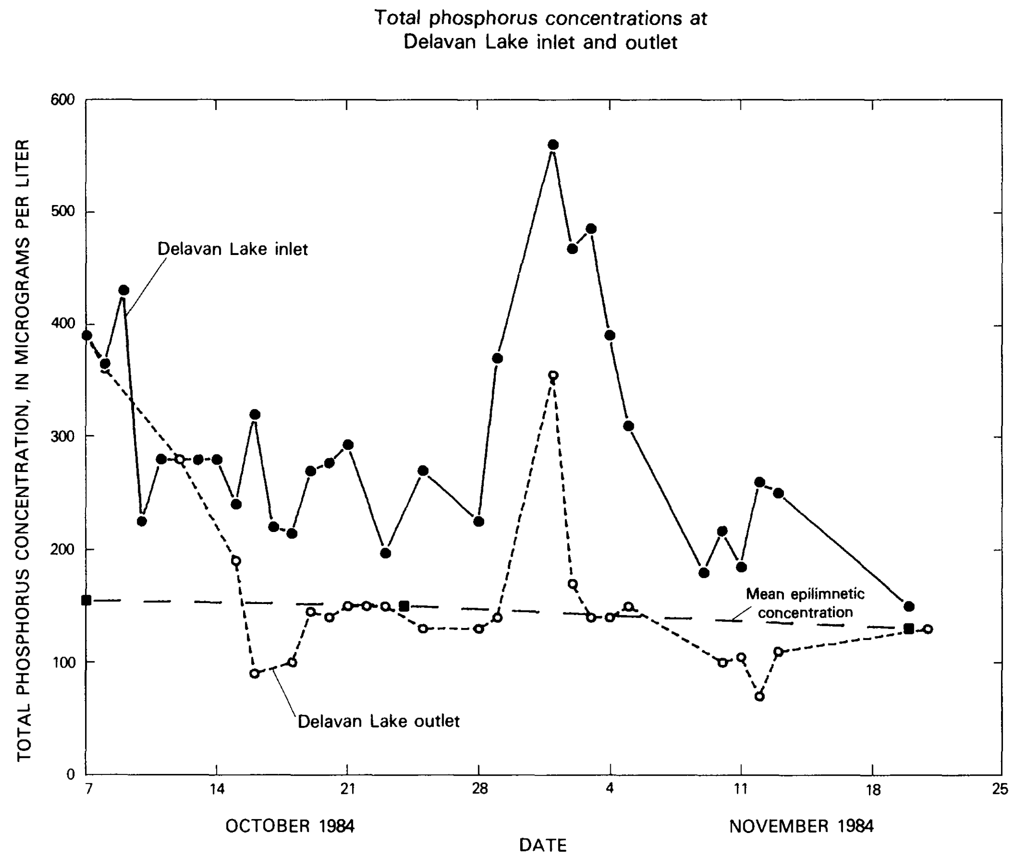


Figure 25. Total phosphorus concentrations at Delavan Lake inlet and outlet.

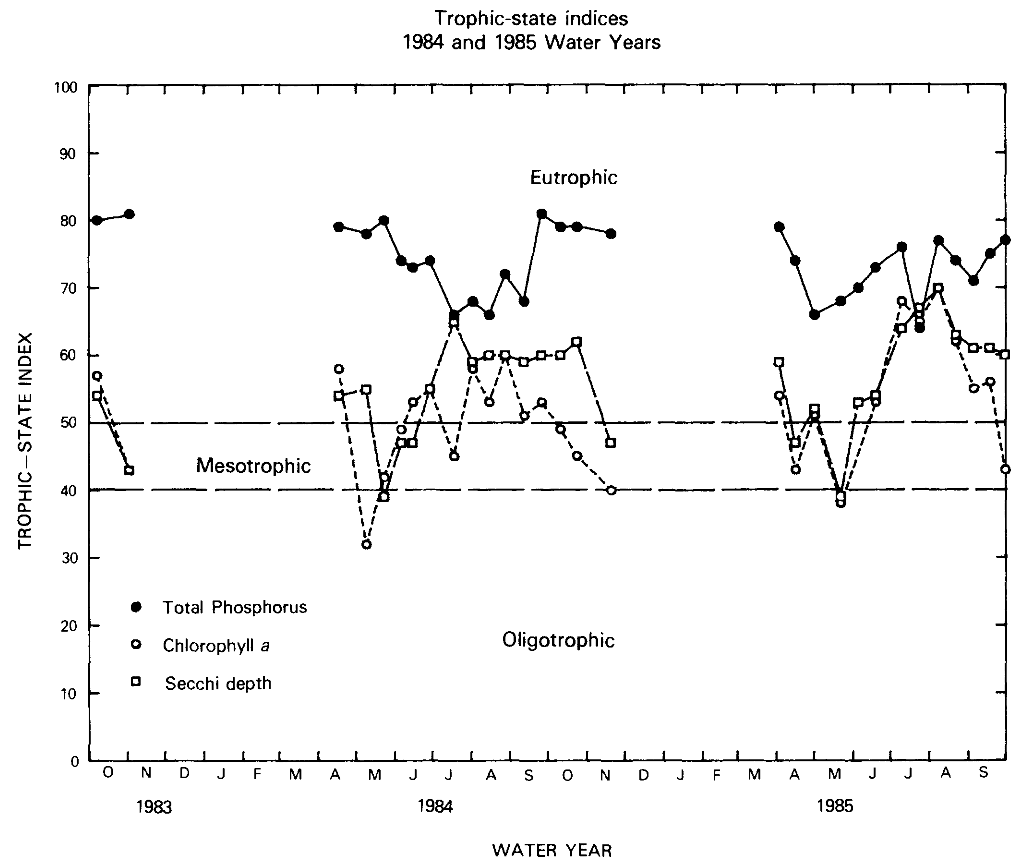


Figure 26. Trophic-state indices, 1984 and 1985 water years.

Table 16. Annual phosphorus and nitrogen budget for Delavan Lake, 1984 and 1985 water years

[lbs, pounds]

	Phosphorus		Nitrite + nitrate nitrogen		Kjeldahl nitrogen	
	Amount (lbs)	Total input (percent)	Amount (lbs)	Total input (percent)	Amount (lbs)	Total input (percent)
			1984 water year			
Inputs						
Delavan Lake inlet	7,040	75	64,300	59	57,500	66
Delavan Lake tributary 1	309	3	6,760	6	1,460	2
Delavan Lake tributary 2	591	6	3,810	3	5,220	6
Delavan Lake drainage shoreline	1,160	12	3,930	4	8,180	9
Delavan Lake precipitation	207	2	6,100	6	8,930	10
Ground water	197	2	23,600	22	6,200	7
TOTAL	9,500	100	109,000	100	87,500	100
Outputs						
Outlet[1]	8,780		28,500		87,900	
Total inputs - total outputs	720		80,500		-400	
TOTAL	9,500		109,000		87,500	
			1985 water year			
Inputs						
Delavan Lake inlet	6,730	75	85,400	58	45,500	57
Delavan Lake tributary 1	279	3	6,150	4	1,260	1
Delavan Lake tributary 2	407	5	4,120	3	3,210	4
Delavan Lake drainage shoreline	1,010	11	3,900	3	6,930	9
Delavan Lake precipitation	243	3	7,340	5	10,100	13
Ground water	311	3	40,500	27	13,100	16
TOTAL	8,980	100	147,000	100	80,100	100
Outputs						
Outlet[1]	7,160		38,300		70,700	
Total inputs - total outputs	1,820		109,000		9,400	
TOTAL	8,980		147,000		80,100	

[1]Corrected for below-dam drainage area.

CARLSON'S TROPHIC-STATE INDEX

The in-lake trophic condition can be evaluated by using Carlson's Trophic State Index (TSI) (Carlson, 1977). The TSI is computed using total phosphorus and chlorophyll *a* concentrations, and Secchi disc transparency readings. Carlson's TSI ranged from 0 for unproductive lakes to 100 for very productive lakes. Carlson, however, did not label ranges of his index in terms of traditional trophic-state terminology. The DNR has used a TSI of 40 to 50 to define mesotrophy, <40 to define oligotrophy, and >50 to define eutrophy (Wisconsin Department of Natural Resources, 1981 and 1983) in evaluating the trophic status of Wisconsin lakes. G.C. Gerloff (University of Wisconsin, written commun., 1984) also uses these boundaries. These boundaries are used in this report to remain consistent with other Wisconsin lake trophic-state evaluations by the DNR.

The water quality of these three categories varies considerably. The waters of oligotrophic lakes are clear, algal populations are low, and the deepest layers are likely supplied with oxygen throughout the year. Mesotrophic lakes have a moderate supply of nutrients and experience moderate algal blooms and occasional oxygen depletions. Eutrophic lakes are nutrient-rich lakes that experience many water-quality problems such as dense algal blooms and oxygen depletion in parts of the lakes during various seasons; fish kills may result at times if severe oxygen depletions occur.

The following equations were utilized to calculate the TSI for Delavan Lake:

$$\text{TSI (Secchi)} = 60 - 33.2\ (\log \text{Secchi depth})$$

$$\text{TSI (chlorophyll } a = 33.60 + 17.64\ (\log \text{chlorophyll } a \text{ concentration})$$

$$\text{TSI (total phosphorus)} = 60 - 33.2 \log \frac{40.5}{\text{total phosphorus concentration}}$$

Values for above are:
- Secchi depth in meters
- Chlorophyll *a* and total phosphorus concentrations in micrograms per liter (values sampled at a 3-ft depth).

The TSI equation for Secchi depth was developed by Carlson (1977) whereas those for chlorophyl *a* and total phosphorus were developed by the DNR (R. Martin, Wisconsin Department of Natural Resources, oral commun., 1985).

The calculated Trophic State Indices for Delavan Lake are well into the eutrophic scale and are shown in figure 26; only values for open-water periods are shown. The illustration shows that total phosphorus is much higher than the TSI calculations for chlorophyll *a* and Secchi disc depth. This is expected during spring and fall periods when algal populations are low but not during summer periods. Therefore, the data suggest that phosphorus is at most times not the limiting nutrient and that there is more phosphorus in the lake than the algal cells can utilize.

VOLLENWEIDER'S MODEL

Total nitrogen and total phosphorus loads to Delavan Lake can be evaluated by comparing these values to those of Vollenweider's model (1971, 1975) for predicting critical levels of total nitrogen and total phosphorus loadings to lakes. The total nitrogen and total phosphorus loading to Delavan Lake for the 1984 and 1985 water years using Vollenweider's classification are shown in figure 27.

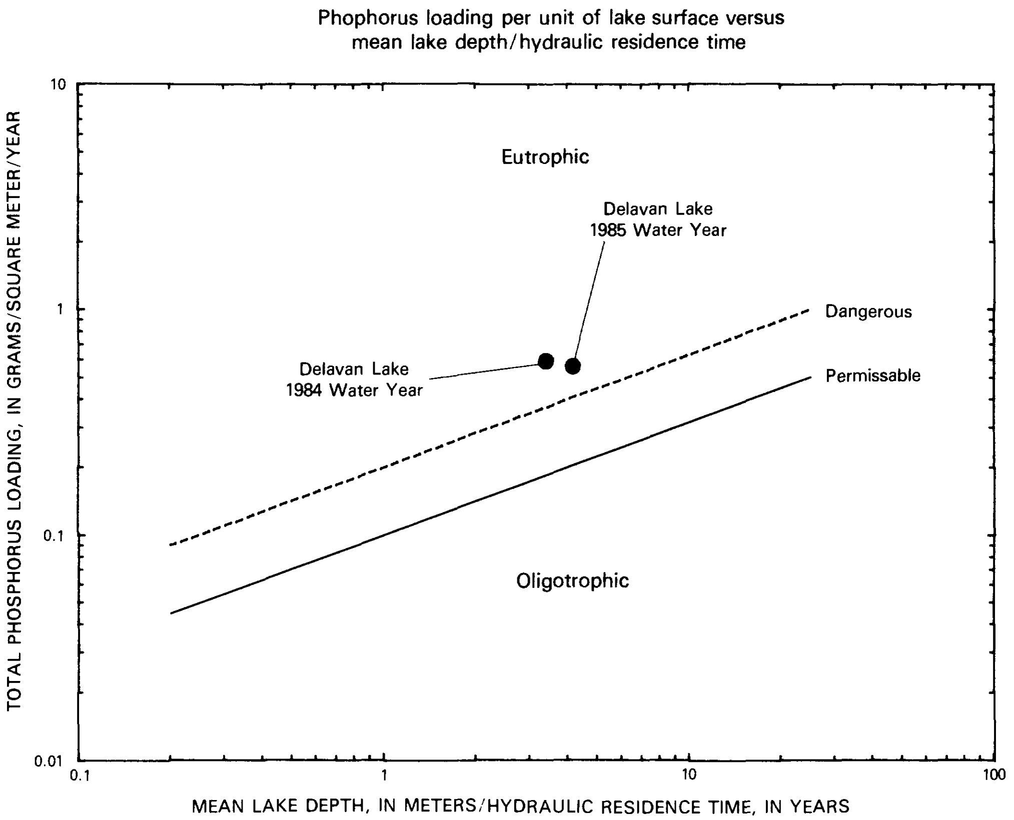
Vollenweider's "dangerous" rate is the rate at which the receiving waters would become eutrophic (nutrient rich) or remain eutrophic. Vollenweider's model for total nitrogen is based on mean lake depth and total nitrogen loading per unit of lake-surface area. Total nitrogen loading rates for Delavan Lake, based on a mean depth of 25 ft (7.6 m), are those greater than 0.00053 lbs/ft^2/yr (2.6 (g/m^2)/yr) (grams per square meter per year). A total nitrogen loading rate of 0.00251 lbs/ft^2/yr (12.3 (g/m^2)/yr) was calculated using Vollenweider's model, based on the 1984 water year total nitrogen load of 196,000 lb. A loading rate of 0.00292 lbs/ft^2/yr (14.3 (g/m^2)/yr) was calculated in the 1985 water year based on the total nitrogen load of 228,000 lb. Total nitrogen loading for both years falls in the "dangerous" category classified by Vollenweider.

Vollenweider's model for evaluating total phosphorus loading to a lake is based on mean lake depth/hydraulic residence time and loading per unit of lake-surface area. Based on the 1984 water year hydraulic residence time of 2.2 years, the total phosphorus dangerous rates are those greater than 0.0000754 (lb/ft^2)/yr [0.37 (g/m^2)/yr]; using the total phosphorus external load of 9,500 lb[7], a phosphorus loading rate of 0.000121 (lb/ft^2)/yr [0.59 (g/m^2)/yr] was calculated. Based on the 1985 water year hydraulic residence time of 1.8 years, the total phosphorus dangerous rates are those greater than 0.0000836 (lb/ft^2)/yr [0.41 (g/m^2)/yr]; using the total phosphorus external load of 8,980 lb, a phosphorus loading rate of 0.000114 (lb/ft^2)/yr [0.56 (g/m^2)/yr] was calculated. Total phosphorus external loading for both years falls into the "dangerous" classification by Vollenweider. Vollenweider's classification does not include internal loading.

Internal Loading

The internal phosphorus supply (phosphorus released from the sediments) can contribute up to 91 percent of total phosphorus input (external and internal load) to a lake

[7] These loads are significantly reduced from these prior to sewage diversion. The total phosphorus contribution in 1972 (U.S. Environmental Protection Agency, 1974) from sewage-treatment plants alone was estimated at 13,400 lb; EPA's total phosphorus estimated load to the lake was 17,600 lb and using Vollenweider's model produced a loading rate of 0.0002296 (lb/ft^2)/yr [1.12 (g/m^2)/yr].



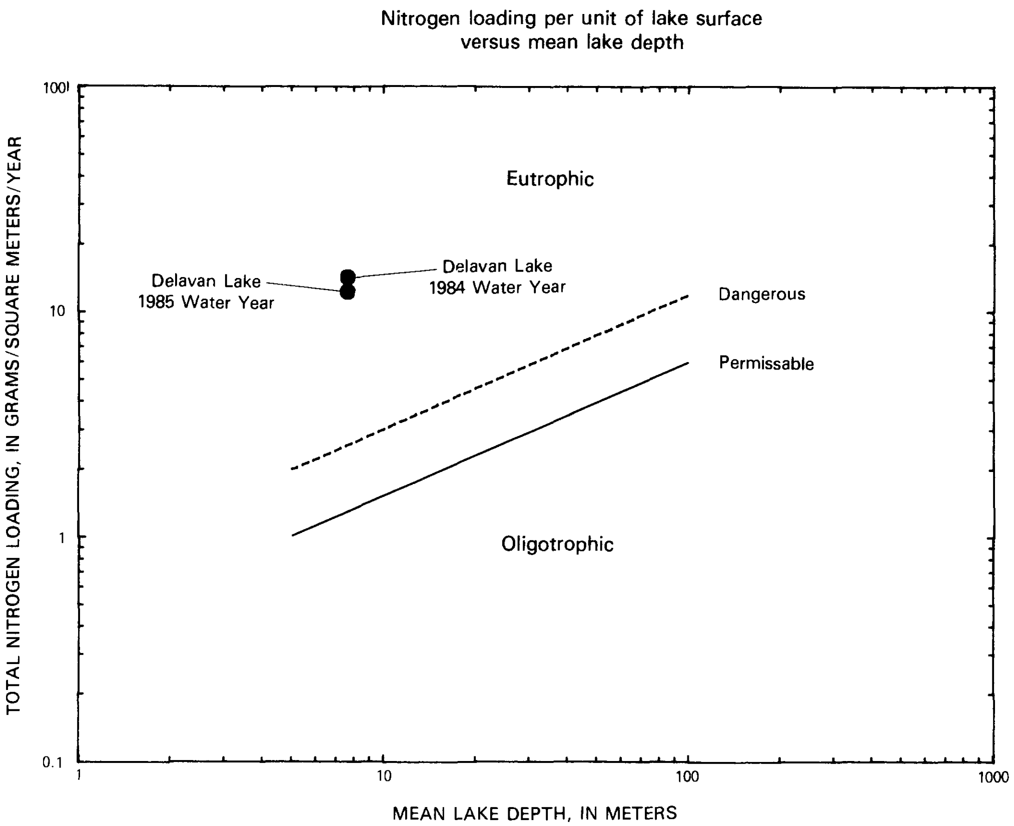


Figure 27. Nitrogen- and phosphorus-loading classifications for Delavan Lake (Vollenweider model).

(Bengtsson, 1978). Nurnberg and Peters (1984) found that for 23 stratified lakes with anoxic hypolimnia, the internal supply contributed an average of 39 percent to the total phosphorus load. They also found in lakes with a long history of high external phosphorus loading the sediments released phosphorus into the anoxic hypolimnia when the external load was reduced. Therefore, these lakes did not respond quickly to external nutrient diversion. The phosphorus release from the Delavan Lake sediments during anoxic periods has been discussed previously in the "Phosphorus" section of this report.

Internal loading to Delavan Lake was calculated using a mass-balance phosphorus budget according to the following equation:

Net gain or loss = change of total phosphorus (TP) in lake + outflow TP mass − inflow TP mass

An increase was considered evidence for internal phosphorus loading, a decrease for sedimentation. A summary of the external input, output, changes in the water column and internal loading/sedimentation are shown in tables 17–18. The data are expressed graphically in figure 15.

Internal loading of phosphorus during both water years exceeded the external loading by more than two times. Internal loading of phosphorus in the 1984 water year was determined to be 23,600 lb, and 26,200 lb for sedimentation. The annual net deposition to the sediments was 2,600 lb. Internal loading of phosphorus in the 1985 water year declined to 19,500 lb from that determined in the 1984 water year. More phosphorus in the 1985 water year was also lost to the sediments, 25,000 lb, for a net loss or deposition of phosphorus to the sediments of 5,500 lb. Net loss of total phosphorus to the sediments for the 2-year period was 8,100 lb.

The phosphorus release rate for the 1984 water year was calculated for the anoxic period, June 10 to September 20, by adding the net gains and dividing by the number of days from June 7 to September 26. This amounted to a release rate of 155 lb/d [70.3 kg/d (kilogram per day)]. When these figures were extrapolated to the weighted mean area of the anoxic bottom sediments (2.70×10^7 ft^2) (2.51×10^6 m^2) the average release rate was 0.574×10^{-5} (lb/ft^2)/d [(28 mg/m^2)/d (milligrams per square meter per day)]. The phosphorus release rate for the 1985 water year was calculated for the anoxic period, June 25 to September 14, by adding the net gains and dividing by the number of days from June 20 to September 18. This amounted to a release rate of 95 lb/d (43.1 kg/d). When these figures were extrapolated to the weighted mean area of the anoxic bottom sediments 2.84×10^7 ft^2 (2.64×10^6 m^2) the average release rate was 0.328×10^{-5} (lb/ft^2)/d [(16 mg/m^2)/d]. These release rates are high when compared to the anoxic lake release rates compiled by Nurnberg (1984): Mendota 0.221×10^{-5} (10.8), Shagawa 0.248×10^{-5} (12.1), White Lake 0.389×10^{-5} (19), Bengundasjoen 0.502×10^{-5} (24.5), Rotsee 0.574×10^{-5} (28). All units are in pounds per square foot per day (milligrams per square meter per day). Rotsee had the highest release rate of the 15 anoxic lakes compiled by Nurnberg. In comparison of the Delavan Lake release rates to that of Lake Mendota, the release rates do not appear excessively high considering the phosphorus accumulation rates due to anoxic release above the bottom sediments for Delavan Lake are almost twice those in Lake Mendota (see section on "Phosphorus").

ASSESSMENT OF LAKE CONDITION

The water-quality goal for Delavan Lake is to reduce phosphorus levels in the lake until phosphorus becomes the limiting nutrient and no longer causes algal problems in the lake. A graph of the phosphorus mass in the lake over time (fig. 28) indicates the trend of the phosphorus mass and whether the lake is improving. An upward trend suggests a worsening condition, a downward trend suggests an improving condition.

The data plotted in the lower graph in figure 28 are the data collected as part of the study and by Stauffer (1974). The data collected by Stauffer show in-lake phosphorus mass as high as 24,800 lb. This translates to an average in-lake concentration of 203 µg/L, using this phosphorus mass and a lake volume of 44,806 acre-ft. The maximum in-lake mass measured during the present study was 22,400 lb and the average phosphorus concentration was 183 µg/L. Stauffer monitored Delavan Lake only from March 12 to October 26, 1972. The maximum in-lake phosphorus mass measured in the 1984 water year was on January 17. Therefore, Stauffer may not have observed the maximum in-lake mass for the water year and it may have been higher than he documented. Stauffer collected the data 9 years prior to sewage diversion and at the time of sewage diversion the phosphorus mass in the lake was likely greater than the present study or Stauffer's data indicate.

The phosphorus data trend shown in figure 28 indicates a reduction in the in-lake phosphorus mass since the start of the project in October 1983, and thus implies an improving condition. It should be noted, however, that the reduction of phosphorus mass was caused by the reduced internal load in the 1985 water year from 1984 because of a shorter anoxic period. Even though the internal load in the 1985 water year was reduced once anoxia began, the dissolved orthophosphorus accumulation rates for both years were approximately the same. Therefore, a longer anoxic period in future years may result in a reversal of the declining phosphorus trend.

CONCLUSIONS

A comprehensive 2-year hydrologic and water-quality investigation of Delavan Lake indicated that, despite the 1981 diversion of sewage effluent and septic leachate from Delavan Lake, large amounts of phosphorus in the bottom sediments

Table 17. Summary of total phosphorus (TP) input, output, and changes in the water column, Delavan Lake, 1984 water year

Period	(1) External TP input (all sources) (pounds)	(2) Date	(3) TP mass in water column (pounds)	(4) Change in TP mass (pounds)	(5) TP output mass (outlet) (pounds)	(6) Internal loading (net TP gain)[2] (pounds)	(6) Sedimentation (net TP loss)[2] (pounds)
		Oct. 1	[1]21,600				
Oct. 1 - 7	27	Oct. 7	21,400	-200	235	8	
Oct. 8 - Nov. 2	220	Nov. 2	20,700	-700	551		369
Nov. 3 - Dec. 7	779	Dec. 7	21,200	+500	919	640	
Dec. 8 - Jan. 17	389	Jan. 17	22,400	+1,200	824	1,640	
Jan. 18 - Mar. 13	2,870	Mar. 13	19,400	-3,000	2,000		3,870
Mar. 14 - Apr. 17	1,240	Apr. 17	17,400	-2,000	1,060		2,180
Apr. 18 - May 9	879	May 9	16,300	-1,100	977		1,000
May 10 - 23	170	May 23	20,600	+4,300	7	4,100	
May 24 - June 6	1,250	June 6	17,000	-3,600	1,100		3,740
June 7 - 29	886	June 29	20,800	+3,800	679	3,590	
June 30 - July 18	400	July 18	12,200	-8,600	314		8,690
July 19 - Aug. 2	47	Aug. 2	9,820	-2,400	55		2,390
Aug. 3 - 15	90	Aug. 15	15,200	+5,400	18	5,330	
Aug. 16 - 28	51	Aug. 28	14,800	-400	22		429
Aug. 29 - Sept. 12	44	Sept. 12	12,000	-2,800	10		2,830
Sept. 13 - 26	143	Sept. 26	20,400	+8,400	6	8,260	
Sept. 26 - 30	14	Sept. 30	19,700	-700	3		711
Total input	9,500		Net change in TP mass:	-1,900	Total outflow: 8,790	23,600	26,200

Internal loading (= Net gains): 23,600
Sedimentation (= Net losses): 26,200
Net deposition (= Sedimentation - Internal loading): 2,600

[1]Estimated from plot.
[2]Net TP gain or loss = ± change in TP mass in lake (4) + outflow TP mass (5) - inflow TP mass (1).

are released when anoxic conditions are reached, causing internal loading to exceed external supply by more than two times. The external loading of phosphorus and nitrogen were assessed using Vollenweider's model and the calculated hydraulic residence times of 2.2 years during the 1984 water year and 1.8 years during the 1985 water year. This model indicated that the loadings are excessive and will cause eutrophic conditions.

Continuous streamflow and water-quality monitoring in the subbasins of the Delavan Lake basin showed a wide range of annual yields of phosphorus and nitrogen. The subbasin of Jackson Creek, which drains mostly the city of Elkhorn, had the greatest average yield of phosphorus (838 lb/mi^2) and Kjeldahl nitrogen (3,600 lb/mi^2). These yields were almost three times those from the headwaters of Jackson Creek, where the largest concentration of livestock is found. Delavan Lake tributary 2 had an extremely low average annual yield of phosphorus (53.1 lb/mi^2) and Kjeldahl nitrogen (550 lb/mi^2). This was due to significantly reduced runoff from storage and evapotranspiration in a large wetland surrounding a large pond in the stream's basin. Most of the average annual input of nutrients flow into Delavan Lake through Delavan Lake inlet via Jackson Creek: phosphorus, 75 percent, nitrate nitrogen, 58 percent, and Kjeldahl nitrogen, 62 percent.

Precipitation was near normal, 32.0 in. during the 1984 water year, but was 7.3 in. greater than normal during the 1985 water year. Phosphorus and Kjeldahl nitrogen loads from external sources were smaller despite the greater than normal precipitation in the second year of study.

The water quality of Delavan Lake indicates eutrophic conditions: average in-lake total phosphorus concentration maximum was 184 μg/L on January 17, 1984; Secchi disc transparency minimum was 1.6 ft on July 10 and August 8,

Table 18. Summary of total phosphorus (TP) input, output, and changes in the water column, Delavan Lake, 1985 water year

Period	(1) External TP input (all sources) (pounds)	(2) Date	(3) TP mass in water column (pounds)	(4) Change in TP mass (pounds)	(5) TP output mass (outlet) (pounds)	(6) Internal loading (net TP gain)[2] (pounds)	(6) Sedimentation (net TP loss)[2] (pounds)
		Oct. 1	[1]19,700				
Oct. 1 - 11	67	Oct. 11	18,100	-1,600	69		1,600
Oct. 12 - 24	419	Oct. 24	18,400	+300	478	359	
Oct. 25 - Nov. 20	1,660	Nov. 20	17,400	-1,000	974		1,690
Nov. 21 - Dec. 18	651	Dec. 18	16,000	-1,400	623		1,430
Dec. 19 - Jan. 24	1,030	Jan. 24	17,100	+1,100	1,070	1,140	
Jan. 25 - Mar. 6	2,060	Mar. 6	13,300	-3,800	966		4,890
Mar. 7 - Apr. 3	1,000	Apr. 3	16,800	+3,500	1,290	3,790	
Apr. 4 - 16	346	Apr. 16	12,300	-4,500	517		4,330
Apr. 17 - May 1	197	May 1	6,630	-5,670	334		5,530
May 2 - 22	196	May 22	9,610	+2,980	4	2,790	
May 23 - June 5	317	June 5	10,100	+500	2	185	
June 6 - 19	91	June 19	11,500	+1,400	4	1,310	
June 20 - July 10	81	July 10	15,300	+3,800	44	3,760	
July 11 - 24	147	July 24	19,500	+4,200	135	4,190	
July 25 - Aug. 8	56	Aug. 8	16,900	-2,600	48		2,610
Aug. 9 - 22	87	Aug. 22	15,700	-1,200	137		1,150
Aug. 23 - Sept. 5	118	Sept. 5	14,000	-1,700	35		1,780
Sept. 6 - 18	389	Sept. 18	14,700	+700	429	740	
Sept. 19-30	66	Sept. 30	16,000	+1,300	8	1,240	
Total input	8,980		Net change in TP mass:	-3,660	Total outflow: 7,170	19,500	25,000

Internal loading (= Net gains): 19,500
Sedimentation (= Net losses): 25,000
Net deposition (= Sedimentation - Internal loading): 5,500

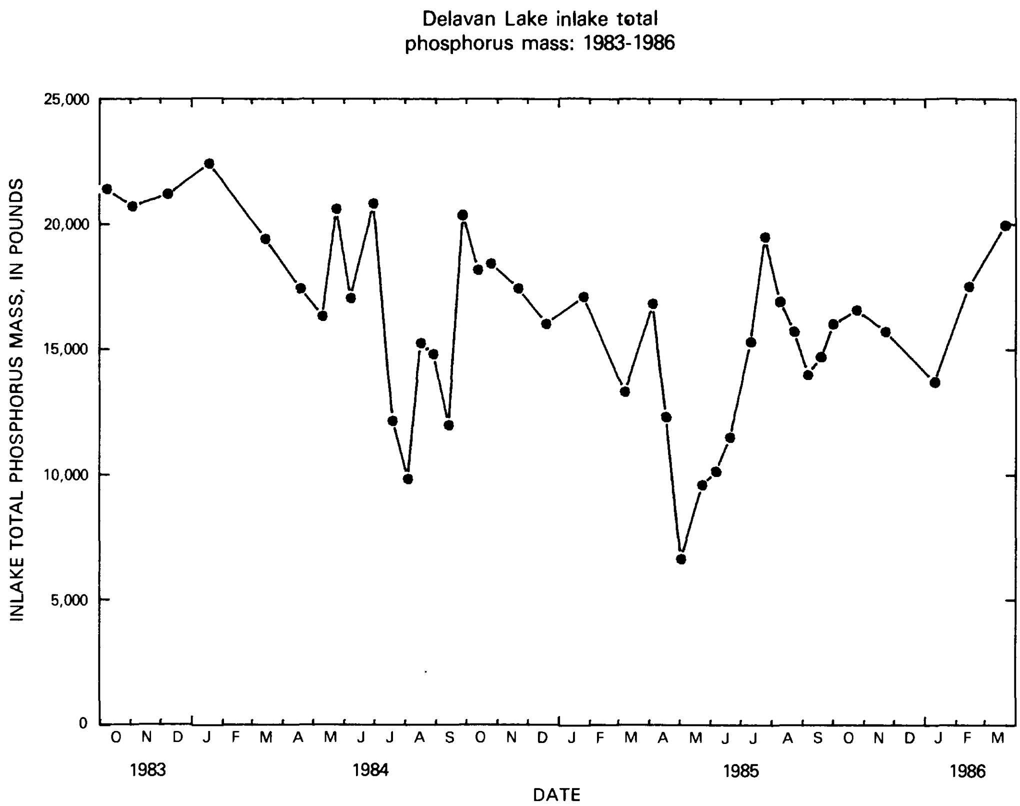
[1]Estimated from plot.
[2]Net TP gain or loss = ± change in TP mass in lake (4) + outflow TP mass (5) - inflow TP mass (1).

1985; chlorophyll *a* concentration maximum was 87 μg/L on July 10. Summer anoxia during the 1984 water year lasted 102 days in 1984 and during the 1985 water year it lasted 81 days. Large amounts of phosphorus are released during summer anoxia into the water column from the bottom sediments, which are high in phosphorus. Dissolved orthophosphorus above the bottom sediments accumulated at a rate of 6.7 μg/L/d during the 1984 water year; during the 1985 water year it was almost the same—7.4 μg/L/d.

Nitrogen limitation occurs frequently in the lake and blue-green algae dominate the summer algal population. Blue-green algae composed 98, 95, and 84 percent of the total algal population during June, July, and August of 1984; the dominant species was *Synechocystis* sp. Blue-green algae declined to 45 percent of the total population during June, 76 percent in July, and 71 percent in August of the 1985 water year; *Synechocystis* sp., *Anabena circinalis*, and *Aphanizomenon flos-aqua* were the dominant species.

Twenty-eight species of zooplankton were found in varying degrees of abundance. The zooplankton community peaked during the 1984 water year in September, after the blue-green algal population declined. The zooplankton community peaked during the 1985 water year in July. The dominant zooplankton in middle to late summer is the cladoceran, *Chydorus sphaericus*.

The benthic community has a small population of macroinvertebrates; the chironomidae are the dominant



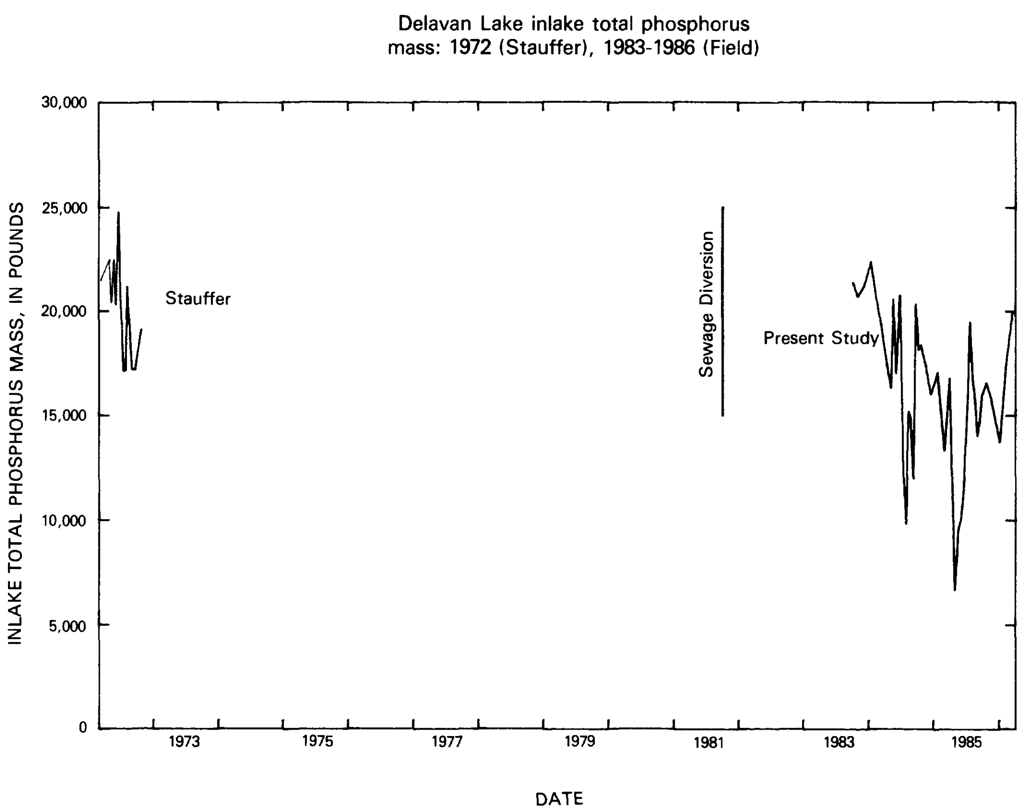


Figure 28. Delavan Lake in-lake phosphorus mass, 1972 and 1983–86.

group. The average number of organisms of 4 sampling periods at 12 sites was 65.7/ft^2 (707/m^2).

The trend of in-lake phosphorus mass is in a declining direction and it suggests an improvement in the water quality of Delavan Lake. However, there is generally more phosphorus in the lake than the algae need to flourish; even though the phosphorus mass is becoming less, a visual improvement in the water quality will not be apparent until phosphorus declines below the point that phosphorus becomes limiting.

The Delavan Lake tributary 2 basin has a large valuable wetland that should be protected from destruction. This wetland reduces storm runoff from this basin by storage and evapotranspiration thereby reducing phosphorus loadings to Delavan Lake.

It is important to maintain a water-quality monitoring program for Delavan Lake and its drainage basin to monitor the phosphorus trend in the lake regardless of the rehabilitation plan chosen. Phosphorus yields in the Jackson Creek tributary basin draining the city of Elkhorn are excessively high: streamflow and phosphorus load monitoring at this gaging station should be continued. Seventy-five percent of the total phosphorus external load flows into Delavan Lake from Jackson Creek through Delavan Lake inlet and therefore this station should also be continued by monitoring streamflow and phosphorus loads. The outlet station at Borg Road should also be continued for monitoring streamflow and phosphorus load. The Delavan Lake tributary 2 gaging station should be operated every 2 to 3 years to insure that runoff characteristics of this valuable basin do not increase. In-lake water-quality monitoring at the same sites as previously monitored for depth profiles of water temperatures, dissolved oxygen, pH, and specific conductance should be continued as well. In-lake samples should also be collected for total phosphorus, dissolved orthophosphate phosphorus, chlorophyll *a*, Secchi depth, phytoplankton, and zooplankton.

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GLOSSARY OF TECHNICAL TERMS

Acre-foot—Volume of water required to cover 1 acre to a depth of 1 foot, and equal to 43,560 ft^3. (Dion and others, 1976)

Aerobic—Having oxygen. (Britton and others, 1975)

Alga, algae, algal—A group of simple primitive plants that live in wet or damp places, and generally are microscopic in size, containing chlorophyll and lacking roots, stems, and leaves. (Britton and others, 1975)

Algal bloom—A high concentration of a particular algal species, amounting to 1/2 million to 1 million cells per liter of water or more. (Britton and others, 1975)

Algicide—A chemical that kills algae. (Britton and others, 1975)

Anaerobic—Devoid of oxygen. (Britton and others, 1975)

Anoxic—See anaerobic. (Britton and others, 1975)

Autumn turnover—The mixing of the entire water mass of a lake in the autumn. (Britton and others, 1975)

Average discharge—As defined in the annual series of U.S. Geological Survey reports on surface-water supply—the arithmetic average of all complete water years of record whether or not they are consecutive. Average discharge is not published for less than 5 years of record. The term "average" is generally reserved for average of record and "mean" is used for averages of shorter periods, namely, daily mean discharge. (Langbein and Iseri, 1960)

Bedrock—A general term for the rock, usually solid, that underlies soil or other unconsolidated, superficial material. (Bates and Jackson, 1980)

Benthic invertebrate—An animal without a backbone, living on or near the bottom of an aquatic environment. (Kuhn and others, 1983)

Benthos, benthic zone—Organisms living in or on the bottom of an aquatic environment. The bottom of a lake or stream. (Dion and others, 1976)

Biomass—The amount of living matter present in a unit area or volume, at any given time. (Dion and others, 1976)

Blue-green algae—A group of algae with a blue pigment, in addition to the green chlorophyll. Blue-green algae group usually causes nuisance conditions in water. (Dion and others, 1976)

*Chlorophyll **a***—Chlorophyll ***a*** is a green photosynthetic pigment present in plant cells, including algae. The concentration of chlorophyll ***a*** in water is a commonly accepted indicator of algal biomass. (Dion and others, 1976)

Color—Color is one control of light transmission through water. High color values in many lakes result from the decomposition of vegetation, which gives the water a brown, tea-like color. Color is determined by a comparison of the water with standardized colored-glass discs and is reported in platinum-cobalt (Pt-CO) units. (Dion and others, 1976)

Cubic feet per second—ft^3/s A unit expressing rates of discharge. One cubic foot per second is equal to the discharge of a stream of rectangular cross section, 1 foot wide and 1 foot deep, flowing water an average velocity of 1 foot per second. (Langbein and Iseri, 1960)

Cubic feet per second day —(ft^3/s)-d) The column of water represented by a flow of 1 cubic foot per second for 24 hours. (Langbein and Iseri, 1960)

Cubic feet per second per square mile—$(ft^3/s)/mi^2$ The average number of cubic feet of water per second flowing from each square mile of area drained by a stream, assuming that the runoff is distributed uniformly in time and area. (Langbein and Iseri, 1960)

Diatom—A unicellular or colonial alga having a siliceous shell. (Dion and others, 1976)

Discharge—In its simplest concept discharge means outflow; therefore, the use of this term is not restricted as to course or location, and it can be applied to describe the volume of the flow of water from a pipe or from a drainage basin. If the discharge occurs in some course or channel, it is correct to speak of the discharge of a canal or of a river. It is also correct to speak of the discharge of a canal or stream into a lake, a stream, or an ocean.

The data in the reports of the Geological Survey on surface water represent the total fluids measured. Thus, the terms discharge, streamflow, and runoff represent water with the solids dissolved in it and the sediment mixed with it. Of these terms, discharge is the most comprehensive. The discharge of drainage basins is distinguished as follows:

Yield—Total water runout or crop; includes runoff plus underflow.

Runoff—That part of water yield that appears in streams.

Streamflow—The actual flow in streams, whether or not subject to regulation, or underflow.

Each of these terms can be reported in total volumes (such as acre-feet) or time rates (such as cubic feet per second or acre-feet per year). The differentiation between runoff as a volume and streamflow as a rate is not accepted. (Langbein and Iseri, 1960)

Dolomite—A carbonate sedimentary rock of which more than 50 percent by weight or by areal percentages under the microscope consists of the mineral dolomite, or a variety of limestone or marble rich in magnesium carbonate. Dolomite occurs in crystalline and noncrystalline forms, is clearly associated and often interbedded with limestone, and usually represents a postdepositional replacement of limestone. Pure dolomite (unless finely pulverized) will effervesce very slowly in cold hydrochloric acid. (Bates and Jackson, 1980)

Drainage area—The drainage are of a stream at a specified location is that area, measured in a horizontal plane, which is enclosed by a drainage divide. (Langbein and Iseri, 1960)

Drainage basin—A part of the surface of the earth that is occupied by a drainage system, which consists of a surface stream or a body of impounded surface water or a body of impounded surface water together with all tributary surface streams and bodies of impounded surface water. (Langbein and Iseri, 1960)

Epilimnion, epilimnetic—The upper, relatively warm, circulating zone of water in a thermally stratified lake. (Dion and others, 1976)

Eutrophication, eutrophic—The natural process of enrichment and aging of a body of water that may be accelerated by the activities of man. Pertains to water bodies in which primary production is high because of a large supply of available nutrients. (Dion and others, 1976)

Evaporation pan—An open tank used to contain water for measuring the amount of evaporation. The U.S. Weather Bureau class A pan is 4 feet in diameter, 10 inches deep, set up on a timber grillage so that the top rim is about 16 inches from the ground. The water level in the pan during the course of observation is maintained between 2 and 3 inches below the rim. (Langbein and Iseri, 1960)

Evaporation, total—The sum of water lost from a given land area during any specific time by transpiration from vegetation and building of plant tissue; by evaporation from water surfaces, moist soil, and snow; and by interception. It has been variously termed "evaporation," evaporation from land areas," evapotranspiration," "total loss," "water losses," and "fly off". (Langbein and Iseri, 1960)

Evapotranspiration—Water withdrawn from a land area by evaporation from water surfaces and moist soil and by plant transpiration. (Langbein and Iseri, 1960)

Gage height—The water-surface elevation referred to some arbitrary gage datum. Gage height is often used interchangeably with the more general term stage although gage height is more appropriate when used with a reading on a gage. (Langbein and Iseri, 1960)

Green algae—Algae that have pigments similar in color to those of higher green plants. Some forms produce algal mats or floating "moss" in lakes. (Dion and others, 1976)

Hardness—Water hardness is defined as the sum of the polyvalent cations expressed as the equivalent quantity of calcium carbonate ($CaCO_3$). As a general rule, hard-water lakes are more productive of plants and animals than soft-water lakes, but there are many exceptions. (Dion and others, 1976)

Hydrology—The science encompassing the behavior of water as it occurs in the atmosphere, on the surface of the ground, and underground. (Langbein and Iseri, 1960)

Hypolimnion, hypolimnetic—The lower, relatively cold, noncirculating water zone in a thermally stratified lake. (Dion and others, 1976)

Limnology—That branch of hydrology pertaining to the study of lakes. (Langbein and Iseri, 1960)

Littoral zone—The shallow zone of a body of water where light penetrates to the bottom. (Dion and others, 1976)

Load—The amount, by weight or volume, of a substance transported by a stream past a specific point during a specified length of time. (Kuhn and others, 1983)

Lugol's solution—A preserving solution for algae made from iodine crystals, potassium iodide, glacial acetic acid, and distilled water. (Dion and others, 1976)

Maximum depth—The difference, in feet of elevation, between the bottom and the surface of the lake. (Dion and others, 1976)

Mean depth—The mean depth, in feet, for a specified lake stage, is obtained by dividing the volume of the lake by its area. (Dion and others, 1976)

Mesotrophic—Intermediate stage in lake classification between the oligotrophic and eutrophic stages, in which primary production occurs at a greater rate than in oligotrophic lakes, but at a lesser rate than in eutrophic lakes. This is due to a moderate supply of nutrients. (See also *Eutrophic* and *Oligotrophic*.) (Dion and others, 1976)

Metalimnion, metalimnetic—The middle layer of water in a thermally stratified lake, in which temperature decreases rapidly with depth. (Dion and others, 1976)

Moraine—A mound, ridge, or other distinct accumulation of unsorted, unstratified glacial drift, predominantly till, deposited chiefly by direct action of glacier ice, in a variety of topographic landforms that are independent of control by the surface on which the drift lies. (Bates and Jackson, 1980)

Nutrient—Any chemical element, ion, or compound that is required by an organism for the continuation of growth, reproduction, and other life processes. (Dion and others, 1976)

Oligotrophic—Pertaining to waters in which primary production is low as a consequence of a small supply of available nutrients. (Britton and others, 1975)

Ordovician—The second earliest period of the Paleozoic era (after the Cambrian and before the Silurian), thought to have covered the span of time between 500 and 440 million years ago. (Bates and Jackson, 1980)

Organic—Pertaining or relating to a compound containing carbon, especially as an essential component. Organic compounds usually have hydrogen bonded to the carbon atom. (Bates and Jackson, 1980)

Paleozoic—An era of geologic time, from the end of the Precambrian to the beginning of the Mesozoic, or from about 570 to about 225 million years ago. (Bates and Jackson, 1980).

pH—pH is the negative logarithm of the effective hydrogen-ion concentration, expressed as a number from 0 to 14. A pH of 7 is neutral, a pH of less than 7 is acidic, and a pH of greater than 7 is basic. (Dion and others, 1976)

Phytoplankton, phytoplanktonic—The plant part of the plankton. (Dion and others, 1976)

Plankton—The individual plant, animal, or bacterium in the plankton community. (Cole, 1979)

Precambrian—All geologic time, and its corresponding rocks, before the beginning of the Paleozoic; it is equivalent to about 90 percent of geologic time. Precambrian time has been divided according to several different systems, all of which use the presence or absence of evidence of life as a criterion. (Bates and Jackson, 1980)

Primary production—The synthesis of organic compounds by green plants in the presence of elements and light energy. (Dion and others, 1976)

Profundal zone—The deep zone of a water body in which plant growth is limited by the absence of light. (Dion and others, 1976)

Quaternary—The second period of the Cenozoic era, following the Tertiary; also, the corresponding system of rocks. It began 2 to 3 million years ago and extends to the present. It consists of two grossly unequal epochs: the Pleistocene, up to about 8,000 years ago, and the Holocene since that time. The Quaternary was originally designated an era rather than a period, with the epochs considered to be periods, and it is still sometimes used as such in the geologic literature. The Quaternary may also be incorporated into the Neogene, when the Neogene is designated as a period of the Tertiary era. (Bates and Jackson, 1980)

Recurrence interval (return period)—The average interval of time within which the given flood will be equaled or exceeded once. (Langbein and Iseri, 1960)

Secchi-disc visibility—Secchi-disc visibility is the depth at which a white-and-black disc (8 inches in diameter) disappears from view when lowered into the water. Secchi-disc visibility depth is a measure of water transparency or clarity. Because changes in biological production can cause changes in the color and turbidity of a lake, Secchi-disc visibility often is used as a gross measure of the plankton in the water. (Dion and others, 1976)

Sediment—Fragmental material, both mineral and organic, that is in suspension or is being transported by the water mass or has been deposited on the bottom of the aquatic environment. (Dion and others, 1976)

Silica—The chemically resistant dioxide of silicon: SiO_2. It occurs naturally in five crystalline polymorphs (the minerals quartz, tridymite, cristobalite, coesite, and stishovite); in cryptocrystalline form (chalcedony); in amorphous and hydrated forms (opal); in less pure forms (e.g., sand, diatomite, tripoli, chert, flint); and combined in silicates as an essential constituent of many minerals. (Bates and Jackson, 1980)

Silurian—A period of the Paleozoic, thought to have covered the span of time between 440 and 400 million years ago; also, the corresponding system of rocks. The Silurian follows the Ordovician and precedes the Devonian; in the older literature, it was sometimes considered to include the Ordovician. (Bates and Jackson, 1980)

Sorption, sorb—To take up and hold by either adhesion or incorporation. A collective term for absorption and adsorption. (Dion and others, 1976)

Species—The basic or final unit for the classification of organisms. (Dion and others, 1976)

Specific conductance—Specific conductance is a measure of the water's ability to conduct an electric current and is used as an approximation of the dissolved-solids concentration in the water. It is measured in units of microsiemens (formerly micromhos) per centimeter at 25° Celsius. (Dion and others, 1976)

Streamflow—The discharge that occurs in a natural channel. Although the term discharge can be applied to the flow of a canal, the word streamflow uniquely describes the discharge in a surface stream course. The term "streamflow" is more general than runoff, as streamflow may be applied to discharge whether or not it is affected by diversion or regulation. (Langbein and Iseri, 1960)

Stream-gaging station—A gaging station where a record of discharge of a stream is obtained. Within the Geological Survey this term is used only for those gaging stations where a continuous record of discharge is obtained. (Langbein and Iseri, 1960)

Surface water—Water on the surface of the earth. (Langbein and Iseri, 1960)

Suspended sediment—Fragmented material, both mineral and organic, that is maintained in suspension in water. (Dion and others, 1976)

Thermal stratification (of a lake)—Vertical temperature stratification that shows the following: the upper layer of the lake, known as the epilimnion, in which water temperature is virtually uniform; a stratum next below, known as the thermocline, in which there is a marked drop in temperature per unit of depth; and the lowermost region or stratum, known as the hypolimnion, in which the temperature from its upper limit to the bottom is nearly uniform. (Langbein and Iseri, 1960)

Unconsolidated material—(a) A sediment that is loosely arranged or unstratified, or whose particles are not cemented together, occurring either at the surface or at depth. (b) Soil material that is in a loosely aggregated form. (Bates and Jackson, 1980)

Water quality—That phase of hydrology that deals with the kinds and amounts of matter dissolved and suspended in natural water, the physical characteristics of the water, and the ecological relationships between aquatic organisms and their environment. (Dion and others, 1976)

Water year—In Geological Survey reports dealing with surface-water supply, the 12-month period, October 1 through September 30. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months. Thus, the year ended September 30, 1959, is called the "1959 water year". (Langbein and Iseri, 1960)

Zooplankton, zooplanktonic—The animal part of the plankton. (Dion and others, 1976)

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HYDROLOGY AND WATER QUALITY OF DELAVAN LAKE IN SOUTHEASTERN WISCONSIN

By
Stephen J. Field *and* Marvin D. Duerk

Water-Resources Investigations Report 87–4168

APPENDICES

Appendix 1a—Phytoplankton populations, (organisms/mL), for Delavan Lake, Southwest End, 1984 Water Year.

Species	10/07 1983	11/02	12/07	1/17 1984	3/13	4/17	5/09	5/23	6/29	7/18	8/02	8/15	8/28	9/12	9/26
CHLOROPHYTA															
Actinastrum hantzschii													2		
Ankyra Judayi	308	36	19	1	15	27	4								
Chlamydomonas flagellate					153	958									
Cosmarium sp.		P									3				
Elakotothrix gelatinosa				1											
Eudorina elegans	10/160	4/32					P	2/64							4
Golenkinia radiata														4	
Oocystis sp.	5	P							97	4				4	
Pandorina morum	20/234							4/64	19/310						
Pediastrum boryanum								2/32	10/640	4/128					
P. duplex									10/1280						
Scenedesmus dimorphous						4									
S. protuberans							P								
S. quadricauda		4													
Schroederia Judayi								40	10		23	72	3		
S. setigera	10	P													
Sphaerocystis schroeteri	15/342						P	9	29	8		8		8	4
Staurastrum sebaldi	15	4	1							16	3	8			4
Tetraedron trigonum						8									
Tetrastrum heteracanthum						4									
T. staurogeniaeformae			1												
CYANOPHYTA															
Anabaena spiroides	29							2	19	8	32	32	59		
Anabaena sp.												144	682	59	10
Aphanizomenon flos-aqua	127	5							78	78	50	8	3	8	
Aphanocapsa rivularis									97	43	6		3		
Coelosphaerium naegelianum									204	4	20	16			
Gomphosphaeria sp.									68	35	6		3	4	2
Lyngbya sp.											117	136	20		2
Merismopedia tenuissima									456	35	35	40	13	21	4
Microcystis aeruginosa		4													
Synechocystis aquatilis		47							22581	5058	6323	8184	208		
Synechocystis sp.															
BACILLARIOPHYTA															
Cyclotella sp.		4	23	1	815	807	P	57							
Fragilaria capucina	54/3480	4/316	8/587			4/64	P	2/28	19/1389		15/1034	8/960	10/359		18/1637
Melosira granulata							P						29/217		
Navicula sp.															
Nitzschia acicularis	P	4	18			428		2				8			
Nitzschia sp.	5					19									
Stephanodiscus astraea	39	2	11	1	2	15	P	2		4	3				
Surirella ovata							P								
CRYPTOPHYTA															
Chroomonas sp.	674	482	307	45	292	303	6	1116		330	152	752	148	181	44
Cryptomonas reflexa	879	160	42					60					63	383	12
Cryptomonas sp.	98	2		63	373	913	8								
Cryptomonas sp.2								146	49		3	8		80	
PYRRHOPHYTA															
Ceratium hirudinella	44	P							107	23	15	72	181	501	106
Gymnoclinium sp.					12	27									
Peridinium sp.													16		
CHRYSOPHYTA															
Dinobryon setularia						15									
Dinobryon sp.	5														
MISCELLANEOUS															
Ciliates											20			105	18
Flagellates	1080	47	13	40	120	261	15							354	409
TOTAL	3318	801	435	152	1782	3789	33	1434	23795	5646	6811	9488	1404	1712	619

Notes: 1. "P" indicates presence of species in the sample.
2. Where stated as a fraction, the numerator is the number of organisms and the denominator is the total number of individuals in that colony.

Appendix 1b—Phytoplankton populations (organisms/mL), for Delavan Lake, Northeast End, 1984 Water Year.

Species	10/07 1983	11/02	12/07	1/17 1984	3/13	4/17	5/09	5/23	6/06	7/18	8/02	8/15	8/28	9/12	9/26
CHLOROPHYTA															
Actinastrum hantzschii	P												21		3
Ankistrodesmus falcatus							1								
Ankyra judayi	155	34	16		33	32	8								
Chlamydomons flagellate					730	1374									
Closterium sp.	P	1													
Coelastrum microsporum	P	1/128													
Cosmarium sp.	3								19					11	
Dictyosphaerium pulchellum															3
Eudorina elegans	P	4/64													5
Golenkinia radiata															3
Oocystis sp.	3/13	1/8							52	10				7	
Pandorina morum	P														8
Pediastrum boryanum	P													4	
P. duplex	3/96														
Scenedesmus acuminatus							1								
S. dimorphous	3													4	
S. protuberans							1								
S. quadricauda	7														
Scenedesmus sp.														4	19
Schroederia judayi								126	19	26	7				
S. setigera	16	3													
Sphaerocystis schroeteri	13/420	1/112						15	6					11	13
Staurastrum sebaldi	10	8	2						6	20		8			3
Tetrastrum heteracanthum							1								
CYANOPHYTA															
Anabaena spiroides	13	1								5		205			3
Anabaena sp.	3	1								10	105		69	11	
Aphanizomenon flos-aqua	92	21									39	174	1109	242	35
Aphanocapsa rivularis									19	103	53	8	7	4	
Coelosphaerium naegelianum									78	31	7	23			
Gomphosphaeria sp.								8	91		13				
Lyngbya sp.									6	10	26		7		8
Merismopedia tenuissima											296	341	7	4	
Microcystis aeruginosa	3	3							142	62	39	8	28	11	
Synechocystis aquatilis		39													
Synechocystis sp.									20474	7189	5514	6340	269		
BACILLARIOPHYTA															
Cyclotella sp.		21	46		388	1173	39			31	13				
Fragilaria capucina	46/2698	8/505	4/217				1/5		19/1729	5/304	7/659			11/1154	29/2031
Melosira granulata										10			14/103	4/29	
Navicula sp.						4	1								
Nitzschia acicularis	26	9	31		52	694		1	6		7	8	7		16
Nitzschia sp.						14									
Stephanodiscus astraea	20		14		3	7	1			10					3
Surirella ovata						11									3
CRYPTOPHYTA															
Chroomonas sp.	570	290	220	590	536	412	34	515		72	665	992	207	18	40
Cryptomonas reflexa	362	128	21					29				16	14	61	8
Cryptomonas sp.	56	9		454	451	1462	8								
Cryptomonas sp.2								24	19		7	45		7	
PYRRHOPHYTA															
Ceratium hirudinella	16	1							32	41	33	68	269	76	159
Gymnoclinium sp.						11									
Peridinium sp.									6				152		
CHRYSOPHYTA															
Mallomonas sp.					88										
MISCELLANEOUS															
Ciliates											26			97	32
Flagellates	319	37	20	18	415	338	18							628	372
TOTAL	1674	606	370	1062	2696	5532	113	718	20975	7630	6850	8236	2166	1200	736

 Appendix 1c—Phytoplankton populations (organisms/mL) for Delavan Lake, Southwest End, 1985 Water Year.

Species	10/11 1984	10/24	11/20 1985	12/18	1/24	3/06	4/02	4/16	5/01	5/22	6/05	6/19	7/10	7/24	8/08	8/22	9/05	9/18	9/30
CHLOROPHYTA																			
Actinastrum hantzschii									43		2	3		15					
Ankistrodesmus falcatus									51										
Chlamydomons flagellate						45	70	634	1291	79	178	21							
Closterium sp.	9		3			1			14		4		7	8		22		38	6
Coelastrum microsporum		2	1						7								4		
Cosmarium sp.	2		2								4			8		7	4		3
Dictyosphaerium pulchellum									36										
Elakotothrix gelatinosa																			5
Eudorina elegans		2																	
Gloeocystis vesiculosa																			2
Oocystis sp.		10	10						7	2	4	12	7	8			7	19	18
Pandorina morum									22	1	2	3							
Pediastrum boryanum											2	3					4		2
P. duplex			1							1				8		7	4	19	6
P. tetras									7										1
Scenedesmus dimorphous		2												23		7			
S. falcatus									22										
Scenedesmus sp.	11	12						3	14		4			8			4	6	
Schroederia judayi		2			1	2	265	3	51	12	32	64	87	68	61	58	18	25	7
Sphaerocystis schroeteri					1					7	6	6						13	3
Staurastrum sebaldi	4	2																	1
Tetrastrum staurogeniaeformae	2	2							29										
CYANOPHYTA																			
Anabaena circinalis										18	1197	618	58	15	61	108	7		3
Anabaena spiroides										1	4			45					
Aphanizomenon flos-aqua	17												7576	3023	1561	2590	1482	1155	16
Aphanocapsa rivularis	2																		
Aphanocapsa sp.										4	2		58	8	8	14			6
Chroococcus limneticus		4																	
Chroococcus dispersus																14	4		
Coelosphaerium naegelianum										1									2
Lyngbya sp.										1	2	3	14		8	22	4		
Microcystis aeruginosa	4	2									2	9	14	23		36	26	13	2
Synechocystis sp.										15	37	10	4329	379	76	58	7		
BACILLARIOPHYTA																			
Asterionella formosa							3												
Cyclotella meneghiniana																		13	
Cyclotella sp.	25	91																	
Fragilaria capucina l.	30/4062	19/3302	42/556	11/430	1/20		22/757				15/842	15/1576	7/216	15/803				13/631	11/792
Gomphonema sp.						3													
Melosira binderana																			5
M. granulata									7					8			15	202	316
Nitzschia acicularis			1	1			16	6		1				15	23				1
Nitzschia sp.															8				
Stephanodiscus astraea		33	32	5	2	1	19	3		1	2								3
S. tenius				3			12540	94	202	6	7		22	83					
Surirella ovata							8												
Synedra sp.														15					
CRYPTOPHYTA																			
Chroomonas sp.	216	152	174	356	385	80	1040	463	916	22	772	876	1600	326	561	137	29	76	5
Cryptomonas reflexa	159	196	105	151	81	11	275	419											
Cryptomonas sp.									1580	48	198	315	36	318	280	238	233	76	42
Cryptomonas sp.2	25	27																	
EUGLENOPHYTA																			
Trachelomonas sp.			5																
PYRRHOPHYTA																			
Ceratium hirudinella	17	27	3							1	28	45		8	8	22	29	6	15
Peridinium sp.							11	19						8		14			
MISCELLANEOUS																			
Ciliates	27	16																	
Flagellates	248	109	58	38	66	55	71	109	1774	35	13	12	498	667	758	224	292	638	52
TOTAL	770	691	395	554	536	198	14318	1753	6073	256	2502	2252	14306	5087	3413	3578	2173	2299	523

Species	10/11 1984	10/24	11/20	12/18	1/24 1985	3/06	4/03	4/16	5/01	5/22	6/05	6/19	7/10	7/24	8/08	8/22	9/05	9/18	9/30
CHLOROPHYTA																			
Actinastrum hantzschii									66	1	8			84	38	7	7		2
Ankistrodesmus falcatus									38	2	4								
Chlamydomons flagellate						56	75	286	298	34	72	17							
Closterium sp.	9					6			5		6			8		7		11	2
Coelastrum microsporum							3												
Cosmarium sp.			1	1					5	2	2			8			7		
Dictyosphaerium pulchellum			1						19										
Elakotothrix gelatinosa												7						4	6
Eudorina elegans	5																7		
Micractinium pusillum																			2
Oocystis sp.	30	11	4	2				3	5	2	4			8		7	7	18	14
Pandorina morum									5	2	2								
Pediastrum boryanum		2	1								2								
P. duplex										5									2
P. tetras																			2
Scenedesmus dimorphous	5								5								14		
Scenedesmus sp.		7						6	24	2		14		17					
Schroederia Judayi		2			1	4	161	8	33	18	106	195	101	42	30	22	65	22	17
Sphaerocystis schroeteri										3	4						7	4	3
Staurastrum sebaldi			2																
Tetrallantos lagerhemii																			2
Tetrastrum staurogeniaeformae		7						3	19										
Truebaria setigerum														17					

Species	10/11 1984	10/24	11/20	12/18	1/24 1985	3/06	4/03	4/16	5/01	5/22	6/05	6/19	7/10	7/24	8/08	8/22	9/05	9/18	9/30
CYANOPHYTA																			
Anabaena circinalis										2	104	779	14	177	136	123	22	11	33
Anabaena spiroides										1				59	8				
Anabaena sp.	5																		
Aphanizomenon flos-aqua												195	3398	3022	2341	3153	1674	1187	174
Aphanocapsa sp.											2		22	51	15		7		2
Chroococcus dispersus																14		7	
Coelosphaerium naegelianum																			2
Lyngbya sp.	5												7	8	8		14		
Microcystis aeruginosa	30	2												8	15	22	22	18	33
Synechocystis sp.										30	9	2164	5144	118	68	22	43		
BACILLARIOPHYTA																			
Cyclotella meneghiniana														673				61	
Cyclotella sp.	69	100																	
Fragilaria capucina 1.	30/4017	9/769	39/1890	12/461			14/472	6/194	5/71		15/1704	36/2380	7/433	8/1263		7/2525	7/433	11/433	25/1563
Melosira binderana																		7	8
M. granulata													7	17			14	325	142
Navicula sp.							6												
Nitzschia acicularis		2	2	2			14	8	9	2	4			8		7		18	3
Nitzschia sp.							42												
Stephanodiscus astraea	14	7	36	1	2	2	14	3		1	6			8					3
S. tenius			5	3	2		352	172	227	57	93	36	7	210		7	72	36	
Surirella ovata				2			11												
Synedra sp.																		7	
CRYPTOPHYTA																			
Chroomonas sp.	964	241	147	253	373	922	744	122	137	33	280	880	418	303	174	7	202	162	5
Cryptomonas reflexa	216	299	98	105	91	34	239	327											
Cryptomonas sp.									412	27	59	65	58	396	114	65	981	216	57
Cryptomonas sp.2	87	11																	
EUGLENOPHYTA																			
Trachelomonas sp.			3																
Phacus sp.									5										
PYRRHOPHYTA																			
Ceratium hirudinella	289	25	1							1	4	7	14		8	22		47	74
Peridinium sp.								69								14	7	4	
MISCELLANEOUS																			
Flagellates	335	120	70	38	41	61	112	211	781	48	51	317	238	438	674	512	375	393	41
TOTAL	2063	836	371	407	510	1085	1773	1218	2093	273	822	4676	9428	5705	3629	4011	3547	2558	629

1. The numerator is the number of organisms and the denominator is the total number of individuals in that colony.

Appendix 2a—Zooplankton populations (count/m^3) for Delavan Lake, Northeast End, 1984 Water Year.

	10/07 1983	11/02	12/07	3/13 1984	4/17	5/23	6/06	6/29	7/18	8/02	8/15	8/28	9/12	9/26
Tow Zone (feet)	29	29	29	30	33	32	29	27	27	24	25	29	30	30
CLADOCERA														
Alona circumfibriata						279								
Bosmina longirostris								203	29599					370
Bosmina spp. (immature)					+									
Chydorus sphaericus	3643	5577	491	54	1731	2653	19063	30425	157864	135182				
Chydorus spp. (immature)											295528	445558	492076	28472
Daphnia catawba				108										
D. galeata mendotae	6147	6587	723	163	+	140		203	1558	1609	3855	3800	3790	1849
D. pulex	683	690	620	136	4699	4189	7525	2231						
D. schodleri									10905	1609	642	+		+
Daphnia spp. (immature)					17806	40491	52675	12170	13501	8851	5782	4750	31584	14790
Diaphanosoma leuchtenbergianum	1366	318								6437	12207	19950	58114	18118
Eubosmina coregoni	62153	18965	1706	54							642	2375	102963	46960
E. longispina		159												
Leptodora kindtii											642	475		
COPEPODA														
Cyclops bicuspidatus thomasi					15828	977	+	203					632	
C. vernalis					+		1505	3043	1558	4023	3855	1425	9475	1479
Diaptomus siciloides	5236	13865	2533	2363	8408	3351	20568	10345	11944	21323	28268	23275	17055	5546
Mesocyclops edax					742	1815	502	3448	3635	3219	21843	16150	13265	6656
Immature copepods				299	26214	33510	249328	28803			30196	25650	27793	26253
Harpacticoida						419			31676	78052				
PARASITIC COPEPODA														
Ergasilus spp. (immature)									519	402			632	1849
ROTIFERA														
Asplanchna spp.									1558				2527	370
Brachionus calyciflorus						140								
Chromogaster spp.														+
Conochiloides spp.					49214			609		402				
Keratella quadrata					247			1420					632	
Keratella spp.									519					
Polyarthra spp.					96203				519					740
Synchaeta spp.							3010							
Trichocerca capucina										402				
Trichocerca spp.											642			
TOTAL (count/m^3)	91300	67781	11786	7509	221092	87964	354176	93103	265355	261511	404102	543408	760538	153452

NOTE: "+" indicates presence in insufficient densities to establish accurate count.

Appendix 2b—Zooplankton populations (count/m³) for Delavan Lake, Northeast End, 1985 Water Year.

	10/11 1984	10/24	11/20	12/18	1/24 1985	3/06	4/03	4/16	5/01	5/22	6/05	6/19	7/10	7/24	8/08	8/22	9/05	9/18	9/30
Tow Zone (feet)	30	30	30	30	42	42	30	30	31	30	30	30	30	30	27	30	30	29	30
CLADOCERA																			
Alona circumfibriata									329		+								
Alona spp. (immature)					92														
Bosmina longirostris			1096	1198	+					327		2325	743	712	921				
Chydorus spp. (immature)	18916	31078	4656	1541	734	108	3613	3513	7560	10790	52297	78708	172364	428704	179525	382087	278944	66546	15653
Daphnia galeata mendotae	757	1366	274	342		108	258	293	657	981	2011	2657	2972	2849	3683	7642	11401	6050	3478
D. pulex						108	1548	585	329	1635	402								
D. retrocurva														712	6444	2866	7601	7778	18262
D. schodleri	378	683	2739	3081	1009				4930	981	2414	10959	8172	1424	6444	+	760	864	
Daphnia spp. (immature)	2648	5123	19721	24137	6328	1190	4645	6733	51274	44794	68791	41513	8915	16379	46953	35343	97288	50126	182621
Diaphanosoma leuchtenbergianum	75286	183053												2849	38667	91701	+	+	870
Eubosmina coregoni			36976	12839	459	+					402	7306	5944	42728	185970	60179	51684	5185	5218
Leptodora kindtii	378													2849	921		760	864	
COPEPODA																			
Cyclops bicuspidatus thomasi	2648	2732	7943	9073	3118	1299	8774	5269	5259	654	1609	332							1739
C. vernalis	378	4098	274	171				+	657	1308	805	1661	+	36319	13810	20060	28882	3457	8696
Diaptomus siciloides	11350	19125	7943	14380	5503	14068	8258	7025	3944	5231	14885	9631	14859	39879	25778	17194	25082	10371	8696
Mesocyclops edax	4162	2049	822				258	585	2301	+	402	7970	14116	19228	14730	21015	12921	14692	4348
Immature copepods	19672	79574	45467	24822	3576	3030	11097	75231	180115	53949	151260	49816	35661	149548	49714	48716	129211	101115	78266
Harpacticoida		342	548	171				+	+	+									
PARASITIC COPEPODA																			
Ergasilus spp. (immature)	757	1025	548		92		258					332							
ROTIFERA																			
Asplanchna spp.		1025	+							+	402								
Brachionus angularis														712					870
B. calyciflorus								+											
B. urceolaris									+										
Conochiloides spp.				342	183	216	258	878	7888										
Filinia spp.															921				
Keratella cochlearis													743				760	1728	870
K. crassa														2136					
K. earlinae		3074	274																
K. quadrata										327	805		+						
Keratella spp.															921				
Polyarthra spp.		342												1424	3683			864	870
Synchaeta spp.				2910	7428	4220	33290	111822		654	402		743						
Trichocerca spp.		342																	
TOTAL (count/m³)	137330	335031	129281	95007	28522	24347	72257	211934	265243	121958	299301	213874	265232	748452	579085	686803	645294	269640	330457

NOTE: "+" indicates presence in insufficient densities to establish accurate count.

Appendix 2c—Zooplankton populations (count/m³) for Delavan Lake, Southwest End, 1984 Water Year.

	10/07 1983	11/02	12/07	1/17 1984	3/13	4/17	5/09	5/23	6/06	6/29	7/18	8/02	8/15	8/28	9/12	9/26
Tow Zone (feet)	29	29	29	31	30	30	30	30	29	27	27	26	23	27	30	30
CLADOCERA																
Alona sp.		35	61													
Bosmina longirostris										576	7749	345				
Bosmina spp. (immature)									+							
Chydorus sphaericus	5495	7333	1478		115	1395	4350	5153	8918	44901	30001	52459				
Chydorus spp. (immature)													125570	92460	358196	14885
Daphnia galeata mendotae	9387	11144	1786	150	161	232						690	1610	6338	14482	8046
D. pulex		718	1170		23	1627	12428	9937	6429	2878						
D. schodleri											5535	2761	1073	746	483	1207
Daphnia spp. (immature)						21385	128009	44534	12859	31661	3321	5867	17709	27589	46826	22930
Diaphanosoma leuchtenbergianum	1602	143										345	2683	10066	44895	26953
Eubosmina coregoni	23125	10209	1909											746	64688	39022
E. longispina		35														
Leptodora kindtii													537	373	965	402
COPEPODA																
Cyclops bicuspidatus thomasi						11622	9321	2944	1452							402
C. vernalis						232	+	+	1244	4030	3321		1610	373	1448	1207
Diaptomus siciloides	8013	6902	5483	3027	1247	9298	6214	11410	1867	8635	16606	8973	12342	2983	13034	5632
Mesocyclops edax						465	3107	2576	10785	7483	5535	1035	14489	8202	13034	3218
Immature copepods					1178	33937	229299	119616	44384	46052	42068	55565	17709	16031	37172	36206
PARASITIC COPEPODA																
Ergasilus spp. (immature)										576		690	537	1491	+	402
ROTIFERA																
Asplanchna spp.										+	1107					
Collotheca spp.													537			
Conochiloides spp.						62529										
Filinia spp.															483	
Keratella cochlearis															483	
K. quadrata							+		1037	2303						
Synchaeta spp.						82984	+	736								
Trichocerca spp.															483	
TOTAL (count/m³)	57924	52012	28087	6054	4919	225706	392728	196906	88975	149095	385253	128730	196406	167398	596672	160512

NOTE: "+" indicates presence in insufficient densities to establish accurate count.

Appendix 2d—Zooplankton populations (count/m³) for Delavan Lake, Southwest End, 1985 Water Year.

	10/11 1984	10/24	11/20	12/18	1/24 1985	3/06	4/03	4/16	5/01	5/22	6/05	6/19	7/10	7/24	8/08	8/22	9/05	9/18	9/30
Tow Zone (feet)	30	30	29	30	42	42	30	30	30	30	30	30	30	24	24	30	30	30	30
CLADOCERA																			
Alona barbulata								+											
A. circumfibriata					113			888			4622								
Alona spp. (immature)				193															
Bosmina longirostris			1983	193	1354	114													
Chydorus spp. (immature)	28054	70994	4250	1926	2369	455	3420	1777	62750	10168	82683	241521	267649	826295	115447	210399	151561	27955	10271
Daphnia galeata mendotae	+	+	1700	1541		569		+	794	1356	3595	4709	2020	6848	7280	6011	17461	3150	5564
D. pulex						1137	950	+	+	4745	514								
D. retrocurva														+		4208	6984	14568	5992
D. schodleri	413	740	1700	3081	1241				6354	7457	3595	11437	2020	5706	8320	+	1397	394	428
Daphnia spp. (immature)	5363	3328	20402	22532	8460	2616	950	13327	50835	84059	34922	54494	10100	13696	26002	45687	50986	20080	20970
Diaphanosoma leuchtenbergianum															20801	55906		1575	1284
Eubosmina coregoni	84574	75062	46187	4815	1692	114		888			1027	9419	46460	104999	172650	88367	32827	5118	8987
Leptodora kindtii		+	283									2018		1141		2405	698		
COPEPODA																			
Cyclops bicuspidatus thomasi	413	14421	6234	6548	5866	2843	4560	5331	15092	+							698	+	+
C. vernalis	5363	4437	567	193		+	190	7996	4766	+	6163	2018	8080	18261	7280	6011	2794	394	1712
Diaptomus siciloides	14852	6286	7651	10207	8799	6141	2850	6219	7943	29827	22597	19510	2020	46793	12481	12023	2095	787	4280
Eucyclops agilis			+																
Mesocyclops edax	1650	4807	283				190	5331	5560	2712	3081	26910	12120	27391	21841	10219	24445	5906	5136
Immature copepods	42907	81717	35703	17911	10378	3866	3610	155480	437661	82025	126849	114369	37370	122118	64483	39074	108957	84258	86449
Harpacticoida			850					888		+									
PARASITIC COPEPODA																			
Ergasilus spp. (immature)		370		385	113		+		794			673			1040		+	787	428
ROTIFERA																			
Ascomorpha spp.													1010						
Brachionus calyciflorus									1589										
Conochiloides spp.				770	564			3554	60367										
Keratella cochlearis	413														2080			394	428
K. crassa														2283					
K. earlinae	825	740									1027								
K. quadrata										+	2054	673							
Keratella spp.													2020						
Polyarthra spp.															2080			394	
Synchaeta spp.				3081	10603	2388	22612	518858		+	514								
Trichocerca multicrinis																+		394	4280
T. similis																			856
Trichocerca spp.	825																		
TOTAL (count/m³)	185652	262902	127793	73376	51552	20243	39332	720537	654505	222349	294270	488424	390869	1175531	461785	480310	400903	166154	157065

NOTE: "+" indicates presence in insufficient densities to establish accurate count.

Appendix 3a—Benthic macroinvertebrate count, Delavan Lake, May 15, 1984.

[units in organisms per square meter]

Site number (fig. 4)	1	2	3	4	5	6	7	8	9	10	11	12
Sampling depth (in feet)	6	10	20	30	40	20	52	75	45	30	15	10
INSECTA												
Diptera												
Chironomidae	1,938	904	732	431	344	3,961	86	5,124	86	388	1,679	120
*Chaoborus sp.					258		861		301			
Trichoptera												
Limnephilidae						43						
Hemiptera												
*Notonectidae		86										
GASTROPODA												
Pulmonata												
Physidae	+	+										
Planorbidae	+	+										+
PELECYPODA												
Sphaeriidae	+	+										+
OLIGOCHAETA												
Tubificidae			+			+		+			+	
HIRUDINEA						172						

1. Each number that appears represents a sample.
2. + denotes presence in sample.

Appendix 3b—Benthic macroinvertebrate count, Delavan Lake, September 15, 1984.

[units in organisms per square meter]

Site number (fig. 4)	1	2	3	4	5	6	7	8	9	10	11	12
Sampling depth (in feet)	6	10	20	30	40	20	52	75	45	30	15	10
INSECTA												
Diptera												
Chironomidae	344/344	43/431	86/43	172/43	43/0	258/0	0/43	388/818			129/258	129/0
*Chaoborus sp.			129/129	560/431	1,033/517		1,206/560	129/0	990/172	603/560		0/86
*Dixidae						43/0						
Ephemeroptera												
Caenidae								0/86				
GASTROPODA												
Pulmonata												
Physidae	+	+	+									+
Lymnaeidae	+											
Planorbidae	+	+	+					+			+	+
Ancylidae						129/43						
Prosobranchia												
Valvatidae		+	+					+			+	+
PELECYPODA												
Sphaeriidae	+	+	+					+			+	+
CRUSTACEA												
Cladocera												
Leptodoridae					+							
*Leptodora kindtii				43/43	0/215			172/0	43/0	43/0		43/0
OLIGOCHAETA												
Tubificidae	+	+										
HIRUDINEA						560/0						
HYDROZOA												
Hydroida						86/0						

1. Where two numbers appear, the numerator is the first sample and the denominator is the second sample.
2. + denotes presence in sample.
3. * means not benthic but found in sample as indicated.

Appendix 3c —Benthic macroinvertebrate count, Delavan Lake, May 23, 1985.

[units in organisms per square meter]

Site number (fig. 4)	1	2	3	4	5	6	7	8	9	10	11	12
Sampling depth (in feet)	6	10	20	30	40	20	52	75	45	30	15	10
INSECTA												
Diptera												
Chironomidae	215/129	431/344	215/129	258/301		517/215		215/344	560/344	0/86	43/43	86/258
*Chaoborus sp.				43/43	215/301		603/861			86/86		
Ephemeroptera												
Caenidae		43/0										
Hemiptera												
*Notonectidae				0/43								
GASTROPODA												
Pulmonata												
Physidae	+	+										
Planorbidae	+										+	
Prosobranchia												
Valvatidae	+	+				+				+		+
PELECYPODA												
Sphaeriidae	+					+						+
OLIGOCHAETA												
Tubificidae	+		+			+		+				+
HYDROZOA												
Hydroida												
Hydra sp.						172/603						

1. Where two numbers appear, the numerator is the first sample and the denominator is the second sample.
2. + denotes presence in sample.
3. * means not benthic but found in sample as indicated.

Appendix 3d—Benthic macroinvertebrate count, Delavan Lake, September 26, 1985.

[units in organisms per square meter]

Site number (fig. 4)	1	2	3	4	5	6	7	8	9	10	11	12
Sampling depth (in feet)	6	10	20	30	40	20	52	75	45	30	15	10
INSECTA												
Diptera												
Chironomidae	258/215	129/172	431/129	172/129	43/86	43/0		86/344		0/215	301/172	258/129
*Chaoborus sp.				0/43	904/603		1,249/947		517/388	172/0		
Trichoptera						43/129						
Limnephilidae								43/0				
GASTROPODA												
Pulmonata												
Lymnaeidae												+
Planorbidae			+			+						+
Ancylidae						+						
Prosobranchia												
Valvatidae												+
PELECYPODA												
Sphaeriidae			+									
CRUSTACEA												
Cladocera												
*Leptodora kindtii	0/43	0/43		43/43	129/43	0/86				0/43	0/43	215/0
OLIGOCHAETA												
Tubificidae		+										
HYDROZOA												
Hydroida												
Hydra sp.						1,033/517						

1. Where two numbers appear, the numerator is the first sample and the denominator is the second sample.
2. + denotes presence in sample.
3. * means not benthic but found in sample as indicated.

Appendix 4a—Suspended-sediment loads at Jackson Creek, 1984 water year.

Jackson Creek near Elkhorn, Wisconsin

Sediment discharge, suspended (tons per day), water year October 1983 to September 1984

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.01	.02	.20	.02	.01	.19	.35	.56	.71	.29	.03	.02
2	.01	.02	.16	.02	.01	.15	.35	.44	.44	.23	.02	.02
3	.01	.02	.12	.03	.01	.12	.35	.41	.27	.18	.02	.01
4	.01	.02	.11	.03	.01	.10	.45	.44	.17	.17	.02	.01
5	.01	.01	.09	.03	.01	.09	.48	.40	.12	.14	.02	.01
6	.01	.01	.08	.03	.01	.05	.44	.36	.08	.12	.02	.01
7	.01	.01	.06	.03	.01	.03	.40	.36	.07	.09	.02	.01
8	.01	.01	.04	.03	.01	.02	.40	.38	.34	.08	.03	.01
9	.01	.01	.03	.03	.01	.01	.41	.46	.21	.08	.02	.01
10	.01	.01	.02	.03	.01	.01	.31	.38	.18	2.4	.01	.01
11	.01	.01	.49	.03	.01	.01	.24	.34	.12	7.3	.01	.01
12	1.0	.01	.72	.03	55	.01	.25	.27	.11	1.0	.01	.01
13	.09	.01	.11	.03	117	.01	.26	.28	.09	.38	.01	.01
14	.04	.01	.06	.03	5.2	.01	.23	.22	.08	.25	.01	.01
15	.03	.01	.07	.03	.94	.45	.24	.20	.06	.19	.01	.01
16	.02	.01	.06	.03	.40	.44	.41	.18	.05	.11	.01	.01
17	.02	.01	.07	.03	.21	.25	.40	.18	.05	.13	.01	.01
18	.02	.01	.06	.03	.25	.17	.32	.20	8.7	.08	.01	.01
19	.02	.10	.06	.03	.70	.05	.26	.23	1.3	.06	.01	.01
20	.02	.81	.05	.02	.30	.27	.22	.21	.27	.05	.01	.01
21	.03	.13	.04	.02	.20	.50	.19	.19	.12	.04	.01	.01
22	.05	.12	.03	.02	.14	.28	.47	.36	.55	.04	.02	.01
23	.22	.97	.02	.02	.18	.40	.88	.41	.76	.04	.01	.01
24	.13	.36	.02	.02	.23	2.4	.31	.19	.19	.03	.01	.03
25	.06	.15	.02	.02	.29	2.7	.10	13	.09	.03	.01	.21
26	.05	.07	.02	.01	.38	1.5	.06	1.1	.06	.03	.02	.09
27	.04	.07	.02	.01	.43	.94	.05	.45	.82	.03	.02	.03
28	.03	1.7	.02	.01	.40	.65	.05	23	.53	.03	.02	.02
29	.03	.29	.02	.01	.25	.48	.92	6.1	.44	.02	.02	.02
30	.02	.27	.02	.01	---	.35	2.4	1.8	.35	.03	.02	.02
31	.02	---	.02	.01	---	.27	---	1.2	---	.03	.02	---
TOTAL	2.05	5.26	2.91	.73	182.61	12.91	12.20	54.30	17.33	13.68	.49	.67
MEAN	.07	.18	.09	.02	6.30	.42	.41	1.75	.58	.44	.02	.02
MAX	1.0	1.7	.72	.03	117	2.7	2.4	23	8.7	7.3	.03	.21
MIN	.01	.01	.02	.01	.01	.01	.05	.18	.05	.02	.01	.01

WATER YEAR 1984 TOTAL 305.13 MEAN .83 MAX 117 MIN .01

Appendix 4b—Total phosphorus loads at Jackson Creek, 1984 water year.

Jackson Creek near Elkhorn, Wisconsin

Phosphorus, total (pounds per day), water year October 1983 to September 1984

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.03	.06	4.86	.25	.16	1.23	2.50	7.09	5.63	.87	.02	.05
2	.03	.07	3.92	.26	.19	1.03	1.17	4.65	4.13	.67	.02	.05
3	.03	.06	3.02	.27	.20	.86	1.06	3.63	2.92	.56	.02	.05
4	.03	.06	2.64	.29	.20	.76	1.23	3.27	2.25	.51	.02	.04
5	.03	.05	2.18	.27	.16	.77	1.19	2.52	1.89	.41	.02	.05
6	.03	.05	1.95	.29	.15	.60	.98	1.89	1.52	.37	.02	.05
7	.03	.05	1.43	.27	.15	.44	.80	1.51	1.98	.27	.03	.06
8	.04	.05	1.02	.27	.15	.40	.72	1.11	1.93	.24	.16	.06
9	.03	.05	.72	.25	.17	.33	.69	.95	1.48	.23	.13	.04
10	.03	.06	.48	.24	.17	.28	.62	.77	1.35	4.50	.08	.05
11	.03	.06	9.23	.23	.28	.26	.59	.73	.99	50.0	.08	.05
12	26.0	.05	25.0	.22	224	.19	1.16	.61	.94	11.0	.08	.04
13	.75	.05	9.73	.22	773	.21	3.86	.65	.85	2.79	.07	.04
14	.26	.05	7.16	.21	159	.22	2.90	.52	.73	1.17	.07	.04
15	.13	.07	5.73	.18	58.0	3.20	3.50	.45	.61	.84	.07	.03
16	.10	.08	4.18	.17	33.0	5.60	9.50	.39	.58	.48	.07	.04
17	.07	.07	3.25	.16	21.0	4.70	9.40	.37	.53	.54	.06	.04
18	.06	.07	2.59	.15	17.0	1.40	6.20	.37	39.0	.30	.06	.03
19	.06	.75	1.96	.15	43.0	.96	3.90	.40	7.39	.21	.05	.03
20	.07	14.0	1.46	.14	15.0	3.00	2.11	.36	3.64	.16	.05	.03
21	.08	4.28	.97	.14	8.84	5.20	1.52	.28	2.68	.12	.05	.03
22	.18	1.34	.60	.14	7.14	3.10	15.0	.54	4.49	.10	.07	.03
23	.63	19.0	.46	.15	5.72	4.20	28.0	.54	4.98	.09	.04	.03
24	.39	6.71	.34	.17	4.59	23.0	19.0	.27	2.93	.06	.05	.39
25	.19	2.39	.25	.18	3.63	24.0	9.63	82.0	2.14	.05	.05	4.15
26	.15	1.65	.25	.17	2.92	14.0	6.65	16.0	1.84	.05	.05	1.47
27	.11	3.15	.25	.19	2.34	9.10	5.44	6.12	17.0	.05	.05	.38
28	.09	55.0	.25	.20	1.89	6.50	6.68	134	4.90	.04	.05	.25
29	.07	20.0	.24	.19	1.59	4.80	20.0	88.0	1.43	.03	.05	.18
30	.06	8.33	.23	.16	---	3.80	41.0	20.0	1.07	.03	.05	.12
31	.06	---	.24	.15	---	3.00	---	8.32	---	.03	.05	---
TOTAL	29.85	137.66	96.59	6.33	1383.64	127.14	207.00	388.31	123.80	76.77	1.74	7.90
MEAN	.96	4.59	3.12	.20	47.7	4.10	6.90	12.5	4.13	2.48	.06	.26
MAX	26.0	55.0	25.0	.29	773	24.0	41.0	134	39.0	50.0	.16	4.15
MIN	.03	.05	.23	.14	.15	.19	.59	.27	.53	.03	.02	.03

WTR YR 1984 TOTAL 2586.69 MEAN 7.07 MAX 773 MIN .02

Appendix 4c—Kjeldahl nitrogen loads at Jackson Creek, 1984 water year.

Jackson Creek near Elkhorn, Wisconsin

Nitrogen, ammonia plus organic, total (pounds per day), water year October 1983 to September 1984

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.22	.99	15.0	2.8	1.7	7.5	51.0	59.0	48.0	5.0	.44	.23
2	.22	1.1	13.0	3.0	1.8	6.6	50.0	53.0	43.0	3.9	.41	.23
3	.21	1.1	11.0	3.2	1.9	5.9	45.0	57.0	38.0	3.4	.40	.23
4	.21	.88	11.0	3.4	1.7	5.5	54.0	69.0	36.0	3.2	.40	.21
5	.20	.75	10.0	3.2	1.5	5.9	53.0	73.0	37.0	2.6	.41	.23
6	.19	.78	10.0	3.5	1.3	4.8	44.0	74.0	34.0	2.4	.48	.24
7	.18	.72	8.2	3.3	1.3	3.8	35.0	81.0	26.0	1.8	.58	.29
8	.29	.77	6.0	3.2	1.3	3.6	32.0	81.0	13.0	1.6	.89	.29
9	.19	.76	4.2	3.0	1.3	3.2	31.0	90.0	9.6	1.6	.64	.32
10	.19	.94	2.8	2.9	1.3	2.7	28.0	69.0	8.9	30.0	.42	.32
11	.22	.96	37.0	2.8	1.8	2.5	27.0	57.0	6.6	194	.41	.34
12	73.0	.77	73.0	2.7	722	2.2	37.0	42.0	6.3	73.0	.41	.36
13	6.5	.73	33.0	2.7	2510	2.6	43.0	40.0	5.8	31.0	.41	.41
14	1.6	.81	27.0	2.7	639	2.6	38.0	28.0	5.1	15.0	.40	.37
15	.90	1.1	23.0	2.7	266	67.0	39.0	21.0	4.2	8.6	.41	.42
16	.70	1.1	19.0	2.6	132	96.0	58.0	16.0	4.1	3.8	.41	.43
17	.62	.98	16.0	2.5	71.0	99.0	56.0	14.0	3.8	3.5	.42	.43
18	.57	.95	14.0	2.3	55.0	16.0	45.0	12.0	212	1.5	.41	.46
19	.59	7.7	11.0	2.2	117	13.0	37.0	12.0	29.0	.89	.38	.25
20	.75	48.0	9.3	2.1	50.0	54.0	32.0	9.2	13.0	.75	.37	.21
21	.94	18.0	7.0	1.9	41.0	75.0	28.0	6.4	9.7	.63	.42	.34
22	2.1	9.6	4.9	1.9	35.0	55.0	90.0	8.6	16.0	.61	.55	.42
23	15.0	61.0	3.9	2.0	28.0	67.0	169	7.5	18.0	.58	.33	.51
24	9.0	32.0	3.2	2.1	23.0	165	87.0	5.5	11.0	.46	.32	1.7
25	2.7	13.0	2.7	2.1	18.0	175	38.0	219	7.7	.40	.30	14.0
26	2.0	8.9	2.8	2.0	15.0	130	27.0	90.0	6.6	.46	.28	3.9
27	1.5	16.0	2.8	2.1	12.0	102	23.0	66.0	60.0	.49	.27	.95
28	1.3	159	2.8	2.2	10.0	85.0	23.0	432	16.0	.49	.23	.76
29	1.1	43.0	2.7	2.0	8.6	72.0	49.0	376	7.5	.40	.23	.68
30	.89	20.0	2.6	1.8	---	62.0	103	107	5.9	.46	.24	.64
31	.94	---	2.7	1.6	---	55.0	---	58.0	---	.48	.22	---
TOTAL	125.02	452.39	391.6	78.5	4769.5	1447.4	1472.0	2333.2	741.8	393.00	12.49	30.17
MEAN	4.03	15.1	12.6	2.53	164	46.7	49.1	75.3	24.7	12.7	.40	1.01
MAX	73.0	159	73.0	3.5	2510	175	169	432	212	194	.89	14.0
MIN	.18	.72	2.6	1.6	1.3	2.2	23.0	5.5	3.8	.40	.22	.21

WTR YR 1984 TOTAL 12246.95 MEAN 33.5 MAX 2510 MIN .18

Appendix 4d—Nitrite plus nitrate nitrogen loads at Jackson Creek, 1984 water year.

Jackson Creek near Elkhorn, Wisconsin

Nitrogen, nitrite plus nitrate (pounds per day), water year October 1983 to September 1984

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.01	2.2	149	16.0	9.4	136	155	688	465	121	.01	.01
2	.01	2.4	127	17.0	10.0	117	150	493	370	94.0	.01	.01
3	.01	2.2	103	18.0	11.0	102	140	420	284	80.0	.01	.01
4	.01	1.9	95.0	18.0	10.0	93.0	165	413	238	75.0	.01	.01
5	.01	1.6	83.0	17.0	9.1	98.0	160	347	216	61.0	.01	.01
6	.01	1.7	78.0	18.0	7.9	78.0	137	284	186	56.0	.01	.01
7	.01	1.6	60.0	17.0	8.2	60.0	119	247	213	41.0	.03	.01
8	.01	1.7	48.0	16.0	8.3	56.0	106	198	177	37.0	.10	.01
9	.01	1.7	39.0	15.0	8.5	49.0	100	183	139	36.0	.03	.01
10	.01	2.2	30.0	14.0	8.5	41.0	88.0	146	129	120	.01	.01
11	.01	2.2	132	14.0	9.6	37.0	82.0	133	97.0	561	.01	.01
12	205	1.8	445	13.0	665	31.0	106	107	95.0	159	.01	.01
13	25.0	1.8	306	13.0	3150	36.0	130	109	88.0	85.0	.01	.01
14	.53	2.0	246	12.0	2140	36.0	125	85.0	78.0	53.0	.01	.01
15	.37	2.6	209	12.0	1290	166	142	70.0	67.0	39.0	.01	.01
16	.32	2.8	163	12.0	823	241	230	58.0	66.0	22.0	.01	.01
17	.34	2.5	135	11.0	689	213	238	53.0	62.0	25.0	.01	.01
18	.35	2.4	110	10.0	674	107	186	52.0	1540	14.0	.01	.01
19	.42	10.0	89.0	9.6	1240	97.0	149	54.0	747	9.3	.01	.01
20	.61	122	70.0	9.3	823	165	124	46.0	429	5.1	.01	.01
21	.87	79.0	51.0	8.9	606	220	105	35.0	303	2.5	.01	.01
22	2.3	39.0	35.0	9.0	527	165	270	52.0	481	1.5	.01	.01
23	9.5	170	26.0	9.3	448	195	643	48.0	514	.86	.01	.01
24	6.9	122	21.0	10.0	380	450	777	31.0	289	.41	.01	.85
25	4.3	74.0	17.0	10.0	319	470	538	1480	202	.21	.01	16.0
26	3.7	51.0	17.0	9.8	271	360	413	980	164	.14	.01	13.0
27	3.2	39.0	17.0	11.0	230	290	371	495	302	.10	.01	3.6
28	3.2	448	17.0	11.0	194	250	397	2190	189	.06	.01	2.6
29	2.7	437	16.0	11.0	161	215	417	2140	178	.03	.01	2.3
30	2.2	229	16.0	9.7	---	185	1330	910	146	.02	.01	2.1
31	2.2	---	16.0	8.8	---	165	---	624	---	.01	.01	---
TOTAL	274.12	1857.3	2966.0	390.4	14730.5	4924.0	8093.0	13171.0	8454.0	1699.24	.44	40.68
MEAN	8.84	61.9	95.7	12.6	508	159	270	425	282	54.8	.01	1.36
MAX	205	448	445	18.0	3150	470	1330	2190	1540	561	.10	16.0
MIN	.01	1.6	16.0	8.8	7.9	31.0	82.0	31.0	62.0	.01	.01	.01

WTR YR 1984 TOTAL 56600.46 MEAN 155 MAX 3150 MIN .01

Appendix 4e—Suspended-sediment loads at Jackson Creek, 1985 water year.

Jackson Creek near Elkhorn, Wisconsin

Sediment discharge, suspended (tons per day), water year October 1984 to September 1985

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.01	21	.56	.70	.03	1.6	1.2	.09	.07	.01	.03	.01
2	.01	1.8	.75	.62	.03	.82	.96	.08	.05	.01	.02	.01
3	.02	.82	.62	.41	.03	.38	.82	.07	.04	.01	.02	.01
4	.02	.54	.40	.36	.03	1.5	.68	.07	.03	.01	.02	.01
5	.02	.38	.22	.30	.04	.87	.67	.08	.02	.01	.02	.01
6	.02	.29	.17	.26	.04	.37	1.8	.08	.02	.01	.02	.01
7	.04	.24	.12	.23	.03	.48	1.7	.05	.01	.01	.02	.01
8	.03	.20	.09	.19	.03	3.1	.65	.05	.01	.01	.02	.02
9	.02	11	.07	.16	.03	1.7	.50	.04	.01	.01	.02	1.1
10	.02	4.3	.09	.14	.03	1.1	.49	.04	.01	.01	.02	.08
11	.02	1.2	.11	.13	.04	1.1	.48	.04	.01	.01	.02	.02
12	.02	.49	.83	.11	.06	.75	.48	.04	.01	.01	.02	.01
13	.02	.39	.77	.10	.07	.59	.55	.03	.01	.02	.06	.01
14	.02	.37	.41	.09	.03	.52	.60	.03	.01	.15	.02	.01
15	.02	.36	.54	.09	.03	.38	.59	.06	.01	.03	.01	.01
16	.15	.30	1.1	.08	.03	.32	.46	.05	.03	.02	.01	.01
17	.16	.28	.60	.08	.03	.25	.37	.07	.04	.02	.01	.01
18	.84	.29	.36	.07	.02	.20	.35	.05	.04	.02	.01	.01
19	4.0	.27	.28	.07	.02	.18	.27	.04	.04	.03	.01	.01
20	.29	.32	.20	.07	.02	.14	.22	.04	.04	.03	.01	.01
21	.33	.38	.20	.06	1.6	.12	.18	.03	.04	.03	.01	.01
22	.38	.37	.17	.06	8.5	.10	.15	.03	.05	.02	.01	.01
23	.34	.37	.13	.05	10	.10	.15	.03	.03	.02	.01	.01
24	.31	.34	.10	.04	15	.17	.17	.03	.02	.02	.10	.01
25	.30	.32	.09	.04	4.2	.15	.13	.03	.02	.04	2.3	.01
26	.27	.29	.08	.04	2.2	.15	.11	.18	.02	.03	.01	.01
27	.64	1.5	.12	.04	1.8	.18	.10	1.7	.01	.02	.01	.01
28	1.2	1.1	2.4	.04	1.6	3.2	.09	.34	.01	.02	.01	.01
29	.38	.91	29	.04	---	1.0	.08	.20	.01	.02	.01	.01
30	.28	.67	3.6	.04	---	.79	.09	.15	.01	.02	.01	.01
31	.57	---	1.1	.03	---	1.2	---	.11	---	.04	.01	---
TOTAL	10.75	51.09	45.28	4.74	45.57	23.51	15.09	3.93	.73	.72	2.88	1.48
MEAN	.35	1.70	1.46	.15	1.63	.76	.50	.13	.02	.02	.09	.05
MAX	4.0	21	29	.70	15	3.2	1.8	1.7	.07	.15	2.3	1.1
MIN	.01	.20	.07	.03	.02	.10	.08	.03	.01	.01	.01	.01

CAL YR 1984 TOTAL 402.03 MEAN 1.10 MAX 117 MIN .01
WTR YR 1985 TOTAL 205.77 MEAN .56 MAX 29 MIN .01

Appendix 4f—Total phosphorus loads at Jackson Creek, 1985 water year.

Jackson Creek near Elkhorn, Wisconsin

Phosphorus, total (pounds per day), water year October 1984 to September 1985

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.10	222	3.51	3.90	.20	19.0	3.04	.19	.30	.08	.02	.05
2	.09	50.0	4.16	3.56	.19	19.0	1.98	.17	.18	.12	.02	.05
3	.10	17.0	2.92	2.43	.19	9.82	2.05	.16	.11	.10	.02	.04
4	.10	8.47	1.94	1.94	.18	18.0	2.22	.16	.07	.09	.01	.04
5	.11	5.49	1.29	1.65	.20	34.0	2.83	.18	.05	.10	.02	.04
6	.12	3.85	1.20	1.46	.20	13.0	5.55	.19	.03	.11	.01	.04
7	.23	2.98	.97	1.31	.17	13.0	4.00	.13	.03	.10	.01	.04
8	.18	2.34	.91	1.12	.15	37.0	2.33	.12	.03	.10	.01	2.34
9	.18	55.0	.81	.86	.15	21.0	2.29	.11	.02	.10	.01	26.0
10	.24	40.0	.79	.78	.15	11.0	2.49	.11	.02	.10	.01	3.58
11	.33	12.0	1.01	.73	.19	11.0	2.66	.11	.03	.09	.01	.67
12	.50	7.74	12.0	.65	.27	7.20	2.95	.13	.02	.10	.01	.32
13	.51	5.84	11.0	.60	.33	5.74	3.69	.09	.02	.13	.06	.19
14	.57	4.95	5.65	.56	.15	5.11	4.38	.09	.02	1.75	.03	.14
15	.55	4.23	8.89	.49	.14	3.77	4.96	.19	.64	.11	.02	.13
16	3.00	3.21	26.0	.45	.14	3.22	4.74	.17	1.08	.07	.02	.11
17	5.41	2.66	12.0	.45	.13	2.52	3.66	.23	.36	.06	.02	.10
18	7.32	2.44	7.72	.45	.12	2.03	3.24	.16	.19	.06	.03	.09
19	65.0	1.91	6.06	.45	.12	1.88	2.36	.15	.12	.08	.03	.09
20	11.0	1.43	4.64	.42	.13	1.50	1.81	.14	.10	.07	.03	.08
21	13.0	1.21	4.84	.32	33.0	1.22	1.37	.11	.13	.06	.05	.08
22	8.49	1.23	4.17	.32	171	1.10	1.08	.12	.16	.05	.05	.09
23	3.96	1.30	3.32	.29	176	1.09	.95	.12	.11	.04	.04	.08
24	2.13	1.26	2.79	.26	202	1.76	.91	.11	.09	.05	.27	.07
25	1.34	1.22	2.48	.25	96.0	1.52	.63	.11	.08	.07	18.0	.06
26	1.28	1.19	2.36	.25	38.0	1.56	.46	.98	.08	.05	.53	.06
27	4.23	21.0	2.66	.25	20.0	1.85	.36	23.0	.08	.03	.09	.05
28	25.0	14.0	48.0	.25	12.0	22.0	.30	4.39	.08	.03	.05	.05
29	7.20	7.78	210	.23	---	5.88	.23	1.68	.07	.02	.07	.04
30	4.10	4.86	30.0	.21	---	3.18	.22	1.01	.07	.02	.14	.05
31	2.42	---	9.24	.20	---	3.78	---	.58	---	.04	.06	---
TOTAL	168.79	508.59	433.33	27.09	751.50	283.73	69.74	35.19	4.37	3.98	19.75	34.77
MEAN	5.44	17.0	14.0	.87	26.8	9.15	2.32	1.14	.15	.13	.64	1.16
MAX	65.0	222	210	3.90	202	37.0	5.55	23.0	1.08	1.75	18.0	26.0
MIN	.09	1.19	.79	.20	.12	1.09	.22	.09	.02	.02	.01	.04

CAL YR 1984 TOTAL 3433.28 MEAN 9.38 MAX 773 MIN .02
WTR YR 1985 TOTAL 2340.77 MEAN 6.41 MAX 222 MIN .01

Appendix 4g—Kjeldahl nitrogen loads at Jackson Creek, 1985 water year.

Jackson Creek near Elkhorn, Wisconsin

Nitrogen, ammonia plus organic, total (pounds per day), water year October 1984 to September 1985

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.64	518	37.0	38.0	1.0	101	48.0	2.6	9.1	.47	.42	.33
2	.53	91.0	55.0	33.0	1.0	73.0	26.0	2.2	7.0	.72	.27	.30
3	.52	40.0	46.0	22.0	.97	34.0	24.0	2.0	5.3	.60	.26	.28
4	.48	26.0	33.0	18.0	.97	100	24.0	1.9	4.6	.50	.26	.27
5	.47	18.0	11.0	15.0	1.1	210	27.0	2.1	3.8	.58	.31	.26
6	.45	13.0	10.0	13.0	1.0	80.0	60.0	2.1	2.5	.59	.25	.25
7	.77	11.0	8.1	11.0	.91	85.0	55.0	1.4	2.2	.51	.22	.23
8	.57	9.3	7.6	8.8	.81	160	41.0	1.2	2.0	.49	.18	6.0
9	.54	569	6.8	7.3	.76	145	35.0	1.1	1.5	.50	.17	61.0
10	.65	266	6.6	6.2	.79	120	33.0	.98	1.0	.48	.25	6.9
11	.85	115	6.9	5.6	1.1	125	31.0	.95	1.5	.44	.19	1.7
12	1.2	73.0	27.0	4.8	1.5	85.0	29.0	1.1	1.4	.45	.19	.83
13	1.2	56.0	32.0	4.2	1.7	58.0	32.0	.73	1.1	.57	2.0	.50
14	1.2	48.0	24.0	3.7	.78	52.0	33.0	.73	.81	5.5	.42	.37
15	1.1	41.0	33.0	3.6	.69	38.0	32.0	1.2	4.3	.66	.19	.34
16	10.0	32.0	70.0	3.2	.71	33.0	28.0	1.0	7.8	.42	.17	.30
17	26.0	27.0	56.0	3.0	.64	26.0	23.0	1.5	3.2	.37	.17	.28
18	31.0	25.0	39.0	2.9	.61	21.0	21.0	1.1	1.3	.36	.18	.27
19	202	20.0	33.0	2.7	.62	19.0	17.0	.93	.98	.48	.19	.26
20	39.0	15.0	26.0	2.4	.64	15.0	14.0	.84	.81	.43	.15	.25
21	42.0	13.0	27.0	2.1	97.0	13.0	11.0	.65	1.0	.34	.31	.27
22	28.0	12.0	23.0	2.0	465	11.0	9.0	.66	1.3	.27	.35	.30
23	15.0	13.0	18.0	1.7	525	11.0	8.4	.69	.80	.25	.28	.31
24	10.0	12.0	15.0	1.5	631	16.0	8.5	.65	.67	.28	1.7	.28
25	7.2	11.0	14.0	1.4	253	12.0	6.2	.67	.58	.60	56.0	.26
26	6.2	10.0	13.0	1.4	123	11.0	4.8	4.1	.59	.34	2.7	.27
27	19.0	103	15.0	1.4	79.0	12.0	4.0	97.0	.55	.27	.67	.24
28	79.0	83.0	175	1.3	65.0	101	3.6	40.0	.51	.26	.39	.22
29	20.0	65.0	938	1.2	---	42.0	2.9	25.0	.48	.25	.50	.21
30	11.0	46.0	188	1.1	---	29.0	3.0	19.0	.46	.27	.97	.24
31	7.4	---	74.0	1.0	---	52.0	---	14.0	---	.80	.40	---
TOTAL	563.97	2381.3	2068.0	224.5	2256.30	1890.0	694.4	230.08	69.14	19.05	70.71	83.52
MEAN	18.2	79.4	66.7	7.24	80.6	61.0	23.1	7.42	2.30	.61	2.28	2.78
MAX	202	569	938	38.0	631	210	60.0	97.0	9.1	5.5	56.0	61.0
MIN	.45	9.3	6.6	1.0	.61	11.0	2.9	.65	.46	.25	.15	.21

CAL YR 1984 TOTAL 16291.20 MEAN 44.5 MAX 2510 MIN .21

WTR YR 1985 TOTAL 10550.84 MEAN 28.9 MAX 938 MIN .15

Appendix 4h—Nitrite plus nitrate nitrogen loads at Jackson Creek, 1985 water year.

Jackson Creek near Elkhorn, Wisconsin

Nitrogen, nitrite plus nitrate (pounds per day), water year October 1984 to Septemper 1985

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	2.1	1960	160	396	26.0	625	314	29.0	75.0	.54	.12	.16
2	1.9	1220	230	356	25.0	550	267	24.0	60.0	.68	.10	.11
3	2.1	630	190	243	25.0	394	247	21.0	51.0	.48	.10	.07
4	2.2	426	140	214	25.0	450	223	19.0	44.0	.34	.10	.06
5	2.5	305	92.0	180	27.0	800	240	19.0	37.0	.33	.12	.06
6	2.7	236	90.0	157	27.0	370	300	18.0	24.0	.28	.10	.06
7	5.2	202	75.0	140	24.0	380	290	11.0	21.0	.21	.09	.05
8	4.1	175	70.0	118	21.0	824	280	9.3	19.0	.17	.07	6.3
9	3.1	678	60.0	102	20.0	600	227	8.2	14.0	.14	.07	96.0
10	2.9	959	60.0	90.0	21.0	500	205	6.9	9.5	.12	.10	12.0
11	2.9	479	65.0	84.0	28.0	520	182	6.3	14.0	.11	.08	2.1
12	3.4	321	151	74.0	40.0	400	167	6.7	13.0	.11	.08	.69
13	3.3	261	150	68.0	47.0	325	173	4.3	10.0	.14	1.2	.29
14	3.5	238	181	63.0	21.0	320	171	4.1	7.5	4.0	.18	.15
15	3.2	219	244	62.0	19.0	258	161	7.5	36.0	.17	.08	.10
16	10.0	178	623	57.0	20.0	218	138	5.9	60.0	.11	.07	.06
17	19.0	159	508	56.0	18.0	170	118	7.5	28.0	.10	.07	.06
18	30.0	157	360	56.0	17.0	136	117	4.8	14.0	.10	.07	.06
19	627	132	317	55.0	17.0	125	96.0	4.0	8.6	.14	.08	.06
20	307	107	249	50.0	18.0	100	83.0	3.4	6.1	.12	.06	.06
21	269	96.0	264	45.0	278	81.0	71.0	2.5	6.5	.10	.10	.07
22	266	100	232	44.0	1330	73.0	63.0	2.4	6.7	.08	.13	.08
23	168	108	188	40.0	1670	70.0	62.0	2.4	3.6	.07	.13	.09
24	120	107	160	35.0	2070	170	66.0	2.2	2.6	.09	.83	.08
25	96.0	107	145	33.0	1320	77.0	51.0	2.1	1.9	.14	97.0	.08
26	86.0	107	140	34.0	625	69.0	42.0	14.0	1.6	.11	9.3	.09
27	111	252	133	34.0	400	71.0	37.0	380	1.3	.09	1.6	.08
28	430	274	486	33.0	420	403	35.0	220	.97	.09	.68	.08
29	319	260	2290	30.0	---	319	31.0	160	.77	.08	.60	.08
30	232	190	841	28.0	---	250	33.0	130	.62	.09	.93	.10
31	171	---	566	26.0	---	270	---	100	---	.18	.27	---
TOTAL	3306.1	10643.0	9460.0	3003.0	8599.0	9918.0	4490.0	1235.5	578.26	9.51	114.51	119.33
MEAN	107	355	305	96.9	307	320	150	39.9	19.3	.31	3.69	3.98
MAX	627	1960	2290	396	2070	824	314	380	75.0	4.0	97.0	96.0
MIN	1.9	96.0	60.0	26.0	17.0	69.0	31.0	2.1	.62	.07	.06	.05

CAL YR 1984 TOTAL 74912.09 MEAN 205 MAX 3150 MIN .01
WTR YR 1985 TOTAL 51475.74 MEAN 141 MAX 2290 MIN .05

Appendix 5a—Suspended-sediment loads at Jackson Creek tributary, 1984 water year.

Jackson Creek tributary near Elkhorn, Wisconsin

Sediment discharge, suspended (tons per day), water year October 1983 to September 1984

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.02	.08	.02	.09	.18	.33	.90	3.0	.16	.07	.04	.09
2	.02	.03	.01	.09	.27	.33	.78	1.7	.11	.06	.04	.03
3	.10	.02	.01	.11	.24	.30	.57	1.4	.09	.06	.03	.03
4	.08	.02	.01	.12	.22	.31	.62	1.2	.08	.05	.03	.03
5	.02	.02	.01	.12	.20	.32	.40	.70	.07	.06	.03	.04
6	.02	.02	.01	.12	.21	.23	.25	.49	2.4	.05	.18	.03
7	.02	.02	.01	.11	.18	.17	.17	.38	.86	.04	3.7	.05
8	.15	.02	.01	.11	.18	.12	.13	.38	.17	.03	.46	.04
9	.01	.02	.01	.10	.18	.08	.11	.36	.06	.04	.04	.04
10	.01	.02	.01	.10	.19	.06	.09	.26	.05	5.2	.05	.06
11	.01	.02	2.3	.10	.29	.05	.07	.17	.04	1.6	.05	.06
12	1.2	.01	.36	.10	32	.03	.53	.10	.04	.15	.07	.06
13	.10	.01	.24	.11	7.2	.01	.20	.46	.03	.09	.12	.07
14	.08	.03	.10	.11	.38	.01	.08	.05	.03	.06	.16	.06
15	.06	.05	.11	.11	.29	3.9	.40	.06	.02	.07	.18	.06
16	.06	.01	.09	.11	.16	.40	.90	.07	.02	.21	.17	.06
17	.05	.01	.09	.11	.10	.08	.35	.08	.05	.56	.21	.06
18	.05	.01	.09	.11	.54	.06	.04	.38	10	.04	.15	.05
19	.04	5.3	.07	.11	.19	.12	.03	.35	.30	.03	.13	.05
20	.06	4.6	.08	.11	.02	.70	.02	.18	.16	.04	.12	.05
21	.06	.19	.08	.12	.03	.60	.02	.14	.10	.03	2.4	.04
22	.20	.13	.07	.13	.05	.30	2.3	1.1	1.3	.03	.18	.04
23	.06	1.7	.07	.15	.08	.83	1.4	.09	.23	.04	.02	.03
24	.04	.06	.07	.16	.12	.87	.25	.04	.05	.04	.02	6.6
25	.04	.06	.07	.17	.18	.50	.09	24	.04	.04	.03	4.2
26	.04	.65	.07	.17	.27	1.3	.05	.32	.45	.04	.04	.17
27	.04	1.3	.07	.17	.40	1.2	1.5	.06	6.4	.04	.08	.09
28	.04	2.3	.07	.16	.40	1.0	.40	16	.09	.04	.11	.07
29	.03	.55	.08	.16	.36	.84	8.3	.84	.09	.04	.14	.05
30	.03	.10	.08	.15	---	.84	6.5	.29	.07	.04	.11	.04
31	.03	---	.08	.16	---	.82	---	.22	---	.05	.07	---
TOTAL	2.77	17.36	4.45	3.85	45.11	16.71	27.45	54.87	23.56	8.94	9.16	12.35
MEAN	.09	.58	.14	.12	1.56	.54	.91	1.77	.79	.29	.30	.41
MAX	1.2	5.3	2.3	.17	32	3.9	8.3	24	10	5.2	3.7	6.6
MIN	.01	.01	.01	.09	.02	.01	.02	.04	.02	.03	.02	.03

WTR YR 1984 TOTAL 226.58 MEAN .62 MAX 32 MIN .01

Appendix 5b—Total phosphorus loads at Jackson Creek tributary, 1984 water year.

Jackson Creek tributary near Elkhorn, Wisconsin

Phosphorus, total (pounds per day), water year October 1983 to September 1984

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	1.14	2.48	1.91	1.02	.77	1.74	3.64	19.0	6.82	1.42	1.47	1.89
2	1.11	1.71	1.70	1.07	1.08	1.68	2.90	13.0	5.10	1.36	1.46	1.19
3	3.20	1.31	1.31	1.25	.95	1.49	2.45	12.0	4.17	1.38	1.43	1.19
4	2.70	1.41	1.20	1.28	.84	1.49	3.09	12.0	3.87	1.18	1.55	1.45
5	1.19	1.22	1.11	1.24	.73	1.60	2.32	8.28	3.65	1.48	1.28	1.37
6	1.17	1.15	1.05	1.19	.73	1.42	1.66	6.72	48.0	1.17	2.89	1.14
7	1.26	1.28	.87	1.05	.71	1.33	1.32	5.77	94.0	.95	59.0	1.91
8	4.50	1.10	.76	1.04	.76	1.12	1.17	4.91	21.0	.90	32.0	1.44
9	1.11	1.11	.67	.94	.82	.95	1.19	4.23	7.39	.98	4.50	1.24
10	1.30	1.21	.59	.92	.98	.95	1.00	4.01	5.72	125	1.76	1.71
11	1.27	1.05	35.0	.89	1.91	1.04	.88	3.85	4.51	37.0	1.35	1.64
12	37.0	.91	20.0	.92	191	1.04	24.0	3.28	4.03	4.50	1.22	1.57
13	2.61	.88	3.62	.93	124	1.04	3.17	31.0	3.62	3.21	1.39	1.72
14	2.10	1.21	4.82	.94	7.28	1.08	1.60	10.0	2.69	2.40	1.32	1.56
15	1.59	1.49	4.00	.88	9.92	75.0	2.79	3.02	2.26	2.76	1.10	1.34
16	1.59	.96	2.82	.86	7.41	21.0	5.51	2.76	1.99	4.83	1.10	.85
17	1.55	.86	2.16	.83	7.93	6.04	5.68	2.58	2.22	21.0	1.39	1.30
18	1.49	.88	1.76	.81	18.0	6.87	3.34	18.0	157	2.85	1.07	1.23
19	1.44	24.0	1.25	.79	23.0	8.98	2.33	13.0	5.42	1.30	.97	1.03
20	1.70	183	1.36	.78	8.75	35.0	1.60	2.58	2.85	1.41	.94	1.04
21	1.93	5.19	1.25	.74	5.12	28.0	1.20	2.45	2.21	1.20	9.33	.87
22	6.00	2.03	1.19	.78	4.08	18.0	65.0	75.0	4.16	1.26	32.0	.82
23	2.40	92.0	1.07	.87	3.24	32.0	68.0	25.0	2.67	1.58	1.21	.65
24	1.80	3.21	1.03	.95	2.68	65.0	22.0	11.0	1.77	1.39	1.28	20.0
25	1.66	1.24	1.02	.94	2.07	50.0	7.75	216	1.52	1.34	1.01	94.0
26	1.54	12.0	1.01	.91	1.65	30.0	3.98	19.0	2.66	1.64	.95	2.14
27	1.44	42.0	1.00	.88	1.52	20.0	28.0	8.01	60.0	1.45	1.17	1.19
28	1.39	120	1.00	.79	2.16	14.0	8.76	140	1.91	1.35	.99	1.07
29	1.34	8.50	.99	.74	1.90	9.00	90.0	33.0	1.79	1.37	.93	.90
30	1.31	2.74	.97	.70	---	4.52	66.0	14.0	1.56	1.62	1.08	.87
31	1.35	---	1.00	.71	---	3.86	---	9.27	---	1.65	1.17	---
TOTAL	93.18	518.13	99.49	28.64	431.99	445.24	432.33	732.72	466.56	232.93	170.31	150.32
MEAN	3.01	17.3	3.21	.92	14.9	14.4	14.4	23.6	15.6	7.51	5.49	5.01
MAX	37.0	183	35.0	1.28	191	75.0	90.0	216	157	125	59.0	94.0
MIN	1.11	.86	.59	.70	.71	.95	.88	2.45	1.52	.90	.93	.65

WTR YR 1984 TOTAL 3801.80 MEAN 10.4 MAX 216 MIN .59

Appendix 5c—Kjeldahl nitrogen loads at Jackson Creek tributary, 1984 water year.

Jackson Creek tributary near Elkhorn, Wisconsin

Nitrogen, ammonia plus organic, total (pounds per day), water year October 1983 to September 1984

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	3.7	13.0	15.0	5.1	4.9	13.0	29.0	60.0	41.0	7.5	3.5	8.6
2	3.6	8.6	14.0	5.4	7.0	13.0	21.0	47.0	40.0	6.8	3.7	5.0
3	18.0	8.0	11.0	6.4	6.0	11.0	19.0	54.0	43.0	6.5	3.8	4.7
4	13.0	8.2	11.0	6.6	5.4	11.0	25.0	62.0	52.0	5.3	4.3	5.3
5	3.9	6.8	11.0	6.5	4.7	12.0	20.0	49.0	65.0	6.2	3.8	4.6
6	3.8	6.1	11.0	6.3	4.8	11.0	15.0	46.0	189	4.7	9.0	3.6
7	4.1	6.5	9.5	5.6	4.6	10.0	13.0	46.0	191	3.6	116	5.6
8	27.0	5.4	8.7	5.6	4.9	8.4	12.0	46.0	37.0	3.2	41.0	3.9
9	3.4	5.2	8.0	4.9	5.6	7.1	13.0	46.0	21.0	3.3	12.0	3.2
10	4.6	5.4	7.5	4.8	6.3	7.1	12.0	43.0	17.0	401	9.2	4.0
11	4.2	4.5	132	5.1	9.5	7.8	11.0	39.0	14.0	195	7.0	3.6
12	330	3.7	64.0	5.2	777	7.8	128	32.0	13.0	23.0	6.3	3.2
13	11.0	3.5	18.0	5.3	502	7.8	85.0	56.0	12.0	13.0	7.2	3.3
14	7.5	5.7	19.0	5.3	85.0	8.4	50.0	31.0	9.7	8.4	6.8	3.0
15	4.2	9.0	17.0	5.0	69.0	246	66.0	26.0	8.6	8.2	5.7	2.6
16	4.3	3.3	12.0	4.8	49.0	72.0	71.0	23.0	8.0	10.0	5.7	1.7
17	4.2	2.8	9.3	5.1	56.0	23.0	41.0	21.0	10.0	62.0	7.2	2.6
18	4.1	2.8	7.7	4.9	72.0	24.0	30.0	30.0	621	6.9	5.6	2.5
19	3.8	219	5.6	4.8	189	29.0	27.0	24.0	28.0	2.1	5.1	2.1
20	5.6	601	6.2	4.8	65.0	120	25.0	18.0	14.0	2.3	4.9	2.2
21	7.4	48.0	5.8	4.7	25.0	98.0	25.0	16.0	11.0	2.0	62.0	1.8
22	42.0	21.0	5.3	5.0	21.0	63.0	380	111	23.0	2.1	50.0	1.7
23	11.0	314	4.8	5.1	18.0	110	450	19.0	15.0	2.8	7.8	1.4
24	7.3	16.0	4.7	5.6	16.0	215	109	5.6	10.0	2.5	8.0	123
25	5.5	4.6	4.6	5.6	14.0	165	70.0	576	9.3	2.5	6.2	744
26	4.8	65.0	4.6	5.6	12.0	105	85.0	47.0	19.0	3.2	5.7	12.0
27	4.3	190	4.5	5.5	12.0	70.0	159	18.0	328	2.9	6.9	3.3
28	4.1	360	5.0	4.9	16.0	52.0	97.0	652	13.0	2.8	5.7	3.0
29	3.8	45.0	4.9	4.6	14.0	34.0	541	106	11.0	2.9	5.2	2.5
30	3.8	20.0	4.9	4.4	---	31.0	286	49.0	8.7	3.6	5.7	2.3
31	4.1	---	5.0	4.4	---	27.0	---	42.0	---	3.8	5.7	---
TOTAL	562.1	2012.1	451.6	162.9	2075.7	1619.4	2915.0	2440.6	1882.3	810.1	436.7	970.3
MEAN	18.1	67.1	14.6	5.25	71.6	52.2	97.2	78.7	62.7	26.1	14.1	32.3
MAX	330	601	132	6.6	777	246	541	652	621	401	116	744
MIN	3.4	2.8	4.5	4.4	4.6	7.1	11.0	5.6	8.0	2.0	3.5	1.4

WTR YR 1984 TOTAL 16338.7 MEAN 44.6 MAX 777 MIN 1.4

Appendix 5d—Nitite plus nitrate nitrogen loads at Jackson Creek tributary, 1984 water year.

Jackson Creek tributary near Elkhorn, Wisconsin

Nitrogen, nitrite plus nitrate (pounds per day), water year October 1983 to September 1984

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	1.2	14.0	34.0	11.0	7.4	42.0	38.0	112	146	34.0	1.8	2.0
2	1.1	9.4	29.0	11.0	11.0	39.0	33.0	77.0	101	32.0	1.8	1.2
3	14.0	7.2	22.0	13.0	9.3	33.0	30.0	80.0	76.0	32.0	1.8	1.1
4	12.0	7.9	20.0	13.0	8.3	31.0	41.0	83.0	66.0	27.0	1.9	1.2
5	1.2	6.9	18.0	12.0	7.3	32.0	34.0	58.0	57.0	33.0	1.6	1.0
6	1.2	6.6	17.0	12.0	7.3	27.0	26.0	49.0	75.0	25.0	5.2	.77
7	1.3	7.4	14.0	10.0	7.1	24.0	22.0	44.0	180	20.0	54.0	1.2
8	16.0	6.5	13.0	10.0	7.6	20.0	22.0	40.0	95.0	19.0	18.0	.82
9	2.0	6.7	14.0	9.0	8.6	15.0	24.0	36.0	56.0	20.0	6.8	.65
10	2.0	7.3	14.0	8.8	9.8	15.0	22.0	35.0	46.0	112	5.1	.81
11	1.7	6.4	100	8.2	14.0	16.0	21.0	34.0	39.0	96.0	3.8	.72
12	56.0	5.7	162	8.4	1240	15.0	38.0	30.0	37.0	29.0	3.3	.63
13	14.0	5.6	76.0	8.5	992	14.0	21.0	65.0	36.0	21.0	3.6	.65
14	12.0	7.8	75.0	8.6	345	15.0	23.0	34.0	29.0	16.0	3.3	.61
15	8.7	9.7	62.0	8.1	334	113	31.0	30.0	26.0	19.0	2.6	.55
16	8.7	6.3	40.0	7.8	248	63.0	47.0	28.0	24.0	13.0	2.5	.37
17	8.5	5.7	28.0	7.6	201	25.0	30.0	27.0	25.0	18.0	3.0	.60
18	8.1	5.9	21.0	7.4	213	28.0	43.0	48.0	822	4.9	2.2	.60
19	7.8	42.0	14.0	7.3	334	34.0	34.0	38.0	182	5.0	1.9	.53
20	9.5	90.0	16.0	6.8	190	80.0	29.0	29.0	99.0	5.3	1.7	.56
21	11.0	34.0	14.0	6.7	131	73.0	26.0	29.0	74.0	4.1	20.0	.50
22	20.0	21.0	13.0	7.1	111	58.0	140	98.0	35.0	3.9	32.0	.49
23	11.0	242	12.0	7.9	93.0	78.0	217	59.0	84.0	4.5	3.0	.41
24	10.0	56.0	11.0	8.6	80.0	110	265	31.0	54.0	3.6	2.8	18.0
25	9.1	28.0	11.0	8.6	65.0	95.0	73.0	1190	45.0	3.1	2.0	286
26	8.4	100	11.0	8.5	55.0	75.0	30.0	426	38.0	3.5	1.7	18.0
27	8.0	175	10.0	8.3	51.0	62.0	49.0	232	209	2.8	1.9	7.0
28	7.5	250	10.0	7.5	63.0	51.0	43.0	1490	67.0	2.4	1.5	3.4
29	7.3	107	10.0	7.0	52.0	40.0	148	831	45.0	2.2	1.3	2.2
30	7.2	49.0	10.0	6.7	---	38.0	273	353	38.0	2.4	1.4	1.5
31	7.4	---	10.0	6.8	---	35.0	---	215	---	2.2	1.3	---
TOTAL	293.9	1327.0	911.0	272.2	4895.7	1396.0	1873.0	5931.0	2906.0	615.9	194.8	354.07
MEAN	9.48	44.2	29.4	8.78	169	45.0	62.4	191	96.9	19.9	6.28	11.8
MAX	56.0	250	162	13.0	1240	113	273	1490	822	112	54.0	286
MIN	1.1	5.6	10.0	6.7	7.1	14.0	21.0	27.0	24.0	2.2	1.3	.37

WTR YR 1984 TOTAL 20970.45 MEAN 57.3 MAX 1490 MIN .37

Appendix 5e—Suspended-sediment loads at Jackson Creek tributary, 1985 water year.

Jackson Creek tributary near Elkhorn, Wisconsin

Sediment discharge, suspended (tons per day), water year October 1984 to September 1985

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.04	58	.12	.36	.02	2.7	.98	.10	.04	.01	.01	.02
2	.04	.36	.61	.27	.03	1.1	.72	.09	.04	.12	.01	.02
3	.05	.14	.25	.23	.03	.31	.85	.08	.04	.02	.01	.03
4	.06	.10	.14	.21	.03	7.4	.90	.07	.04	.04	.01	.02
5	.06	.08	.11	.17	.03	1.4	3.2	.18	.04	.03	.02	.02
6	.07	.06	.10	.16	.03	.63	1.6	.08	.03	.01	.02	.02
7	3.6	.05	.09	.15	.02	.46	1.2	.09	.04	.01	.04	.02
8	.20	.06	.09	.13	.02	4.9	.73	.06	.04	.01	.02	20
9	.17	36	.08	.12	.02	1.4	.59	.06	.04	.01	.01	17
10	.14	2.6	.08	.11	.03	1.2	.49	.06	.04	.01	.12	.18
11	.13	.83	2.1	.10	.03	1.4	.45	.06	.06	.01	.02	.10
12	.47	.54	2.0	.10	.03	.85	.40	.13	.05	.01	.01	.06
13	.05	.45	.40	.09	.03	.75	.41	.05	.04	.04	2.0	.05
14	.04	.50	.70	.09	.03	.68	.35	.05	.04	4.5	.05	.05
15	.68	.46	1.2	.09	.03	.47	.33	.90	.23	.03	.04	.05
16	3.6	.38	.79	.07	.03	.38	.28	.27	.40	.02	.05	.06
17	.60	.29	.11	.07	.04	.31	.23	.15	.08	.02	.04	.12
18	15	.29	.06	.06	.05	.28	.27	.05	.03	.02	.05	.05
19	9.9	.29	.05	.05	.06	.25	.22	.05	.02	.09	.05	.04
20	.39	.37	.04	.05	.07	.20	.20	.05	.02	.02	.05	.04
21	1.2	.47	.40	.05	6.6	.16	.17	.04	.02	.01	.05	.20
22	.85	.55	.13	.05	13	.13	.19	.04	.03	.02	.05	.04
23	.59	.61	.03	.05	12	.50	.46	.03	.02	.01	.04	.13
24	.36	.58	.03	.05	15	1.1	.28	.03	.01	.02	.62	.04
25	.27	.57	.03	.04	4.3	.19	.18	.02	.01	.22	.71	.04
26	.20	.48	.03	.04	1.8	.13	.15	2.1	.01	.02	.04	.02
27	7.5	4.6	.33	.04	1.1	.70	.13	.99	.01	.01	.03	.02
28	.86	.33	5.6	.04	1.2	18	.13	.07	.01	.01	.03	.01
29	.14	.20	47	.03	---	.98	.13	.05	.01	.01	.23	.01
30	.09	.16	1.1	.03	---	.37	.11	.05	.01	.03	.05	.02
31	1.9	---	.55	.03	---	2.0	---	.05	---	.15	.02	---
TOTAL	49.25	110.40	64.35	3.13	55.66	51.33	16.33	6.10	1.50	5.54	4.50	38.48
MEAN	1.59	3.68	2.08	.10	1.99	1.66	.54	.20	.05	.18	.15	1.28
MAX	15	58	47	.36	15	18	3.2	2.1	.40	4.5	2.0	20
MIN	.04	.05	.03	.03	.02	.13	.11	.02	.01	.01	.01	.01

CAL YR 1984 TOTAL 426.00 MEAN 1.16 MAX 58 MIN .01

WTR YR 1985 TOTAL 406.56 MEAN 1.11 MAX 58 MIN .01

Appendix 5. Total phosphorus loads at Jackson Creek tributary, 1985 water year.

Jackson Creek tributary near Elkhorn, Wisconsin

Phosphorus, total (pounds per day), water year October 1984 to September 1985

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.77	206	2.50	6.48	.70	41.0	11.0	.91	1.84	.38	2.50	.74
2	.72	17.0	9.03	4.97	.77	23.0	7.12	.80	1.44	1.94	.41	.94
3	.65	9.09	3.23	4.60	.77	9.22	6.02	.68	1.27	.60	.42	1.30
4	.67	6.48	1.92	4.40	.77	39.0	8.89	.59	1.06	1.12	.48	1.11
5	.60	4.84	1.53	4.03	.71	23.0	8.11	.90	.90	.80	.73	1.04
6	.61	3.82	1.33	3.80	.71	11.0	36.0	.67	.83	.50	.86	1.00
7	38.0	3.04	1.23	3.40	.65	14.0	18.0	.69	.96	.36	4.89	.91
8	1.66	3.56	1.17	3.06	.65	44.0	7.81	.48	1.00	.40	2.93	140
9	.62	83.0	1.05	2.81	.65	25.0	6.04	.46	.98	.49	.67	127
10	.31	31.0	1.04	2.59	.65	24.0	4.81	.46	1.07	.33	7.62	11.0
11	.18	13.0	13.0	2.48	.65	22.0	4.24	.46	1.40	.35	2.76	6.32
12	9.81	9.58	27.0	2.26	.65	12.0	3.68	.61	1.12	.35	2.80	4.28
13	.71	7.85	11.0	2.36	.65	10.0	3.65	.37	.98	4.58	39.0	3.71
14	.40	8.48	9.60	2.26	.65	9.17	3.06	.37	.84	53.0	1.15	3.58
15	7.51	7.75	15.0	2.04	.65	6.35	2.74	55.0	11.0	.70	.88	3.14
16	22.0	6.00	24.0	1.85	.59	5.16	2.30	22.0	14.0	.56	.81	4.28
17	23.0	4.49	8.76	1.65	.65	4.22	1.87	13.0	7.62	.38	.58	5.45
18	61.0	4.38	4.92	1.47	.70	3.74	2.19	5.52	1.66	.33	.62	4.48
19	76.0	4.00	3.48	1.29	.76	3.31	1.82	3.78	1.27	6.75	.56	4.14
20	6.42	3.39	2.41	1.29	.81	2.64	1.61	2.81	1.09	2.59	.54	3.80
21	23.0	2.96	7.48	1.21	34.0	2.13	1.36	1.92	1.31	.24	.49	7.19
22	4.79	2.95	3.33	1.21	134	1.73	1.48	1.45	1.60	.24	.46	4.32
23	2.09	2.82	2.47	1.21	124	4.16	5.30	1.33	.93	.21	.44	12.0
24	1.58	2.30	1.96	1.13	130	12.0	2.76	1.42	.63	.25	4.48	4.67
25	1.43	2.05	1.67	1.05	52.0	3.70	1.83	1.02	.49	10.0	13.0	4.73
26	1.30	2.09	1.69	1.05	22.0	2.36	1.51	50.0	.45	2.59	.54	3.74
27	23.0	48.0	3.76	.97	14.0	4.84	1.32	118	.42	.22	.54	2.68
28	23.0	9.67	52.0	.91	23.0	66.0	1.25	10.0	.41	.25	.52	2.31
29	6.59	4.25	171	.91	---	8.80	1.19	4.51	.39	.34	16.0	1.91
30	3.51	3.34	16.0	.83	---	3.59	1.02	3.42	.39	.72	4.63	3.66
31	11.0	---	8.86	.76	---	19.0	---	2.63	---	8.49	2.67	---
TOTAL	352.93	517.18	413.42	70.33	546.79	460.12	159.98	306.26	59.35	100.06	114.98	375.43
MEAN	11.4	17.2	13.3	2.27	19.5	14.8	5.33	9.88	1.98	3.23	3.71	12.5
MAX	76.0	206	171	6.48	134	66.0	36.0	118	14.0	53.0	39.0	140
MIN	.18	2.05	1.04	.76	.59	1.73	1.02	.37	.39	.21	.41	.74

CAL YR 1984 TOTAL 4374.52 MEAN 12.0 MAX 216 MIN .18
WTR YR 1985 TOTAL 3476.78 MEAN 9.53 MAX 206 MIN .18

Appendix 5g—Kjeldahl nitrogen loads at Jackson Creek tributary, 1985 water year.

Jackson Creek tributary near Elkhorn, Wisconsin

Nitrogen, ammonia plus organic, total (pounds per day), water year October 1984 to September 1985

Mean value

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	1.8	697	20.0	34.0	2.3	154	61.0	5.7	6.4	.94	5.5	2.8
2	2.3	58.0	57.0	24.0	2.4	83.0	33.0	5.1	5.3	25.0	1.0	3.1
3	2.9	36.0	24.0	20.0	2.4	27.0	30.0	4.4	4.9	8.0	.96	3.8
4	4.1	29.0	15.0	20.0	2.4	248	37.0	3.9	4.4	14.0	.99	3.0
5	4.5	24.0	13.0	17.0	2.4	116	45.0	5.9	3.8	10.0	1.4	2.9
6	4.6	21.0	12.0	16.0	2.4	55.0	220	4.4	3.4	1.3	1.5	2.9
7	148	18.0	11.0	14.0	2.2	72.0	77.0	4.6	3.9	.93	2.7	2.7
8	6.9	24.0	11.0	12.0	2.2	205	30.0	3.2	4.0	1.0	1.3	493
9	2.3	788	10.0	12.0	2.2	142	23.0	3.2	3.8	1.2	1.1	420
10	1.1	106	11.0	10.0	2.3	140	19.0	3.1	4.0	.77	25.0	36.0
11	.56	44.0	60.0	9.3	2.3	135	17.0	3.2	16.0	.82	6.5	8.6
12	24.0	34.0	195	8.7	2.2	60.0	15.0	4.3	4.1	.83	1.2	4.7
13	2.8	29.0	81.0	8.7	2.2	71.0	15.0	2.6	3.5	13.0	95.0	3.3
14	1.3	33.0	42.0	8.0	2.2	70.0	13.0	2.6	3.0	168	5.7	2.8
15	37.0	31.0	56.0	7.3	2.1	40.0	11.0	129	35.0	8.0	4.8	2.0
16	116	25.0	92.0	6.4	2.1	33.0	9.6	9.8	48.0	2.2	4.9	2.3
17	85.0	19.0	44.0	5.8	2.3	26.0	7.8	7.0	25.0	1.6	3.8	16.0
18	350	19.0	27.0	4.9	2.5	23.0	9.0	4.0	18.0	1.5	4.4	10.0
19	281	18.0	21.0	4.2	2.7	20.0	7.4	3.6	4.5	21.0	4.4	2.0
20	42.0	16.0	16.0	4.0	2.8	16.0	6.5	3.6	3.7	6.0	4.7	1.8
21	120	14.0	28.0	3.9	159	13.0	5.5	3.2	4.5	1.3	4.6	23.0
22	30.0	14.0	17.0	3.7	471	10.0	5.9	3.0	5.2	1.4	4.3	12.0
23	18.0	14.0	13.0	3.6	408	17.0	27.0	2.9	2.9	1.3	4.0	8.2
24	13.0	11.0	10.0	3.5	429	39.0	16.0	3.2	1.9	1.5	31.0	2.4
25	12.0	9.8	9.0	3.2	195	12.0	11.0	2.3	1.4	34.0	49.0	2.5
26	11.0	9.9	9.2	3.1	94.0	9.4	9.2	200	1.3	6.0	4.5	2.0
27	58.0	291	20.0	2.9	69.0	22.0	8.1	546	1.1	.99	3.9	1.5
28	53.0	96.0	260	2.8	83.0	571	7.7	45.0	1.1	1.0	3.3	1.3
29	23.0	37.0	638	2.8	---	124	7.4	14.0	.97	1.2	54.0	1.1
30	17.0	28.0	96.0	2.6	---	39.0	6.4	11.0	.96	2.4	13.0	2.2
31	32.0	---	45.0	2.3	---	118	---	8.7	---	28.0	3.2	---
TOTAL	1505.16	2593.7	1963.2	280.7	1954.6	2710.4	790.5	1052.5	226.03	365.18	351.65	1079.9
MEAN	48.6	86.5	63.3	9.05	69.8	87.4	26.3	34.0	7.53	11.8	11.3	36.0
MAX	350	788	638	34.0	471	571	220	546	48.0	168	95.0	493
MIN	.56	9.8	9.0	2.3	2.1	9.4	5.5	2.3	.96	.77	.96	1.1

CAL YR 1984 TOTAL 19374.98 MEAN 52.9 MAX 788 MIN .56

WTR YR 1985 TOTAL 14873.39 MEAN 40.7 MAX 788 MIN .56

Appendix 5h—Nitrite plus nitrate nitrogen loads at Jackson Creek tributary, 1985 water year.

Jackson Creek tributary near Elkhorn, Wisconsin

Nitrogen, nitrite plus nitrate (pounds per day), water year October 1984 to September 1985

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	1.8	787	54.0	57.0	18.0	292	155	20.0	18.0	3.1	.60	1.1
2	3.0	243	95.0	48.0	20.0	269	130	18.0	16.0	10.0	.64	1.1
3	4.9	156	60.0	44.0	19.0	189	121	16.0	16.0	4.5	.71	1.1
4	9.1	121	35.0	44.0	19.0	304	130	14.0	15.0	4.5	.87	.75
5	13.0	99.0	30.0	42.0	19.0	318	138	27.0	13.0	5.3	1.4	.73
6	13.0	85.0	27.0	40.0	19.0	223	295	17.0	12.0	3.1	1.8	.75
7	101	74.0	26.0	39.0	17.0	230	195	18.0	14.0	2.1	3.7	.72
8	24.0	94.0	26.0	35.0	17.0	361	132	13.0	15.0	2.2	1.7	302
9	6.7	348	25.0	35.0	17.0	295	106	13.0	14.0	2.6	1.4	182
10	2.1	264	25.0	32.0	18.0	280	87.0	13.0	16.0	1.6	10.0	17.0
11	.71	147	47.0	32.0	18.0	258	80.0	13.0	20.0	1.6	1.2	9.2
12	20.0	109	175	32.0	18.0	185	71.0	22.0	16.0	1.6	1.1	6.1
13	8.2	88.0	137	34.0	18.0	174	73.0	11.0	14.0	4.0	53.0	5.2
14	7.1	94.0	120	33.0	18.0	166	63.0	11.0	12.0	72.0	4.7	5.2
15	33.0	85.0	228	32.0	18.0	122	59.0	57.0	48.0	3.5	3.7	4.6
16	112	65.0	334	30.0	18.0	105	51.0	33.0	66.0	2.2	3.5	6.1
17	95.0	48.0	174	28.0	19.0	91.0	42.0	20.0	32.0	1.2	2.5	13.0
18	342	46.0	111	26.0	21.0	86.0	49.0	8.6	23.0	.84	2.7	6.0
19	665	41.0	87.0	23.0	23.0	80.0	41.0	5.9	18.0	8.0	2.5	5.7
20	131	34.0	66.0	23.0	24.0	68.0	37.0	4.5	14.0	.80	2.5	5.4
21	246	30.0	124	24.0	200	58.0	32.0	3.1	17.0	.30	2.3	20.0
22	110	31.0	76.0	25.0	624	50.0	35.0	2.4	22.0	.24	2.1	7.8
23	64.0	31.0	59.0	25.0	781	90.0	85.0	2.2	11.0	.17	1.9	37.0
24	47.0	27.0	48.0	26.0	880	155	60.0	2.4	7.0	.21	10.0	7.7
25	40.0	25.0	43.0	24.0	500	66.0	34.0	1.8	5.3	15.0	34.0	8.1
26	35.0	27.0	46.0	24.0	280	57.0	29.0	57.0	4.5	.80	4.9	6.6
27	286	199	57.0	22.0	235	110	26.0	195	4.2	.23	3.6	4.9
28	259	109	268	21.0	230	219	25.0	42.0	3.7	.28	2.6	4.4
29	89.0	72.0	749	21.0	---	91.0	25.0	30.0	3.5	.40	23.0	3.8
30	57.0	64.0	106	20.0	---	75.0	22.0	27.0	3.3	.92	4.0	7.5
31	45.0	---	70.0	18.0	---	230	---	23.0	---	11.0	1.5	---
TOTAL	2870.61	3643.0	3528.0	959.0	4108.0	5297.0	2428.0	740.9	493.5	164.29	190.12	681.55
MEAN	92.6	121	114	30.9	147	171	80.9	23.9	16.4	5.30	6.13	22.7
MAX	665	787	749	57.0	880	361	295	195	66.0	72.0	53.0	302
MIN	.71	25.0	25.0	18.0	17.0	50.0	22.0	1.8	3.3	.17	.60	.72

CAL YR 1984 TOTAL 28480.15 MEAN 77.8 MAX 1490 MIN .37

Appendix 6a—Suspended-sediment loads at Delavan Lake tributary 2, 1984 water year.

Delavan Lake tributary at South Shore Drive at Delavan Lake, Wisconsin

Sediment discharge, suspended (tons per day), water year October 1983 to September 1984

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.13	.01	.05	.01	.05	.05	.05	.05	.26	.03	.05	.06
2	.11	.01	.04	.02	.05	.03	.04	.07	.21	.03	.05	.06
3	.09	.01	.05	.02	.05	.03	.05	.10	.17	.03	.05	.05
4	.07	.01	.05	.02	.05	.02	.06	.14	.14	.03	.05	.05
5	.06	.01	.06	.02	.05	.01	.06	.17	.13	.03	.05	.05
6	.05	.01	.06	.03	.04	.01	.06	.22	.12	.03	.05	.04
7	.04	.01	.06	.03	.04	.01	.06	.23	.08	.03	.05	.05
8	.05	.01	.04	.03	.04	.01	.07	.18	.05	.03	.17	.04
9	.04	.01	.03	.03	.05	.01	.07	.16	.04	.03	.08	.04
10	.04	.01	.02	.03	.05	.01	.06	.15	.04	.23	.06	.04
11	.04	.01	.07	.03	.05	.01	.04	.16	.03	.07	.06	.04
12	.05	.01	.06	.04	1.1	.01	.04	.15	.03	.05	.05	.04
13	.05	.01	.05	.04	1.9	.01	.04	.16	.03	.05	.05	.03
14	.24	.01	.05	.04	.71	.01	.02	.16	.02	.05	.05	.03
15	.25	.01	.05	.05	.38	.02	.02	.15	.02	.05	.05	.03
16	.23	.02	.04	.05	.22	.03	.01	.15	.02	.05	.05	.03
17	.05	.02	.03	.05	.13	.01	.02	.16	.02	.06	.05	.03
18	.04	.01	.04	.05	.10	.02	.02	.16	11	.05	.05	.02
19	.21	.03	.05	.05	.13	.01	.02	.18	.28	.05	.05	.02
20	.27	.06	.04	.05	.06	.01	.01	.18	.21	.06	.05	.02
21	.06	.06	.03	.05	.05	.02	.01	.19	.15	.05	.06	.02
22	.34	.05	.02	.05	.06	.04	.02	.30	.12	.05	.08	.02
23	.33	.11	.01	.05	.07	.06	.01	.29	.10	.05	.05	.02
24	.32	.05	.01	.06	.09	.30	.01	.24	.08	.05	.05	.17
25	.05	.01	.01	.06	.11	.40	.02	3.0	.06	.05	.06	.21
26	.04	.01	.01	.06	.13	.30	.02	.55	.05	.05	.06	.02
27	.03	.06	.01	.05	.13	.24	.02	.21	.04	.06	.07	.02
28	.02	.13	.01	.05	.08	.17	.02	.66	.04	.06	.07	.01
29	.02	.09	.01	.05	.06	.12	.03	.80	.03	.05	.07	.01
30	.02	.05	.01	.05	---	.09	.04	.44	.03	.06	.06	.01
31	.02	---	.01	.05	---	.07	---	.32	---	.06	.05	---
TOTAL	3.36	.91	1.08	1.27	6.03	2.14	1.02	10.08	13.60	1.63	1.85	1.28
MEAN	.11	.03	.03	.04	.21	.07	.03	.33	.45	.05	.06	.04
MAX	.34	.13	.07	.06	1.9	.40	.07	3.0	11	.23	.17	.21
MIN	.02	.01	.01	.01	.04	.01	.01	.05	.02	.03	.05	.01

WTR YR 1984 TOTAL 44.25 MEAN .12 MAX 11 MIN .01

Appendix 6b—Total phosphorus loads at Delavan Lake tributary 2, 1984 water year.

Delavan Lake tributary at South Shore Drive at Delavan Lake, Wisconsin

Phosphorus, total (pounds per day), water year October 1983 to September 1984

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	1.13	.81	1.85	.27	.15	.39	.73	1.15	7.77	1.07	.23	.20
2	1.05	.76	1.53	.28	.16	.35	.67	1.23	6.11	.97	.22	.20
3	.97	.76	1.33	.26	.16	.32	.66	1.35	4.65	.87	.21	.18
4	.83	.77	1.16	.29	.12	.31	.71	1.35	3.64	.83	.19	.18
5	.76	.96	1.12	.29	.12	.24	.69	1.24	3.25	.75	.19	.18
6	.68	.92	.95	.28	.11	.22	.61	1.22	2.91	.70	.18	.18
7	.59	.97	.78	.28	.11	.21	.54	1.03	3.01	.59	.22	.23
8	.77	1.13	.60	.26	.14	.19	.50	.87	3.25	.52	.63	.19
9	.68	1.20	.49	.25	.19	.17	.49	.83	2.89	.54	.42	.19
10	.72	1.16	.44	.24	.23	.16	.45	.77	2.73	1.40	.33	.21
11	.75	1.21	.91	.23	.25	.14	.41	.76	2.27	1.20	.32	.20
12	.75	1.10	2.42	.22	14.0	.13	.46	.69	2.14	.62	.29	.20
13	.66	1.05	2.15	.22	64.0	.15	.50	.68	2.05	.53	.25	.20
14	1.05	1.05	2.03	.21	27.0	.28	.55	.63	1.76	.52	.24	.19
15	1.10	1.15	1.94	.21	14.0	.80	.66	.57	1.50	.48	.23	.18
16	.95	1.22	1.61	.20	8.39	1.70	1.00	.52	1.38	.41	.23	.18
17	.91	1.38	1.22	.20	5.57	.73	.95	.48	1.32	.41	.22	.17
18	.82	.95	.97	.19	3.68	.91	.90	.47	9.34	.35	.22	.15
19	.90	1.20	.78	.19	3.34	.62	.60	.46	8.64	.32	.21	.15
20	1.30	2.20	.63	.18	2.89	1.30	.50	.43	7.23	.33	.20	.15
21	1.20	2.30	.53	.15	1.94	1.80	.40	.42	5.24	.30	.27	.14
22	2.30	1.70	.41	.16	1.59	2.20	2.00	1.54	4.37	.29	.39	.12
23	2.20	4.09	.33	.17	1.30	2.90	2.40	1.50	3.78	.28	.20	.12
24	1.90	3.65	.28	.19	1.07	13.0	2.00	1.27	3.11	.27	.18	.80
25	1.60	2.48	.25	.19	.89	18.0	1.70	6.96	2.52	.27	.19	2.92
26	1.46	1.91	.24	.18	.72	3.20	1.29	8.39	2.17	.27	.19	.28
27	1.36	1.99	.23	.18	.59	2.50	1.20	6.76	1.90	.29	.19	.25
28	1.17	3.45	.23	.15	.44	1.80	1.10	13.0	1.62	.28	.18	.18
29	1.07	2.71	.24	.15	.41	1.40	1.25	17.0	1.32	.26	.19	.17
30	.97	2.30	.25	.15	---	1.00	1.33	14.0	1.16	.25	.19	.15
31	.87	---	.26	.15	---	.75	---	10.0	---	.24	.16	---
TOTAL	33.47	48.53	28.16	6.57	153.56	57.87	27.25	97.57	105.03	16.41	7.56	8.84
MEAN	1.08	1.62	.91	.21	5.30	1.87	.91	3.15	3.50	.53	.24	.29
MAX	2.30	4.09	2.42	.29	64.0	18.0	2.40	17.0	9.34	1.40	.63	2.92
MIN	.59	.76	.23	.15	.11	.13	.40	.42	1.16	.24	.16	.12

WTR YR 1984 TOTAL 590.81 MEAN 1.61 MAX 64.0 MIN .11

Appendix 6c—Kjeldahl nitrogen loads at Delavan Lake tributary 2, 1984 water year.

Delavan Lake tributary at South Shore Drive at Delavan Lake, Wisconsin

Nitrogen, ammonia plus organic, total (pounds per day), water year October 1983 to September 1984

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	11.0	6.2	27.0	5.4	4.0	4.5	24.0	14.0	40.0	3.3	1.7	1.3
2	9.8	5.8	26.0	5.6	4.3	4.2	21.0	15.0	34.0	2.9	1.7	1.3
3	9.1	5.9	26.0	5.8	3.9	4.0	21.0	18.0	27.0	2.6	1.6	1.1
4	8.3	6.3	26.0	6.0	3.7	4.1	22.0	20.0	23.0	2.5	1.5	1.0
5	7.5	8.0	28.0	6.0	3.6	3.8	21.0	20.0	21.0	2.3	1.4	.97
6	6.8	7.9	27.0	6.0	3.4	3.6	18.0	22.0	20.0	2.1	1.4	.94
7	5.5	8.5	25.0	6.0	3.2	3.5	16.0	21.0	17.0	1.7	1.8	1.1
8	6.7	10.0	17.0	5.8	4.1	3.4	15.0	19.0	14.0	1.6	5.7	.94
9	4.8	11.0	11.0	5.3	5.7	3.2	14.0	20.0	12.0	1.6	3.4	.88
10	4.2	11.0	8.6	5.1	6.7	3.0	13.0	16.0	12.0	14.0	2.3	.87
11	3.6	11.0	8.7	5.0	7.0	2.9	11.0	14.0	9.6	12.0	2.0	.81
12	3.1	10.0	14.0	4.8	93.0	2.7	13.0	11.0	9.1	6.0	1.8	.78
13	2.7	9.8	15.0	4.6	495	3.2	13.0	9.6	8.7	4.6	1.6	.74
14	11.0	9.9	17.0	4.5	232	3.7	12.0	7.8	7.5	4.3	1.5	.74
15	12.0	11.0	19.0	4.4	98.0	19.0	12.0	6.1	6.4	5.1	1.4	.73
16	10.0	11.0	18.0	4.3	62.0	19.0	13.0	4.9	5.9	5.4	1.4	.74
17	6.8	13.0	16.0	4.2	49.0	8.1	13.0	4.0	5.7	7.0	1.4	.71
18	5.8	8.8	14.0	4.0	27.0	10.0	12.0	3.4	148	7.4	1.4	.69
19	8.5	13.0	12.0	4.0	36.0	7.6	11.0	2.9	28.0	8.1	1.3	.69
20	16.0	23.0	11.0	3.8	29.0	9.3	9.8	2.4	20.0	7.8	1.2	.66
21	14.0	24.0	10.0	3.7	40.0	11.0	9.2	2.0	15.0	6.4	1.7	.64
22	25.0	18.0	8.3	4.0	31.0	13.0	14.0	2.7	12.0	5.6	2.7	.61
23	23.0	36.0	6.6	4.2	22.0	16.0	12.0	2.3	11.0	5.0	1.8	.61
24	21.0	17.0	5.6	4.3	16.0	32.0	13.0	2.2	9.0	4.4	1.6	3.8
25	18.0	10.0	5.1	4.2	11.0	40.0	13.0	85.0	7.4	4.0	1.6	12.0
26	15.0	7.8	4.8	4.2	7.9	38.0	13.0	60.0	6.4	3.7	1.6	1.5
27	13.0	13.0	4.6	4.1	5.9	36.0	13.0	37.0	5.7	3.6	1.5	1.3
28	11.0	34.0	4.7	4.1	4.6	33.0	12.0	135	4.9	3.0	1.4	1.1
29	10.0	30.0	4.8	4.0	4.5	31.0	14.0	160	4.0	2.6	1.4	.91
30	8.5	29.0	5.1	3.9	---	29.0	15.0	150	3.5	2.3	1.3	.76
31	8.0	---	5.3	3.9	---	26.0	---	51.0	---	2.0	1.1	---
TOTAL	319.7	419.9	431.2	145.2	1313.5	427.8	433.0	938.3	547.8	144.9	55.2	40.92
MEAN	10.3	14.0	13.9	4.68	45.3	13.8	14.4	30.3	18.3	4.67	1.78	1.36
MAX	25.0	36.0	28.0	6.0	495	40.0	24.0	160	148	14.0	5.7	12.0
MIN	2.7	5.8	4.6	3.7	3.2	2.7	9.2	2.0	3.5	1.6	1.1	.61

WTR YR 1984 TOTAL 5217.37 MEAN 14.3 MAX 495 MIN .61

Appendix 6d—Nitrite plus nitrate nitrogen loads at Delavan Lake tributary 2, 1984 water year.

Delavan Lake tributary at South Shore Drive at Delavan Lake, Wisconsin

Nitrogen, nitrite plus nitrate (pounds per day), water year October 1983 to September 1984

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	27.0	5.9	11.0	5.4	6.2	8.6	13.0	9.7	15.0	9.2	8.0	6.4
2	25.0	5.8	11.0	5.6	6.8	8.4	12.0	11.0	13.0	8.7	7.8	6.5
3	23.0	5.1	11.0	5.8	6.5	8.4	12.0	12.0	11.0	8.2	7.6	5.8
4	21.0	4.3	11.0	6.4	6.2	8.8	13.0	12.0	9.3	8.3	7.6	5.6
5	19.0	4.8	12.0	6.5	5.9	8.3	13.0	11.0	9.1	7.9	7.6	5.6
6	17.0	4.0	12.0	6.6	5.7	8.1	11.0	11.0	8.9	7.7	7.3	5.6
7	14.0	3.6	11.0	6.7	5.4	8.7	10.0	9.3	9.0	6.9	7.5	6.9
8	16.0	3.6	9.1	6.5	5.7	8.6	9.3	8.0	9.3	6.5	8.5	6.0
9	10.0	3.4	8.4	6.6	5.7	8.6	8.9	7.7	8.7	7.1	8.0	5.8
10	8.7	3.3	8.4	6.4	4.6	8.2	8.3	7.4	8.7	9.1	7.4	6.2
11	7.1	3.5	14.0	6.1	3.4	8.2	7.5	7.6	7.7	8.9	6.7	6.0
12	5.8	3.2	21.0	6.2	27.0	8.1	8.5	7.2	7.8	8.7	6.6	6.0
13	4.7	3.1	19.0	5.9	78.0	9.8	8.9	7.4	7.9	8.5	6.2	5.7
14	6.7	3.2	19.0	6.1	61.0	11.0	8.9	7.1	7.2	8.7	6.3	5.8
15	6.9	3.5	18.0	6.0	80.0	14.0	9.5	6.6	6.5	8.6	6.3	5.7
16	6.4	3.8	16.0	6.1	79.0	14.0	11.0	6.3	6.4	7.6	6.3	5.8
17	5.8	4.3	12.0	6.0	65.0	8.9	11.0	6.1	6.5	8.2	6.2	5.7
18	5.5	3.0	11.0	5.7	50.0	13.0	11.0	6.2	26.0	7.2	6.4	5.5
19	6.2	4.6	9.5	5.8	47.0	11.0	9.8	6.4	11.0	7.0	6.1	5.5
20	7.5	7.8	7.7	5.5	45.0	16.0	9.4	6.2	8.9	7.6	5.8	5.4
21	7.3	8.1	7.1	5.4	38.0	18.0	9.2	6.2	7.9	7.1	7.2	5.2
22	8.9	6.3	6.0	5.8	31.0	19.0	12.0	9.3	8.1	7.0	7.9	5.0
23	8.8	11.0	5.1	6.2	24.0	20.0	10.0	7.7	8.6	7.1	6.2	5.1
24	8.4	9.0	4.7	6.8	19.0	28.0	10.0	7.3	8.7	7.3	5.9	8.9
25	7.9	7.9	4.2	6.6	15.0	29.0	10.0	24.0	8.7	7.4	5.1	9.3
26	7.3	7.1	4.2	6.5	12.0	50.0	10.0	21.0	9.2	7.8	5.6	5.1
27	7.1	8.1	4.1	6.3	9.9	42.0	9.7	7.9	9.9	8.6	6.0	5.2
28	6.7	12.0	4.2	6.3	8.0	33.0	9.0	18.0	10.0	8.4	6.1	5.0
29	6.4	12.0	4.5	6.2	8.2	24.0	10.0	24.0	10.0	8.0	6.2	5.1
30	6.2	12.0	4.8	6.1	---	18.0	11.0	22.0	9.5	8.4	6.1	5.3
31	6.0	---	5.0	6.1	---	14.0	---	18.0	---	8.2	5.3	---
TOTAL	324.3	177.3	306.0	190.2	759.2	493.7	306.9	331.6	288.5	245.9	207.8	176.7
MEAN	10.5	5.91	9.87	6.14	26.2	15.9	10.2	10.7	9.62	7.93	6.70	5.89
MAX	27.0	12.0	21.0	6.8	80.0	50.0	13.0	24.0	26.0	9.2	8.5	9.3
MIN	4.7	3.0	4.1	5.4	3.4	8.1	7.5	6.1	6.4	6.5	5.1	5.0

WTR YR 1984 TOTAL 3808.1 MEAN 10.4 MAX 80.0 MIN 3.0

Appendix 6e—Suspended-sediment loads at Delavan Lake tributary 2, 1985 water year.

Delavan Lake tributary at South Shore Drive at Delavan Lake, Wisconsin

Sediment discharge, suspended (tons per day), water year October 1984 to September 1985

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.01	.33	.09	.12	.16	.88	.37	.28	.12	.02	.40	.04
2	.02	.47	.07	.08	.15	1.1	.48	.29	.15	.04	.23	.03
3	.03	.30	.05	.05	.14	1.1	.55	.26	.13	.05	.21	.04
4	.03	.14	.04	.08	.13	1.6	.56	.26	.10	.06	.09	.05
5	.04	.09	.04	.16	.10	1.9	.48	.32	.10	.10	.10	.07
6	.06	.06	.03	.33	.08	2.0	.47	.27	.09	.13	.09	.07
7	.24	.04	.02	.59	.06	1.8	.45	.26	.08	.15	.09	.05
8	.11	.03	.02	.59	.04	1.9	.40	.25	.08	.19	.08	2.5
9	.11	.06	.01	.57	.03	2.1	.33	.23	.07	.17	.06	.34
10	.11	.16	.01	.53	.03	2.0	.31	.23	.05	.12	.09	.12
11	.11	.16	.01	.49	.02	2.0	.28	.23	.05	.10	.06	.09
12	.18	.07	.02	.49	.02	1.7	.30	.31	.04	.32	.06	.08
13	.16	.05	.02	.45	.02	1.4	.30	.26	.03	.42	3.9	.07
14	.14	.04	.02	.39	.01	1.3	.30	.26	.03	5.8	.17	.06
15	.19	.03	.02	.32	.01	1.0	.31	.41	.05	.20	.13	.06
16	.22	.02	.02	.24	.01	.80	.28	.34	.03	.15	.10	.06
17	.28	.02	.03	.17	.01	.65	.29	.31	.03	.19	.10	.05
18	.22	.01	.04	.14	.01	.55	.27	.26	.02	.15	.10	.05
19	.12	.01	.07	.11	.01	.49	.24	.25	.02	.13	.06	.04
20	.05	.06	.11	.08	.01	.45	.24	.23	.02	.14	.06	.03
21	.05	.20	.18	.06	.03	.44	.24	.21	.03	.10	.06	.05
22	.04	.19	.32	.06	.19	.43	.23	.21	.03	.12	.09	.03
23	.04	.17	.53	.05	.61	.45	.28	.21	.02	.15	.08	.02
24	.04	.15	.65	.05	1.7	.54	.31	.18	.02	.16	.04	.02
25	.03	.14	.20	.06	1.0	.45	.27	.31	.02	.36	.07	.02
26	.03	.07	.06	.08	.73	.16	.24	23	.02	.18	.06	.02
27	.04	.19	.02	.10	.79	.13	.24	1.8	.02	.15	.05	.02
28	.05	.16	.03	.14	.79	.33	.25	.27	.02	.13	.04	.02
29	.04	.13	.19	.17	---	.19	.25	.22	.02	.12	.04	.01
30	.03	.11	.40	.17	---	.25	.27	.18	.02	.43	.04	.01
31	.02	---	.20	.17	---	.34	---	.14	---	.57	.04	---
TOTAL	2.84	3.66	3.52	7.09	6.89	30.43	9.79	32.24	1.51	11.10	6.79	4.12
MEAN	.09	.12	.11	.23	.25	.98	.33	1.04	.05	.36	.22	.14
MAX	.28	.47	.65	.59	1.7	2.1	.56	23	.15	5.8	3.9	2.5
MIN	.01	.01	.01	.05	.01	.13	.23	.14	.02	.02	.04	.01

CAL YR 1984 TOTAL 48.92 MEAN .13 MAX 11 MIN .01
WTR YR 1985 TOTAL 119.98 MEAN .33 MAX 23 MIN .01

Appendix 6f—Total phosphorus loads at Delavan Lake tributary 2, 1985 water year.

Delavan Lake tributary at South Shore Drive at Delavan Lake, Wisconsin

Phosphorus, total (pounds per day), water year October 1984 to September 1985

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.15	13.0	1.25	1.37	.15	3.90	.70	.38	.20	.15	.68	.12
2	.16	17.0	1.16	2.04	.14	3.54	.81	.37	.24	.22	.26	.11
3	.17	13.0	1.05	.94	.14	2.75	1.40	.32	.23	.22	.17	.11
4	.17	9.06	.94	.68	.13	3.02	2.44	.30	.18	.19	.08	.10
5	.16	6.23	.90	.58	.12	2.84	3.06	.34	.19	.27	.11	.18
6	.16	4.34	.74	.52	.11	2.48	3.48	.29	.19	.28	.12	.23
7	.71	3.24	.59	.49	.10	1.99	4.03	.26	.18	.25	.14	.21
8	.31	2.41	.49	.44	.09	1.84	3.69	.25	.20	.27	.10	1.93
9	.26	4.64	.45	.42	.08	1.83	2.51	.22	.21	.25	.05	1.11
10	.22	8.05	.43	.39	.08	1.51	1.84	.21	.18	.21	.05	.63
11	.21	5.32	.52	.36	.09	1.41	1.43	.20	.18	.20	.02	.49
12	.90	3.51	.90	.36	.11	1.18	1.34	.26	.16	1.64	.01	.45
13	.49	2.73	.79	.33	.12	1.02	1.19	.21	.16	2.06	3.79	.42
14	.33	2.13	.84	.29	.10	.96	1.04	.20	.16	16.0	.68	.41
15	.50	1.70	.92	.29	.08	.82	.98	.30	.27	.37	.51	.45
16	.60	1.35	1.07	.28	.07	.65	.88	.24	.20	.28	.39	.45
17	.90	1.17	1.03	.24	.07	.55	.88	.21	.19	.36	.37	.44
18	1.29	1.07	.96	.24	.07	.48	.75	.17	.17	.30	.35	.41
19	5.43	.91	.80	.25	.07	.39	.64	.16	.17	.26	.23	.37
20	4.14	.77	.66	.20	.07	.32	.58	.14	.18	.27	.21	.31
21	3.30	.65	.60	.20	.42	.28	.56	.13	.34	.21	.19	.50
22	2.46	.59	.58	.19	1.06	.25	.51	.13	.30	.22	.29	.36
23	1.80	.56	.51	.19	14.0	.24	.57	.14	.25	.19	.26	.31
24	1.35	.52	.45	.18	21.0	.26	.62	.12	.22	.19	.13	.27
25	1.14	.51	.39	.17	19.0	.23	.51	.33	.20	.69	.23	.29
26	.98	.50	.30	.16	11.0	.20	.42	2.12	.20	.30	.20	.29
27	1.22	1.60	.29	.16	7.76	.71	.41	1.49	.21	.16	.16	.24
28	1.29	1.44	.50	.15	4.65	1.33	.40	.39	.17	.15	.14	.24
29	1.12	1.39	1.31	.15	---	.51	.37	.32	.15	.16	.13	.24
30	1.03	1.37	1.93	.15	---	.59	.38	.28	.15	.80	.15	.24
31	.87	---	1.55	.15	---	.72	---	.23	---	1.19	.14	---
TOTAL	33.82	110.76	24.90	12.56	80.88	38.80	38.42	10.71	6.03	28.31	10.34	11.91
MEAN	1.09	3.69	.80	.41	2.89	1.25	1.28	.35	.20	.91	.33	.40
MAX	5.43	17.0	1.93	2.04	21.0	3.90	4.03	2.12	.34	16.0	3.79	1.93
MIN	.15	.50	.29	.15	.07	.20	.37	.12	.15	.15	.01	.10

CAL YR 1984 TOTAL 650.13 MEAN 1.78 MAX 64.0 MIN .11
WTR YR 1985 TOTAL 407.43 MEAN 1.12 MAX 21.0 MIN .01

Appendix 6g—Kjeldahl nitrogen loads at Delavan Lake tributary 2, 1985 water year.

Delavan Lake tributary at South Shore Drive at Delavan Lake, Wisconsin

Nitrogen, ammonia plus organic, total (pounds per day), water year October 1984 to September 1985

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.80	44.0	8.0	13.0	.50	46.0	20.0	1.4	2.9	.96	13.0	1.2
2	.84	49.0	7.2	11.0	.48	42.0	20.0	1.4	3.4	1.4	12.0	1.1
3	.83	39.0	6.2	9.9	.46	33.0	25.0	1.3	3.1	1.4	1.9	1.1
4	.80	28.0	5.4	7.9	.41	36.0	32.0	1.2	2.4	1.3	.76	1.1
5	.74	20.0	4.9	6.4	.40	34.0	28.0	1.4	2.5	1.9	.77	1.9
6	.74	14.0	4.0	5.4	.38	31.0	30.0	1.2	2.4	2.0	.69	2.3
7	1.9	11.0	3.0	4.8	.33	25.0	37.0	1.1	2.1	1.8	.64	2.2
8	.83	8.7	2.4	4.3	.29	24.0	36.0	1.1	2.1	2.0	.60	27.0
9	.78	46.0	2.2	3.9	.27	24.0	26.0	.95	2.1	1.9	.45	7.2
10	.75	80.0	2.2	3.4	.26	20.0	19.0	.92	1.6	1.7	.61	2.6
11	.75	64.0	2.8	3.0	.29	20.0	14.0	.91	1.6	1.6	.38	2.0
12	1.9	47.0	5.4	2.8	.34	17.0	13.0	1.2	1.3	12.0	.39	1.8
13	1.8	37.0	5.1	2.5	.36	15.0	11.0	,97	1.2	18.0	38.0	1.6
14	1.6	29.0	5.5	2.1	.31	14.0	8.9	.94	1.1	117	4.2	1.5
15	3.2	23.0	6.3	2.0	.25	12.0	7.9	1.5	1.7	3.6	3.2	1.7
16	4.1	19.0	7.5	1.8	.21	10.0	6.8	1.2	1.2	2.8	2.3	1.6
17	5.9	16.0	7.4	1.5	.21	8.8	6.5	1.1	1.1	3.7	2.2	1.6
18	8.5	15.0	7.0	1.4	.18	7.8	5.3	.86	.91	3.2	2.1	1.5
19	26.0	13.0	5.9	1.3	.18	6.5	4.3	.80	.82	2.9	1.3	1.3
20	20.0	11.0	5.0	1.1	.18	5.6	3.7	.72	.90	3.1	1.2	1.1
21	16.0	9.3	4.6	1.0	3.3	5.2	3.4	.71	1.8	2.5	1.1	1.8
22	12.0	8.2	4.5	.90	15.0	4.9	3.0	.72	1.6	2.8	1.7	1.3
23	8.9	7.3	4.0	.85	65.0	5.0	3.2	.78	1.3	2.5	1.6	1.1
24	6.8	6.4	3.7	.76	126	5.8	3.3	.70	1.2	2.5	.84	.97
25	5.9	5.9	3.1	.71	111	5.4	2.6	2.8	1.1	5.6	1.6	1.0
26	5.1	5.5	2.7	.65	86.0	5.0	2.0	25.0	1.2	2.4	1.4	1.0
27	6.4	12.0	2.5	.63	73.0	13.0	1.9	18.0	1.2	1.8	1.3	.86
28	15.0	10.0	7.5	.59	55.0	28.0	1.8	6.0	1.0	1.5	1.1	.86
29	14.0	9.7	16.0	.58	---	19.0	1.6	4.8	.93	1.4	1.0	.85
30	11.0	9.2	21.0	.57	---	21.0	1.5	4.1	.93	13.0	1.3	.85
31	8.8	---	16.0	.54	---	23.0	---	3.3	---	17.0	1.2	---
TOTAL	192.66	697.2	189.0	97.28	540.59	567.0	378.7	89.08	48.69	237.26	100.83	73.99
MEAN	6.21	23.2	6.10	3.14	19.3	18.3	12.6	2.87	1.62	7.65	3.25	2.47
MAX	26.0	80.0	21.0	13.0	126	46.0	37.0	25.0	3.4	117	38.0	27.0
MIN	.74	5.5	2.2	.54	.18	4.9	1.5	.70	.82	.96	.38	.85

CAL YR 1984 TOTAL 5125.43 MEAN 14.0 MAX 495 MIN .61

WTR YR 1985 TOTAL 3212.24 MEAN 8.80 MAX 126 MIN .18

Appendix 6h—Nitrite plus nitrate nitrogen loads at Delavan Lake tributary 2, 1985 water year.

Delavan Lake tributary at South Shore Drive at Delavan Lake, Wisconsin

Nitrogen, nitrite plus nitrate (pounds per day), water year October 1984 to September 1985

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	5.1	17.0	15.0	12.0	9.3	57.0	12.0	1.9	11.0	5.6	12.0	3.0
2	5.5	14.0	15.0	11.0	9.3	54.0	11.0	2.1	13.0	7.9	7.3	2.9
3	5.6	14.0	15.0	10.0	8.9	44.0	13.0	2.1	13.0	7.8	5.4	2.6
4	5.6	13.0	15.0	10.0	8.8	51.0	14.0	2.2	11.0	6.8	3.0	2.5
5	5.3	11.0	15.0	9.9	8.7	50.0	12.0	3.0	12.0	9.3	4.1	4.2
6	5.5	11.0	13.0	8.0	8.6	48.0	12.0	2.8	12.0	9.6	4.9	5.0
7	7.7	10.0	12.0	7.9	8.0	42.0	14.0	2.9	11.0	8.2	6.0	4.5
8	6.0	10.0	11.0	8.0	7.2	42.0	15.0	3.1	12.0	8.7	5.9	6.4
9	6.1	13.0	11.0	8.2	7.1	46.0	14.0	3.2	12.0	8.1	4.7	3.0
10	6.2	16.0	11.0	8.1	7.3	41.0	13.0	3.4	9.9	6.7	6.6	2.3
11	6.5	16.0	12.0	8.1	8.3	42.0	11.0	3.8	10.0	6.4	4.3	2.2
12	8.4	14.0	9.4	8.6	10.0	38.0	12.0	5.5	8.6	12.0	4.5	2.4
13	6.5	13.0	11.0	8.5	11.0	36.0	12.0	5.1	8.6	15.0	11.0	2.8
14	6.7	11.0	13.0	8.1	10.0	37.0	11.0	5.5	8.3	24.0	2.2	3.3
15	7.9	10.0	10.0	8.6	8.8	35.0	12.0	9.5	14.0	2.5	2.3	4.4
16	8.8	9.5	8.1	8.7	7.8	30.0	12.0	8.8	10.0	2.7	2.3	5.3
17	8.6	9.4	6.0	8.2	7.6	28.0	11.0	8.6	9.5	4.9	2.9	5.4
18	8.9	9.9	5.8	8.6	7.5	26.0	8.9	7.9	8.4	5.5	3.6	5.2
19	11.0	9.6	5.2	8.6	7.7	23.0	7.0	8.3	7.9	6.8	3.2	4.9
20	8.5	9.3	4.6	8.6	7.9	21.0	6.0	8.4	8.3	8.4	4.0	4.2
21	8.6	8.9	4.5	9.2	12.0	20.0	5.4	9.2	16.0	3.2	4.7	7.1
22	8.2	9.0	4.6	9.1	18.0	19.0	4.6	10.0	14.0	1.4	7.6	5.2
23	7.8	9.4	4.4	9.7	41.0	20.0	4.8	12.0	11.0	.53	6.7	4.6
24	7.5	9.5	4.3	9.6	63.0	24.0	4.9	11.0	9.3	.54	3.3	4.2
25	8.0	10.0	3.8	9.5	102	23.0	3.8	11.0	8.5	9.5	6.0	4.6
26	8.0	11.0	3.5	9.1	94.0	22.0	2.9	26.0	8.4	5.0	5.1	4.7
27	9.7	12.0	3.4	9.1	82.0	28.0	2.6	20.0	8.4	1.3	4.1	4.1
28	11.0	13.0	5.8	9.1	65.0	18.0	2.4	12.0	6.7	.87	3.6	4.2
29	13.0	14.0	13.0	9.3	---	13.0	2.1	11.0	5.9	.96	3.2	4.3
30	15.0	15.0	14.0	9.4	---	13.0	2.0	11.0	5.7	1.2	3.7	4.4
31	15.0	---	13.0	9.4	---	14.0	---	10.0	---	13.0	3.3	---
TOTAL	252.2	352.5	292.4	280.2	646.8	1005.0	268.4	241.3	304.4	204.40	151.5	123.9
MEAN	8.14	11.7	9.43	9.04	23.1	32.4	8.95	7.78	10.1	6.59	4.89	4.13
MAX	15.0	17.0	15.0	12.0	102	57.0	15.0	26.0	16.0	24.0	12.0	7.1
MIN	5.1	8.9	3.4	7.9	7.1	13.0	2.0	1.9	5.7	.53	2.2	2.2

CAL YR 1984 TOTAL 3897.56 MEAN 10.6 MAX 80.0 MIN 3.4
WTR YR 1985 TOTAL 4122.97 MEAN 11.3 MAX 102 MIN .53

Appendix 7a—Suspended-sediment loads at Delavan Lake outlet, 1984 water year.

Delavan Lake outlet at Borg Road near Delavan, Wisconsin

Sediment discharge, suspended (tons per day), water year October 1983 to September 1984

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.17	.01	4.2	.11	.06	.86	4.7	6.6	25	.23	.26	.14
2	.16	.01	2.8	.11	.04	.45	3.4	1.8	23	.31	.16	.19
3	.16	.01	1.8	.11	.04	.35	2.8	1.4	7.8	.31	.09	.15
4	1.7	.01	1.2	.11	.04	.31	2.6	1.3	.11	.29	.09	.13
5	2.4	.01	.53	.14	.04	.23	2.4	1.2	.10	.27	.09	.11
6	2.2	.01	.28	.14	.04	.14	1.9	1.2	4.5	.24	.07	.10
7	2.0	.01	.18	.14	.04	.12	1.5	.45	14	.22	.08	.11
8	2.0	.01	.17	.14	.04	.11	1.4	.09	5.9	.20	.06	.07
9	1.8	.01	.11	.14	.04	.12	1.3	.14	.64	.19	.05	.05
10	1.8	.02	.08	.14	.28	.06	.94	.17	.60	.31	.05	.04
11	1.8	.02	.18	.14	.36	.05	.59	.08	1.8	2.2	.05	.03
12	1.7	.02	.12	.14	.62	.05	.20	.02	3.5	2.7	.04	.03
13	1.7	.02	.12	.14	1.5	.05	.04	.02	7.4	2.5	.09	.03
14	1.5	.03	.18	.15	5.6	.12	.06	.03	5.0	2.3	.10	.03
15	1.4	.03	.19	.16	8.5	.29	.08	.03	1.3	2.3	.10	.02
16	1.3	.04	.18	.17	14	.49	.10	.03	.05	2.1	.12	.02
17	1.2	.04	.18	.19	12	.38	.08	.03	.04	2.1	.13	.02
18	1.1	.05	.17	.22	10	.29	.11	.04	10	1.5	.11	.02
19	1.2	.09	.16	.19	8.8	.34	.17	.04	10	.78	.12	.02
20	1.2	.12	.16	.17	7.2	1.1	.28	.04	9.5	.80	.07	.02
21	1.0	.20	.16	.14	6.0	2.2	.50	.03	8.4	.77	.05	.02
22	.99	.30	.16	.14	4.9	2.8	.52	.01	6.8	.65	.06	.02
23	.97	2.7	.23	.10	4.1	5.6	9.6	.01	5.7	.56	.07	.01
24	.92	2.7	.24	.07	3.1	8.9	16	.01	5.1	.59	.09	.02
25	.36	.89	.23	.10	2.4	8.5	25	3.9	2.1	.49	.09	.02
26	.01	.51	.22	.11	2.0	8.0	28	3.4	.11	.43	.11	.01
27	.01	.73	.21	.08	1.7	7.5	23	4.4	.11	.41	.17	.02
28	.01	2.9	.15	.06	1.2	7.1	18	18	.11	.41	.24	.02
29	.01	2.8	.11	.00	1.0	6.2	16	7.1	.13	.36	.31	.02
30	.01	3.8	.11	.06	---	5.7	13	7.8	.17	.35	.21	.01
31	.01	---	.11	.06	---	5.2	---	15	---	.32	.19	---
TOTAL	32.79	18.10	14.92	3.87	95.64	73.61	174.27	74.37	158.97	27.19	3.52	1.50
MEAN	1.06	.60	.48	.12	3.30	2.37	5.81	2.40	5.30	.88	.11	.05
MAX	2.4	3.8	4.2	.22	14	8.9	28	18	25	2.7	.31	.19
MIN	.01	.01	.08	.00	.04	.05	.04	.01	.04	.19	.04	.01

WTR YR 1984 TOTAL 678.74 MEAN 1.85 MAX 28 MIN .00

Appendix 7b—Total phosphorus loads at Delavan Lake outlet, 1984 water year.

Delavan Lake outlet at Borg Road near Delavan, Wisconsin

Phosphorus, total (pounds per day), water year October 1983 to September 1984

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	6.69	.82	125	12.0	6.64	34.0	53.0	32.0	102	2.82	3.23	.86
2	6.54	1.09	108	13.0	6.45	20.0	39.0	25.0	89.0	3.21	2.05	.93
3	6.48	1.60	93.0	13.0	6.61	18.0	33.0	29.0	44.0	3.62	1.24	.78
4	47.0	1.04	81.0	12.0	6.55	17.0	31.0	28.0	2.14	4.25	1.28	.74
5	62.0	1.00	47.0	13.0	6.30	14.0	30.0	26.0	2.05	5.00	1.23	.63
6	56.0	1.10	34.0	13.0	6.42	11.0	24.0	26.0	38.0	5.49	1.11	.65
7	50.0	1.18	30.0	13.0	6.62	11.0	19.0	10.0	97.0	6.27	1.19	.72
8	48.0	1.20	28.0	13.0	6.89	13.0	18.0	1.97	41.0	7.27	1.06	.49
9	44.0	1.52	27.0	13.0	6.61	13.0	18.0	2.12	5.80	7.26	.95	.38
10	40.0	2.22	24.0	13.0	11.0	10.0	16.0	2.37	4.42	7.60	1.00	.30
11	39.0	1.75	38.0	13.0	12.0	9.76	13.0	1.04	13.0	34.0	.93	.29
12	35.0	1.55	31.0	13.0	48.0	9.67	5.23	.26	28.0	41.0	.86	.31
13	35.0	1.65	29.0	13.0	65.0	9.94	1.22	.24	65.0	37.0	1.92	.31
14	32.0	1.88	30.0	12.0	128	11.0	1.57	.24	50.0	35.0	2.33	.30
15	32.0	1.98	31.0	12.0	187	13.0	1.79	.27	16.0	34.0	2.45	.27
16	29.0	2.05	30.0	13.0	195	13.0	2.24	.26	1.66	32.0	2.94	.28
17	28.0	2.12	29.0	14.0	150	12.0	2.22	.29	1.44	31.0	3.15	.35
18	27.0	2.23	28.0	16.0	138	11.0	2.19	.39	80.0	20.0	2.94	.41
19	27.0	3.12	27.0	15.0	154	19.0	2.29	.35	69.0	3.97	3.04	.45
20	27.0	3.22	26.0	13.0	95.0	28.0	2.44	.36	54.0	4.27	1.89	.52
21	25.0	4.00	26.0	13.0	85.0	38.0	60.0	.41	43.0	4.42	1.42	.52
22	25.0	4.76	27.0	13.0	79.0	37.0	75.0	.36	32.0	4.01	1.45	.53
23	24.0	21.0	26.0	9.49	73.0	51.0	54.0	.30	30.0	3.67	.74	.47
24	22.0	37.0	27.0	6.44	61.0	73.0	74.0	.35	33.0	4.14	.44	.60
25	9.15	32.0	26.0	8.90	52.0	73.0	103	61.0	15.0	3.71	.76	.70
26	.53	28.0	25.0	12.0	49.0	71.0	111	27.0	1.25	3.49	.96	.52
27	.48	26.0	24.0	9.07	48.0	70.0	99.0	76.0	1.87	3.56	1.08	.89
28	.40	60.0	17.0	6.63	37.0	68.0	86.0	432	1.91	3.88	1.13	.94
29	.57	73.0	12.0	6.38	35.0	62.0	81.0	91.0	2.37	3.61	1.15	.85
30	.60	94.0	12.0	6.60	---	59.0	61.0	87.0	2.53	3.78	.90	.77
31	.70	---	12.0	6.45	---	56.0	---	83.0	---	3.70	.96	---
TOTAL	786.14	414.08	1130.0	359.96	1761.09	955.37	1119.19	1044.58	966.44	367.00	47.78	16.76
MEAN	25.4	13.8	36.5	11.6	60.7	30.8	37.3	33.7	32.2	11.8	1.54	.56
MAX	62.0	94.0	125	16.0	195	73.0	111	432	102	41.0	3.23	.94
MIN	.40	.82	12.0	6.38	6.30	9.67	1.22	.24	1.25	2.82	.44	.27

WTR YR 1984 TOTAL 8968.29 MEAN 24.5 MAX 432 MIN .24

Appendix 7c—Kjeldahl nitrogen loads at Delavan Lake outlet, 1984 water year.

Delavan Lake outlet at Borg Road near Delavan, Wisconsin

Nitrogen, ammonia plus organic, total (pounds per day), water year October 1983 to September 1984

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	67.0	7.6	1260	130	83.0	273	515	1380	915	28.0	40.0	11.0
2	65.0	10.0	1100	134	81.0	167	381	1150	916	41.0	21.0	11.0
3	65.0	15.0	954	141	83.0	153	316	996	416	45.0	9.1	8.5
4	360	10.0	833	134	83.0	156	302	1020	17.0	49.0	9.1	7.9
5	487	9.8	488	135	80.0	129	288	1050	16.0	53.0	8.5	6.8
6	460	11.0	354	136	82.0	106	225	1130	464	54.0	7.4	7.0
7	432	12.0	319	138	85.0	104	178	461	1180	56.0	7.7	7.7
8	422	13.0	305	139	89.0	132	175	100	510	60.0	6.6	5.3
9	397	16.0	293	141	86.0	137	172	99.0	58.0	60.0	5.8	4.2
10	364	25.0	272	142	156	113	152	38.0	51.0	84.0	5.9	3.2
11	356	20.0	315	144	245	110	123	6.7	135	295	5.3	3.1
12	375	18.0	275	145	324	113	59.0	1.3	285	330	4.8	3.4
13	421	20.0	270	147	400	114	29.0	1.2	556	300	19.0	3.3
14	381	23.0	280	141	615	101	37.0	1.2	443	283	26.0	3.3
15	377	25.0	292	138	1070	94.0	40.0	1.3	168	281	28.0	3.0
16	345	26.0	287	144	1220	90.0	48.0	1.3	13.0	262	32.0	3.1
17	325	28.0	280	161	1120	83.0	46.0	1.4	13.0	257	33.0	3.9
18	314	30.0	275	190	858	77.0	45.0	1.9	520	167	30.0	4.6
19	311	43.0	262	171	965	138	47.0	1.8	473	44.0	30.0	5.0
20	306	46.0	260	153	721	217	49.0	1.8	390	48.0	17.0	5.8
21	285	58.0	258	153	743	292	58.0	2.1	331	50.0	11.0	5.9
22	275	72.0	267	152	682	292	41.0	1.8	256	46.0	11.0	6.0
23	262	299	262	113	612	461	468	1.5	224	43.0	7.7	5.3
24	243	387	275	77.0	491	732	921	1.7	217	49.0	7.3	6.8
25	99.0	270	259	107	408	723	1520	191	94.0	44.0	9.9	8.0
26	5.2	302	251	149	373	704	1800	156	7.8	42.0	12.0	5.9
27	4.7	363	242	110	355	689	1770	227	11.0	43.0	13.0	10.0
28	3.8	751	177	81.0	282	671	1680	1320	14.0	48.0	13.0	11.0
29	5.5	896	128	78.0	278	609	1770	753	14.0	45.0	13.0	9.6
30	5.6	952	127	81.0	---	575	1560	952	19.0	47.0	11.0	8.6
31	6.5	---	128	80.0	---	550	---	674	---	47.0	12.0	---
TOTAL	7825.3	4758.4	11348	4085.0	12670.0	8905.0	14815.0	11724.0	8726.8	3301.0	467.1	188.2
MEAN	252	159	366	132	437	287	494	378	291	106	15.1	6.27
MAX	487	952	1260	190	1220	732	1800	1380	1180	330	40.0	11.0
MIN	3.8	7.6	127	77.0	80.0	77.0	29.0	1.2	7.8	28.0	4.8	3.0

WTR YR 1984 TOTAL 88813.5 MEAN 243 MAX 1800 MIN 1.2

Appendix 7d—Nitrite plus nitrate nitrogen loads at Delavan Lake outlet, 1984 water year.

Delavan Lake outlet at Borg Road near Delavan, Wisconsin

Nitrogen, nitrite plus nitrate (pounds per day), water year October 1983 to September 1984

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	32.0	3.4	219	28.0	16.0	169	318	165	442	4.7	5.8	11.0
2	30.0	4.9	199	29.0	16.0	97.0	235	230	435	4.9	3.6	11.0
3	27.0	7.1	180	30.0	16.0	85.0	195	718	224	5.6	2.1	9.0
4	52.0	4.5	163	28.0	16.0	83.0	187	620	17.0	6.8	2.0	8.6
5	53.0	4.2	99.0	28.0	16.0	68.0	178	481	16.0	8.3	1.9	7.6
6	42.0	4.5	75.0	28.0	16.0	55.0	139	389	43.0	9.4	1.6	8.0
7	33.0	4.6	70.0	28.0	17.0	54.0	111	128	163	11.0	1.7	9.0
8	34.0	4.6	69.0	28.0	18.0	68.0	108	19.0	123	13.0	1.4	6.3
9	37.0	5.6	67.0	28.0	17.0	70.0	106	17.0	24.0	12.0	1.2	5.1
10	39.0	8.0	63.0	28.0	31.0	57.0	93.0	19.0	19.0	10.0	1.2	4.0
11	44.0	6.1	66.0	28.0	48.0	56.0	75.0	8.3	42.0	92.0	1.1	4.0
12	48.0	5.3	70.0	28.0	76.0	57.0	31.0	2.1	79.0	115	.96	4.5
13	51.0	5.4	71.0	28.0	150	58.0	7.8	1.9	125	105	3.2	4.4
14	47.0	6.0	73.0	27.0	541	58.0	7.1	2.0	101	99.0	4.5	4.0
15	47.0	6.1	75.0	26.0	924	61.0	5.6	2.1	43.0	99.0	5.1	3.4
16	44.0	6.2	73.0	27.0	967	65.0	4.8	2.1	3.8	93.0	6.6	3.3
17	42.0	6.2	71.0	30.0	792	65.0	3.5	2.3	3.9	92.0	7.5	3.8
18	42.0	6.3	69.0	35.0	580	65.0	3.5	3.1	63.0	56.0	7.5	4.2
19	42.0	8.6	65.0	31.0	454	104	3.7	2.8	125	6.9	8.3	4.3
20	43.0	8.6	64.0	28.0	379	176	4.0	2.9	146	7.6	5.5	4.6
21	40.0	10.0	63.0	28.0	397	272	4.9	3.3	153	7.8	4.4	4.4
22	40.0	12.0	64.0	28.0	383	313	3.6	2.9	141	7.1	5.4	4.1
23	40.0	28.0	62.0	21.0	363	498	36.0	2.4	130	6.6	5.0	3.4
24	39.0	46.0	65.0	14.0	306	736	129	2.8	131	7.4	4.3	4.0
25	37.0	52.0	60.0	20.0	269	676	365	188	59.0	6.6	7.6	4.4
26	15.0	58.0	58.0	28.0	259	596	444	138	5.7	6.3	9.4	3.0
27	1.2	60.0	55.0	21.0	254	529	387	176	6.8	6.4	10.0	5.0
28	1.2	91.0	40.0	15.0	193	470	326	436	4.5	7.0	11.0	5.2
29	1.1	111	29.0	15.0	179	407	303	381	4.7	6.5	11.0	4.7
30	1.7	164	28.0	16.0	---	369	233	408	4.6	6.9	9.4	4.3
31	2.0	---	28.0	15.0	---	341	---	402	---	6.7	11.0	---
TOTAL	1047.2	748.2	2453.0	792.0	7693.0	6778.0	4047.5	4956.0	2878.0	926.5	161.26	162.6
MEAN	33.8	24.9	79.1	25.5	265	219	135	160	95.9	29.9	5.20	5.42
MAX	53.0	164	219	35.0	967	736	444	718	442	115	11.0	11.0
MIN	1.1	3.4	28.0	14.0	16.0	54.0	3.5	1.9	3.8	4.7	.96	3.0

WTR YR 1984 TOTAL 32643.08 MEAN 89.2 MAX 967 MIN 96

Appendix 7e—Suspended-sediment loads at Delavan Lake outlet, 1985 water year.

Delavan Lake outlet at Borg Road near Delavan, Wisconsin

Sediment discharge, suspended (tons per day), water year October 1984 to September 1985

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.10	5.8	.66	6.9	.80	24	15	.22	.01	.08	.42	.35
2	.12	3.8	.55	7.3	.77	23	14	.18	.01	.10	.33	.37
3	.14	3.9	.47	7.5	.75	22	15	.08	.01	.11	.29	.35
4	.18	6.3	.63	7.9	.74	22	16	.03	.01	.11	.29	.60
5	.27	6.7	.46	8.4	.73	22	17	.03	.01	.11	.28	.64
6	.34	7.0	.44	8.6	.70	20	18	.04	.02	.13	.28	.72
7	.61	7.2	.41	8.6	.70	18	20	.04	.02	.13	.30	.82
8	1.1	7.3	.36	8.0	.70	17	21	.03	.02	.14	.31	5.4
9	1.6	7.6	.35	7.6	.68	16	23	.03	.02	.15	.33	15
10	1.8	4.7	.35	7.0	.68	15	18	.04	.01	.15	.39	15
11	2.0	3.9	.20	6.8	.66	14	21	.03	.01	.16	.37	15
12	3.8	1.5	1.6	6.5	.66	14	20	.03	.01	.16	.39	13
13	3.8	1.3	2.0	6.1	.66	15	19	.03	.01	.17	4.7	7.7
14	3.3	1.3	1.6	5.7	.66	15	17	.03	.02	6.9	7.0	.23
15	4.6	1.1	1.4	5.4	.65	16	16	.03	.02	1.5	4.0	.22
16	4.4	1.1	1.3	5.3	.63	16	15	.03	.02	1.3	.28	.18
17	4.1	1.1	1.3	5.1	.66	17	15	.03	.02	1.0	.23	.14
18	4.3	.94	1.2	4.9	.77	17	14	.03	.01	.80	.18	.13
19	7.9	.92	1.2	4.6	3.2	16	14	.04	.01	.68	.15	.13
20	4.1	1.0	1.1	4.4	7.6	6.9	14	.04	.02	.70	.14	.10
21	3.1	1.3	1.1	4.2	10	2.3	13	.04	.02	.55	.14	.09
22	3.0	1.7	1.0	4.1	13	1.8	13	.04	.02	.54	.14	.10
23	2.6	1.6	1.0	3.8	8.8	1.4	6.1	.03	.02	.51	.15	.08
24	2.9	1.5	1.0	3.6	19	1.2	2.7	.02	.02	.39	.14	.04
25	3.3	1.4	.92	3.5	29	.95	2.6	.02	.07	.51	.19	.04
26	2.2	1.0	.97	3.3	28	6.4	2.6	.03	.09	.58	.20	.03
27	3.4	1.6	1.4	3.2	27	19	2.4	.02	.10	.47	.20	.02
28	3.4	1.6	2.2	3.0	25	22	2.4	.01	.10	.44	.18	.01
29	2.1	1.6	4.0	2.8	---	18	.84	.02	.09	.46	.22	.01
30	4.3	1.1	6.1	1.5	---	19	.19	.02	.09	.43	.34	.01
31	5.1	---	6.7	.81	---	16	---	.02	---	.61	.32	---
TOTAL	83.96	88.86	43.97	166.41	183.20	453.95	387.83	1.31	.91	20.07	22.88	76.51
MEAN	2.71	2.96	1.42	5.37	6.54	14.6	12.9	.04	.03	.65	.74	2.55
MAX	7.9	7.6	6.7	8.6	29	24	23	.22	.10	6.9	7.0	15
MIN	.10	.92	.20	.81	.63	.95	.19	.01	.01	.08	.14	.01

CAL YR 1984 TOTAL 829.72 MEAN 2.27 MAX 28 MIN .00
WTR YR 1985 TOTAL 1529.83 MEAN 4.19 MAX 29 MIN .01

Appendix 7f—Total phosphorus loads at Delavan Lake outlet, 1985 water year.

Delavan Lake outlet at Borg Road near Delavan, Wisconsin

Phosphorus, total (pounds per day), water year October 1984 to September 1985

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	1.10	85.0	19.0	34.0	5.54	56.0	45.0	1.35	.14	1.51	3.54	3.45
2	.93	60.0	19.0	36.0	5.29	56.0	44.0	1.08	.16	1.96	2.89	3.64
3	.86	49.0	20.0	36.0	5.38	55.0	43.0	.49	.18	1.96	2.75	3.09
4	.82	47.0	28.0	37.0	5.30	57.0	44.0	.17	.20	1.91	2.80	3.22
5	.95	47.0	21.0	39.0	5.08	59.0	43.0	.17	.26	1.90	2.85	3.24
6	.92	41.0	20.0	38.0	5.02	58.0	43.0	.18	.29	2.03	2.81	3.62
7	2.90	34.0	21.0	38.0	4.97	58.0	44.0	.17	.32	2.02	2.95	4.10
8	12.0	29.0	21.0	36.0	4.92	58.0	43.0	.14	.38	2.10	3.00	37.0
9	16.0	26.0	21.0	35.0	4.97	60.0	44.0	.13	.38	2.20	3.03	86.0
10	16.0	31.0	22.0	35.0	4.97	61.0	36.0	.15	.36	2.18	3.43	84.0
11	17.0	32.0	11.0	33.0	4.78	62.0	45.0	.11	.37	2.16	3.12	85.0
12	30.0	22.0	19.0	32.0	4.81	62.0	45.0	.11	.35	2.09	3.18	74.0
13	33.0	31.0	26.0	31.0	4.85	62.0	45.0	.09	.43	2.15	34.0	50.0
14	30.0	34.0	27.0	29.0	4.74	62.0	45.0	.09	.55	38.0	46.0	2.03
15	37.0	32.0	26.0	28.0	4.97	61.0	43.0	.09	.72	23.0	30.0	1.90
16	26.0	32.0	25.0	28.0	4.72	59.0	44.0	.09	.65	18.0	2.91	1.58
17	27.0	33.0	25.0	28.0	5.08	58.0	40.0	.07	.64	13.0	2.47	1.24
18	38.0	33.0	25.0	27.0	6.30	57.0	37.0	.08	.55	9.10	2.10	1.21
19	38.0	32.0	25.0	26.0	15.0	56.0	38.0	.09	.60	6.98	1.82	1.14
20	43.0	29.0	25.0	26.0	31.0	23.0	37.0	.10	.65	6.56	1.80	.90
21	46.0	24.0	25.0	25.0	51.0	7.00	36.0	.07	.77	4.67	1.75	.85
22	45.0	26.0	25.0	24.0	67.0	7.24	35.0	.06	.77	4.09	1.76	.94
23	47.0	28.0	25.0	23.0	44.0	7.13	17.0	.07	.71	2.93	1.78	.76
24	47.0	30.0	24.0	23.0	47.0	7.40	8.90	.07	.73	2.23	1.60	.55
25	43.0	33.0	24.0	22.0	57.0	7.49	8.90	.07	3.67	3.03	1.97	.59
26	34.0	28.0	25.0	20.0	58.0	26.0	9.43	.10	4.70	3.62	2.01	.58
27	30.0	20.0	25.0	19.0	57.0	75.0	8.90	.08	4.25	3.08	2.04	.55
28	31.0	13.0	26.0	18.0	56.0	79.0	8.90	.06	3.38	3.08	1.81	.52
29	37.0	17.0	32.0	18.0	---	52.0	3.84	.09	2.39	3.33	2.17	.47
30	38.0	19.0	34.0	10.0	---	53.0	1.11	.12	1.95	3.28	3.37	.43
31	38.0	---	35.0	5.60	---	48.0	---	.13	---	4.93	3.20	---
TOTAL	807.48	997.0	746.0	859.60	574.69	1509.26	985.98	5.87	31.50	179.08	180.91	456.60
MEAN	26.0	33.2	24.1	27.7	20.5	48.7	32.9	.19	1.05	5.78	5.84	15.2
MAX	47.0	85.0	35.0	39.0	67.0	79.0	45.0	1.35	4.70	38.0	46.0	86.0
MIN	.82	13.0	11.0	5.60	4.72	7.00	1.11	.06	.14	1.51	1.60	.43

CAL YR 1984 TOTAL 9188.59 MEAN 25.1 MAX 432 MIN .24
WTR YR 1985 TOTAL 7333.89 MEAN 20.1 MAX 86.0 MIN .06

Appendix 7g—Kjeldahl nitrogen loads at Delavan Lake outlet, 1985 water year.

Delavan Lake outlet at Borg Road near Delavan, Wisconsin

Nitrogen, ammonia plus organic, total (pounds per day), water year October 1984 to September 1985

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	12.0	454	497	251	42.0	503	312	18.0	3.5	13.0	29.0	61.0
2	10.0	441	457	259	40.0	531	293	14.0	3.8	18.0	23.0	63.0
3	9.2	385	419	256	39.0	557	284	6.1	3.9	18.0	21.0	52.0
4	8.6	344	524	261	39.0	615	282	2.3	3.9	17.0	21.0	53.0
5	9.8	408	355	268	38.0	671	270	2.3	4.8	17.0	20.0	54.0
6	9.3	532	308	264	37.0	672	265	2.4	5.3	18.0	19.0	62.0
7	43.0	697	284	258	37.0	663	262	2.2	5.6	18.0	20.0	71.0
8	99.0	895	258	243	37.0	663	255	1.8	6.3	19.0	22.0	340
9	132	1150	232	230	36.0	680	257	1.5	6.1	20.0	25.0	740
10	138	812	211	219	35.0	686	204	1.8	5.7	20.0	32.0	720
11	153	1230	114	211	35.0	687	247	1.3	5.5	18.0	33.0	730
12	289	749	165	204	35.0	684	241	1.2	5.2	17.0	37.0	640
13	329	705	213	195	35.0	676	235	.93	6.0	17.0	300	440
14	303	663	223	183	35.0	672	228	.97	7.5	248	410	19.0
15	417	560	214	176	35.0	655	219	.88	9.5	103	270	13.0
16	485	496	208	174	34.0	633	214	.87	8.4	88.0	45.0	8.3
17	516	442	214	170	36.0	619	203	.68	7.7	74.0	39.0	6.6
18	524	395	207	163	42.0	583	195	.73	6.6	57.0	33.0	6.9
19	559	337	208	157	64.0	585	197	.85	7.0	49.0	30.0	6.9
20	587	271	203	152	136	270	199	.79	7.3	52.0	30.0	5.8
21	544	208	206	146	241	115	197	.63	8.5	41.0	30.0	5.9
22	480	221	199	140	401	119	195	.63	8.3	40.0	30.0	6.9
23	489	242	197	136	309	117	124	.81	7.4	32.0	30.0	5.9
24	584	260	191	130	292	128	91.0	1.1	7.5	24.0	26.0	4.6
25	620	287	190	125	400	129	92.0	1.6	24.0	32.0	32.0	5.3
26	488	241	190	119	434	249	95.0	2.8	29.0	37.0	32.0	5.5
27	427	284	191	115	453	468	96.0	2.9	28.0	30.0	32.0	5.6
28	417	443	199	110	475	514	98.0	2.5	24.0	29.0	28.0	5.6
29	459	542	239	105	---	475	39.0	3.1	20.0	30.0	36.0	5.4
30	497	552	251	67.0	---	407	14.0	3.7	17.0	29.0	62.0	5.2
31	463	---	255	42.0	---	346	---	3.6	---	42.0	58.0	---
TOTAL	10100.9	15246	7822	5529.0	3872.0	15372	5903.0	84.97	293.3	1267.0	1855.0	4148.4
MEAN	326	508	252	178	138	496	197	2.74	9.78	40.9	59.8	138
MAX	620	1230	524	268	475	687	312	18.0	29.0	248	410	740
MIN	8.6	208	114	42.0	34.0	115	14.0	.63	3.5	13.0	19.0	4.6

CAL YR 1984 TOTAL 98050.81 MEAN 268 MAX 1800 MIN 1.2
WTR YR 1985 TOTAL 71493.30 MEAN 196 MAX 1230 MIN . .63

Appendix 7h—Nitrite plus nitrate nitrogen loads at Delavan Lake outlet, 1985 water year.

Delavan Lake outlet at Borg Road near Delavan, Wisconsin

Nitrogen, nitrite plus nitrate (pounds per day), water year October 1984 to September 1985

Mean values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	6.4	131	106	174	42.0	519	353	53.0	5.4	4.8	4.4	4.4
2	5.8	107	104	183	40.0	535	355	42.0	5.6	6.1	3.8	4.9
3	5.9	103	103	183	39.0	547	353	19.0	5.3	5.9	3.8	4.4
4	6.1	98.0	137	190	39.0	590	357	7.4	5.1	5.6	4.0	4.8
5	7.7	100	100	198	38.0	629	349	7.4	5.8	5.5	4.3	4.9
6	8.0	115	93.0	199	37.0	620	348	7.9	6.3	5.7	4.5	5.4
7	36.0	132	92.0	197	37.0	603	350	7.4	6.6	5.5	4.9	6.2
8	22.0	149	90.0	188	37.0	594	347	6.1	7.3	5.6	4.9	90.0
9	18.0	174	87.0	181	36.0	600	357	5.3	6.8	5.7	4.9	290
10	15.0	219	85.0	175	35.0	596	288	6.4	6.2	5.5	5.4	280
11	14.0	296	49.0	173	35.0	588	355	4.8	6.0	5.4	4.8	285
12	21.0	152	76.0	170	35.0	577	353	4.6	5.5	5.2	4.8	240
13	24.0	171	102	164	35.0	562	350	3.6	6.2	5.4	80.0	130
14	22.0	179	110	156	35.0	551	347	3.8	7.6	65.0	120	4.0
15	25.0	168	109	154	35.0	528	339	3.5	9.4	33.0	70.0	3.6
16	46.0	165	110	154	34.0	503	339	3.6	8.1	24.0	5.7	2.9
17	58.0	163	117	152	36.0	485	336	2.9	7.3	16.0	4.8	2.4
18	60.0	161	115	150	42.0	467	337	3.1	6.1	11.0	4.0	2.5
19	66.0	153	117	146	62.0	445	356	3.7	6.4	7.5	3.4	2.5
20	76.0	135	116	143	103	203	376	3.5	6.5	6.6	3.2	2.1
21	62.0	111	120	140	136	85.0	388	2.9	7.4	4.4	3.1	2.1
22	60.0	113	118	137	184	86.0	400	2.8	7.0	3.5	2.9	2.5
23	63.0	118	119	134	205	84.0	265	3.1	6.2	2.4	2.8	2.2
24	68.0	121	117	130	340	91.0	203	3.4	6.1	1.9	2.4	1.7
25	66.0	126	118	125	456	90.0	215	4.3	5.7	2.7	2.7	1.9
26	52.0	101	120	119	483	170	233	6.7	5.4	3.3	2.6	2.0
27	47.0	81.0	122	115	492	316	244	5.9	5.9	3.0	2.5	2.0
28	58.0	78.0	130	110	504	353	262	4.8	6.1	3.1	2.1	2.0
29	60.0	101	158	105	---	380	108	5.6	5.8	3.6	2.4	2.0
30	79.0	110	169	67.0	---	399	40.0	6.3	5.9	3.7	3.8	1.9
31	81.0	---	174	42.0	---	364	---	5.8	---	5.8	3.9	---
TOTAL	1238.9	4131.0	3483.0	4654.0	3632.0	13160.0	9303.0	250.6	191.0	272.4	376.8	1390.3
MEAN	40.0	138	112	150	130	425	310	8.08	6.37	8.79	12.2	46.3
MAX	81.0	296	174	199	504	629	400	53.0	9.4	65.0	120	290
MIN	5.8	78.0	49.0	42.0	34.0	84.0	40.0	2.8	5.1	1.9	2.1	1.7

CAL YR 1984 TOTAL 37247.6 MEAN 102 MAX 967 MIN .96
WTR YR 1985 TOTAL 42082.6 MEAN 115 MAX 629 MIN 1.7