LPL-087

United States Department of the Interior

U.S. GEOLOGICAL SURVEY

Water Resources Division
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July 30, 1996

Ms. Mary Platner
Alma-Moon Lake Protection and Rehabilitation District
N61 W29911 Rybeck Road
Hartland, Wisconsin 53029

Dear Ms. Platner:

This letter describes the progress on the evaluation of the water quality of Moon Lake according to the data collected from October 1994 to September 1995 as stated in our agreement. The format for this progress report is different from that of previous years, but it contains essentially the same type of information.

In reviewing the data, it may be helpful to refer to the methods and explanation of physical and chemical characteristics sections in the USGS annual lake data report "Water-Quality and Lake-Stage Data for Wisconsin Lakes, Water Year 1995" and to Shaw and others (1994) "Understanding Lake Data."

Hydrologic conditions during water year 1995:

Annual variability in lake condition often reflects variability in climatic and hydrologic conditions. Air temperature in northcentral Wisconsin was, on the average, 3.6 °F warmer than normal for the period December 1994 through March 1995; April and May were 4.0 °F cooler than normal; and the period June through August was 3.2 °F warmer than normal (National Oceanic and Atmospheric Administration "Climatological Data--Wisconsin".) Precipitation during water year 1995 was 93 percent of normal precipitation for the northcentral division in Wisconsin (Pamela Naber-Knox, UW-Extension, Geological and Natural History Survey, written common., 1995). Watershed runoff in the region of Moon Lake was between 60 and 80 percent of long-term average runoff (Holmstrom and others, 1996, "Water Resources Data--Wisconsin").

Lake description and sampling locations:

Moon Lake is classified as a seepage lake with no inlet or outlet. Moon Lake has a mean depth of 17 feet and a surface area of 124 acres (0.194 square miles). The water-quality monitoring site is located at the deepest point in the lake at a depth of about 38 feet. Lake stage was monitored along the southwest

shoreline of Alma Lake. Because Alma and Moon Lakes are connected seepage lakes with no inlets or outlets, their water surface altitudes are the same. The location of these monitoring sites are shown in Figure 1.

Lake Data for 1995:

Data collected during the year, as published in the lake data report are enclosed. The following summary presents some highlights from the tables.

Lake-stage fluctuations:

Lake-stages were read by Douglas Pagel intermittently and by the USGS on sampling dates. Stages ranged from 10.55 feet on September 27 to 10.91 feet on May 19 and 29. This range of fluctuation is the lowest seen in the four years of monitoring. Stage values read by Douglas Pagel are listed in Table 1, and the USGS values are listed in the table in the top half of Figure 2.

Lake-depth profiles:

Vertical profiles of water temperature, dissolved oxygen, pH, and specific conductance are similar to those from the previous year; with the exception of specific conductance values. Specific conductance values were significantly higher, in percentage, in February, April, and June 1995 as compared to the 1994 values, but lower in August 1995 than August 1994 values. However, overall values are low in comparison to other lakes in northcentral Wisconsin. These profiles, which were measured over the deepest point in the lake, are listed in Table 2 and shown in Figure 2. During the sampling period, complete water-column mixing was observed on April 26. The lake thermally stratified through the summer. A layer of biological activity occurs in and below the thermocline, which is indicated by the increased values of dissolved oxygen for the June, July, and August sampling dates as shown in Figure 2. In June and August the lower 1.5 feet of water was anoxic (devoid of oxygen). The anoxic zone is unable to support fish. The pH, which ranged between 5.7 and 7.4, is common for northeast Wisconsin lakes and poses no problems for aquatic life.

Chemical constituents:

Analyses of water samples collected on April 26 for selected chemical constituents for chemical characterization of the lake are shown in Figure 2. Samples collected at 1.5 and 37-foot depths show similar constituent concentrations, as would be expected under mixed water column conditions. The constituent values for color, chlorophyll a, calcium, pH, alkalinity, total-nitrogen, and total-phosphorus are within regional values for this area as described by Lillie and Mason in "Limnological Characteristics of

Wisconsin Lakes," 1983, Technical Bulletin No. 138, Department of Natural Resources; while values for chloride and magnesium are below regional values.

The ratio of dissolved-nitrogen to dissolved-phosphorus was 45:1, based on the surface concentrations on April 26. This ratio suggests the lake is phosphorus limited, which means algal growth is dependent on the amount of available phosphorus rather than nitrogen.

Three common measures of water quality used as indices are concentrations of near-surface total-phosphorus and chlorophyll a, and Secchi depth. Total-phosphorus concentrations ranged from <0.007 mg/L on July 19 to 0.009 mg/L on April 26, chlorophyll a ranged from <0.01 µg/L on July 19 to 4.4 µg/L on April 26, and Secchi depths ranged from 3.3 m on April 26 to 5.6 m on June 13.[1]

Surface total-phosphorus and chlorophyll a concentrations, and Secchi depths for the 1992-95 period are shown in Figure 3. No general year to year or seasonal trends are apparent from the data.

Total-phosphorus concentrations 1.5 feet above the lake bottom ranged from 0.018 mg/L on April 26 to 0.048 mg/L on June 13. The low total-phosphorus concentrations observed during anoxic periods are indicative of a minor phosphorus release from the bottom sediments.

Lake condition:

Water-quality index:

Lillie and Mason (1983) classified all Wisconsin lakes using a random data set collected in the summer (July and August). The index, shown on page 12 of "Water-Quality and Lake-Stage Data for Wisconsin Lakes, Water Year 1995," is based on surface total-phosphorus, chlorophyll a concentrations, and Secchi depths. According to the index, surface total-phosphorus and chlorophyll a (using only the August value) concentrations, and Secchi depth in Moon Lake indicate "very good" water quality.

Lillie and Mason (1983) also provided a means of comparing the condition of Moon Lake with other lakes in northeast Wisconsin. The comparison on page 4 shows the percentage distribution of northeast Wisconsin lakes within each condition group and the relative position of Moon Lake.

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1. The extremely low chlorophyll a value for July 19 is believed to be erroneous and the result of laboratory error. Abnormally low chlorophyll a values were obtained for samples from numerous other lakes sampled during a two week period in July. These low values for chlorophyll a were not accompanied by corresponding decreases in the total-phosphorus or increases in Secchi depth as would generally be expected.

	Parameter		Percentage distribution of lakes in northeast Wisconsin within parameter range
	Total-phosphorus (mg/L)		
Moon Lake values	<0.010	best condition	22
	0.010-0.020	↓	41
	0.020-0.030	↓	21
	0.030-0.050	↓	12
	>0.050	worst condition	5
	Chlorophyll a (µg/L)		
Moon Lake values	0-5	best condition	34
	5-10	↓	38
	10-15	↓	11
	15-30	↓	11
	>30	worst condition	5
	Secchi depth (feet)		
	>19.7	best condition	4
Moon Lake values	9.8-19.7	↓	32
	6.6-9.8	↓	22
	3.3-6.6	↓	26
	<3.3	worst condition	16

Trophic status:

Another means of assessing the nutrient, or trophic, status of a lake is to use Carlson's Trophic State Index (TSI). The 1995 TSI data is listed in Table 3. Figure 4 is a graphical illustration of the variation in Trophic State Indices for Moon Lake during the 4 year study period. The chlorophyll a value for July 1995 is not included in Figure 4. The data from 1995 show the lake to be lower mesotrophic to upper oligotrophic, or a lake with moderate to low nutrient levels.

The data that have been collected for Moon Lake from 1992 through 1995 are useful for understanding the lake's water quality, and for managing the lake. These data define the present water quality of the lake and provide a basis for assessing trends or changes in water quality in the future. Continued monitoring will help to build on this valuable data base.

If you have questions regarding this evaluation, please contact me at (608) 276-3834.

Sincerely,

William J. Rose

William Rose
Hydrologist

Enclosures

cc: Bob Young, DNR, Rhinelander

Table 1. Lake stages for Alma and Moon Lakes, near St. Germain, Wisconsin, 1995 water year

LOCATION.--Lat 45°54'26", long 89°25'47", in NE 1/4 sec.36, T.40 N., R.8 E., Vilas County, Hydrologic Unit 07070001, 3 mi east of St. Germain.

LAKE-STAGE RECORDS

PERIOD OF RECORD.--October 1984 to September 1990, May 1992 to current year.

GAGE.--Staff gage read by Douglas Pagel.

EXTREMES FOR PERIOD OF RECORD.--Maximum gage height observed, 12.35 ft, Apr. 11, 12, 1986; minimum observed, 8.98 ft, Oct. 26, 27, 1989.

EXTREMES FOR CURRENT YEAR.--Maximum gage height observed, 10.91 ft, May 19, 29; minimum observed, 10.55 ft, Sept. 27.

GAGE HEIGHT, FEET, WATER YEAR OCTOBER 1994 TO SEPTEMBER 1995

DAILY MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	---	---	---	---	---	---	---	---
2	---	---	---	---	---	---	---	---	---	10.69	---	---
3	---	---	---	---	---	---	---	---	---	---	---	---
4	---	---	---	---	---	---	---	---	10.87	---	---	10.77
5	---	---	---	---	---	---	---	---	---	---	---	---
6	---	---	---	---	---	---	---	10.73	---	---	10.61	---
7	---	---	---	---	---	---	---	---	---	---	---	---
8	---	---	---	---	---	---	---	---	---	---	---	10.71
9	---	---	---	---	---	---	---	---	---	10.67	---	---
10	---	---	---	---	---	---	---	---	---	---	---	---
11	---	---	---	---	---	---	---	10.81	---	---	---	---
12	---	---	---	---	---	---	---	---	10.83	---	---	---
13	---	---	---	---	---	---	---	---	10.82	---	10.77	---
14	---	---	---	---	---	---	---	---	---	---	---	---
15	---	---	---	---	---	---	---	---	---	---	---	---
16	---	---	---	---	---	---	---	---	---	10.71	10.87	---
17	---	---	---	---	10.72	---	---	---	10.74	---	---	10.63
18	---	---	---	---	---	---	---	---	---	---	---	---
19	---	---	---	---	---	---	---	10.91	---	10.72	---	---
20	---	---	---	---	---	---	---	---	---	---	10.83	---
21	---	---	---	---	---	---	---	---	---	---	---	---
22	---	---	---	---	---	---	---	---	---	---	---	---
23	---	---	---	---	---	---	---	---	10.73	10.71	---	---
24	---	---	---	---	---	---	---	---	---	---	---	---
25	---	---	---	---	---	---	---	---	---	---	---	---
26	---	---	---	---	---	---	10.76	---	---	---	---	---
27	---	---	---	---	---	---	---	---	---	---	10.85	10.55
28	---	---	---	---	---	---	---	---	---	10.73	---	---
29	---	---	---	---	---	---	---	10.91	---	---	---	---
30	---	---	---	---	---	---	---	---	---	---	---	---
31	---	---	---	---	---	---	---	---	---	---	---	---

Table 2. Lake depth profiles for Moon Lake near St. Germain, Wisconsin, 1995 water year

455504089260500 - MOON LAKE NEAR ST. GERMAIN, WI

WATER-QUALITY DATA

DATE	SAMPLING DEPTH (FEET) (00003)	TEMPERATURE WATER (DEG C) (00010)	SPECIFIC CONDUCTANCE (US/CM) (00095)	PH WATER WHOLE FIELD (STANDARD UNITS) (00400)	OXYGEN, DISSOLVED (MG/L) (00300)
FEB 1995					
17...	3.00	3.0	30	6.8	11.0
17...	6.00	4.0	29	6.9	10.2
17...	9.00	4.0	27	6.7	10.1
17...	12.0	4.0	27	6.6	10.1
17...	15.0	4.0	27	6.6	9.9
17...	18.0	4.0	27	6.5	9.6
17...	21.0	4.0	27	6.5	8.5
17...	24.0	4.0	27	6.4	4.5
17...	27.0	4.5	28	6.2	2.0
17...	30.0	4.5	30	6.0	1.2
17...	33.0	4.5	32	6.0	0.8
17...	36.0	--	--	--	--
APR					
26...	1.50	6.5	27	6.4	11.7
26...	4.00	6.5	27	6.4	11.8
26...	8.00	6.0	26	6.4	11.9
26...	12.0	5.5	24	6.4	11.8
26...	16.0	5.5	25	6.4	11.6
26...	20.0	5.5	25	6.4	11.4
26...	24.0	5.0	25	6.4	11.3
26...	28.0	5.0	25	6.4	11.2
26...	32.0	5.0	25	6.4	11.2
26...	36.0	5.0	25	6.3	10.9
26...	37.0	5.0	25	6.3	10.9
26...	38.5	--	--	--	--
JUN					
13...	1.50	19.0	23	6.8	9.2
13...	4.00	19.0	23	6.8	9.3
13...	8.00	19.0	23	6.8	9.3
13...	12.0	18.0	23	6.9	9.4
13...	16.0	16.5	23	7.1	10.2
13...	20.0	14.0	22	7.1	10.3
13...	24.0	10.5	22	6.7	10.2
13...	28.0	8.5	22	6.2	6.5
13...	32.0	8.0	24	5.8	4.0
13...	36.0	8.0	25	5.7	1.9
13...	37.0	7.5	25	5.7	0.5
13...	38.5	--	--	--	--
JUL					
19...	1.50	22.5	23	6.8	8.3
19...	4.00	22.5	23	6.8	8.3
19...	8.00	22.5	23	6.9	8.3
19...	12.0	22.5	22	6.9	8.3
19...	16.0	21.5	22	6.9	8.7
19...	20.0	18.5	23	7.3	10.3
19...	24.0	14.0	21	7.1	10.9
19...	28.0	11.0	21	6.5	8.5
19...	32.0	10.0	22	6.1	4.0
19...	36.0	10.0	24	6.0	1.3
19...	37.5	--	--	--	--
AUG					
16...	1.50	24.5	15	7.1	8.1
16...	4.00	24.5	14	7.1	8.1
16...	8.00	24.5	14	7.2	8.2
16...	12.0	24.5	14	7.2	8.2
16...	16.0	24.5	14	7.0	8.2
16...	20.0	23.0	13	7.4	8.6
16...	24.0	16.5	11	7.2	11.3
16...	28.0	13.0	10	6.9	11.2
16...	32.0	11.0	11	6.1	2.6
16...	36.0	10.5	19	6.2	0.3
16...	37.5	--	--	--	--

Table 3.--Water clarity and water-quality analyses and their associated Trophic State Indices (TSI) for Moon Lake, 1995 water year

[- indicates not applicable; -- indicates no data available]

Date	Secchi Disk			Sampling	Total Phosphorus			Chlorophyll a		Dissolved Ortho-phosphate Phosphorus
	Depth (meters)	Depth (feet)	T.S.I.	Depth (feet)	Conc. (mg/L)	Conc. (µg/L)	T.S.I	Conc. (µg/L)	T.S.I.	Conc. (mg/L)
04/26/95	3.3	10.8	43	1.5	0.009	9	45	4.4	46	<0.002
	-	-	-	37	0.018	18	-	-	-	<0.002
06/13/95	5.6	18.4	35	1.5	0.007	7	43	0.9	34	--
	-	-	-	37	0.048	48	-	-	-	--
07/19/95	4.0	13.1	40	1.5	<0.007	7	43	<0.1	17	--
	-	-	-	36	0.025	25	-	-	-	--
08/16/95	4.2	13.8	39	1.5	0.007	7	43	2.4	41	--
	-	-	-	36	0.036	36	-	-	-	--

EXPLANATION

▲ Water-quality monitoring site

■ Lake-stage monitoring site

Figure 1. Locations of water-quality and lake-stage monitoring sites on Alma and Moon Lakes near St. Germain, Wisconsin.

LOCATION.--Lat 45°55'04", long 89°26'05", in SE 1/4 SE 1/4 sec.25, T.40 N., R.8 E., Vilas County, Hydrologic Unit 07070001, 2.9 mi northeast of St. Germain.

PERIOD OF RECORD.--May 1985 to September 1988 and October 1989 to September 1990, Secchi depth only; February 1992 to current year.

REMARKS.--The stage of Moon Lake is the same as Alma Lake; lake stages read at Alma Lake. Lake sampled near center at the deep hole. Lake ice-covered during February measurements. Water-quality analyses done by Wisconsin State Laboratory of Hygiene.

WATER-QUALITY DATA, FEBRUARY 17 TO AUGUST 16, 1995
(Milligrams per liter unless otherwise indicated)

	Feb. 17		Apr. 26		June 13		July 19		Aug. 16	
Depth of sample (ft)	3.0	33	1.5	37	1.5	37	1.5	36	1.5	36
Lake stage (ft)	10.72		10.76		10.82		10.72		10.87	
Specific conductance (µS/cm)	30	32	27	25	23	25	23	24	15	19
pH (units)	6.8	6.0	6.4	6.3	6.8	5.7	6.8	6.0	7.1	6.2
Water temperature (°C)	3.0	4.5	6.5	5.0	19.0	7.5	22.5	10.0	24.5	10.5
Color (Pt-Co. scale)	---	---	5	10	---	---	---	---	---	---
Turbidity (NTU)	---	---	0.60	0.80	---	---	---	---	---	---
Secchi-depth (meters)	---		3.3		5.6		4.0		4.2	
Dissolved oxygen	11.0	0.8	11.7	10.9	9.2	0.5	8.3	1.3	8.1	0.3
Hardness, as CaCO3	---	---	9	9	---	---	---	---	---	---
Calcium, dissolved (Ca)	---	---	2.1	2.2	---	---	---	---	---	---
Magnesium, dissolved (Mg)	---	---	0.8	0.8	---	---	---	---	---	---
Sodium, dissolved (Na)	---	---	0.7	0.7	---	---	---	---	---	---
Potassium, dissolved (K)	---	---	0.4	0.3	---	---	---	---	---	---
Alkalinity, as CaCO3	---	---	7	7	---	---	---	---	---	---
Sulfate, dissolved (SO4)	---	---	3.0	4.0	---	---	---	---	---	---
Chloride, dissolved (Cl)	---	---	0.8	0.6	---	---	---	---	---	---
Fluoride, dissolved (F)	---	---	<0.1	<0.1	---	---	---	---	---	---
Silica, dissolved (SiO2)	---	---	0.3	0.1	---	---	---	---	---	---
Solids, dissolved, at 180°C	---	---	18	12	---	---	---	---	---	---
Nitrogen, NO2 + NO3, diss. (as N)	---	---	0.06	0.04	---	---	---	---	---	---
Nitrogen, ammonia, dissolved (as N)	---	---	<0.03	<0.03	---	---	---	---	---	---
Nitrogen, organic, total (as N)	---	---	0.40	0.30	---	---	---	---	---	---
Nitrogen, amm. + org., total (as N)	---	---	0.40	0.30	---	---	---	---	---	---
Nitrogen, total (as N)	---	---	0.46	0.34	---	---	---	---	---	---
Phosphorus, total (as P)	---	---	0.009	0.018	0.007	0.048	<0.007	0.025	0.007	0.036
Phosphorus, ortho, dissolved (as P)	---	---	<0.002	<0.002	---	---	---	---	---	---
Iron, dissolved (Fe) µg/L	---	---	20	20	---	---	---	---	---	---
Manganese, dissolved (Mn) µg/L	---	---	4	6	---	---	---	---	---	---
Chlorophyll a, phytoplankton (µg/L)	---	---	4.4	---	0.9	---	<0.01	---	2.4	---

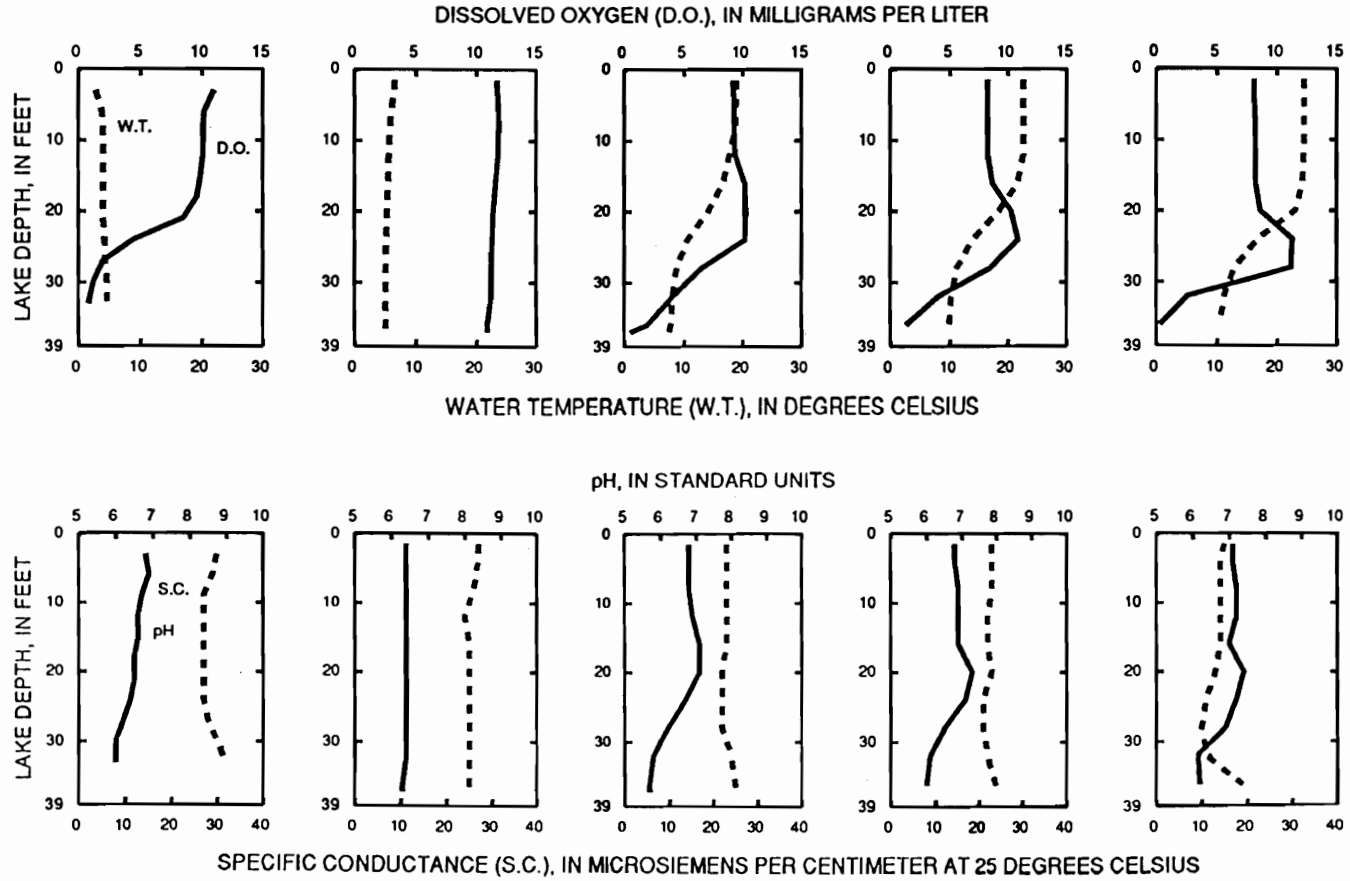

Figure 2. Water quality data and depth profiles for Moon Lake near St. Germain, Wisconsin, 1995 water year

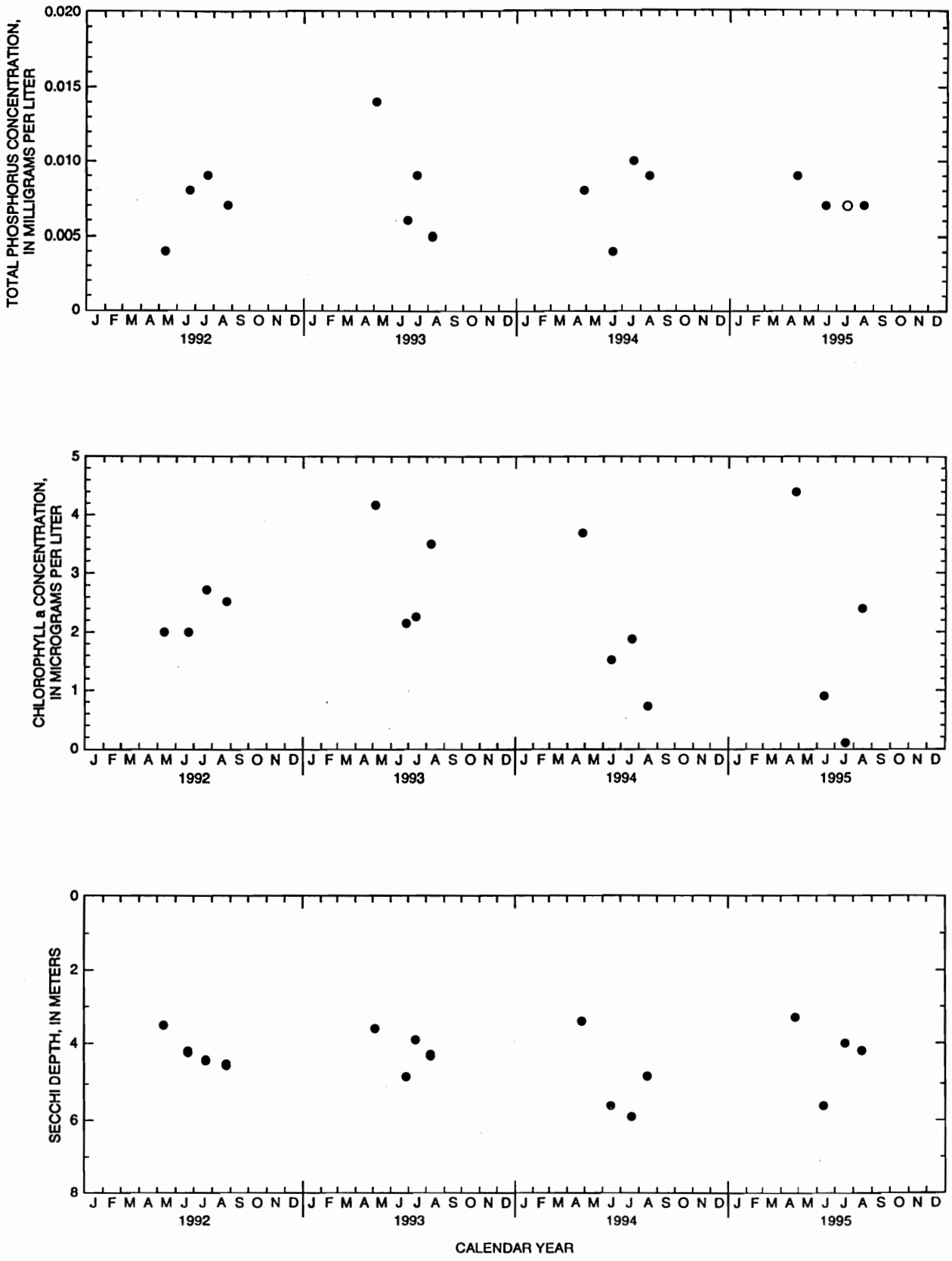

Figure 3. Surface total phosphorus and chlorophyll a concentrations, and Secchi depths for Moon Lake near St. Germain, Wisconsin.

(Circles indicate laboratory detection limit for selected analyses. Actual concentrations for these particular analyses are less than the plotted circles.)

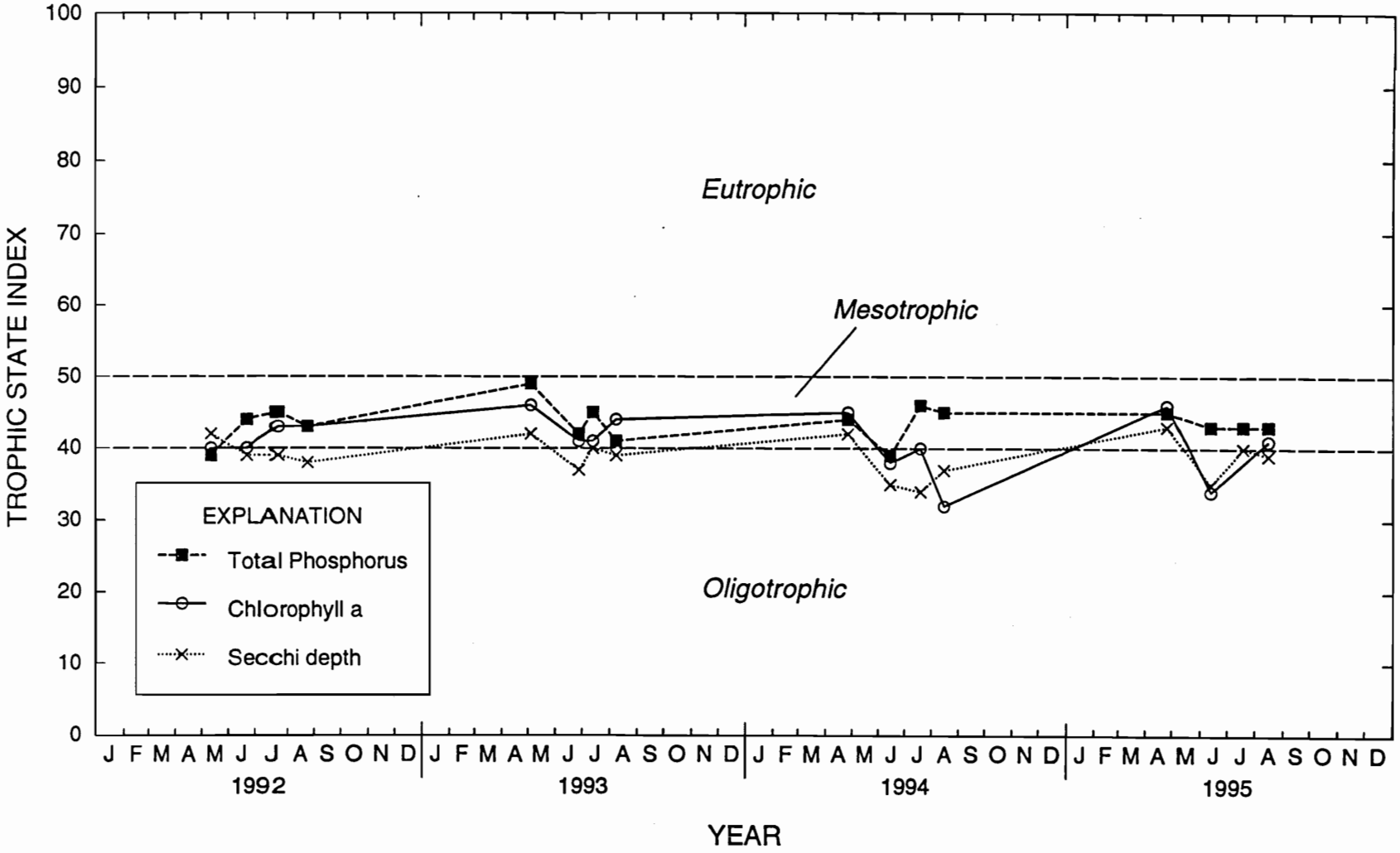

Figure 4. Trophic state indices for Moon Lake near St. Germain, Wisconsin