LPL-814-02

Water- and sediment-quality data for Spooner Lake and Crystal Brook near Spooner, Wisconsin

Data Summary

This summary contains all data that were collected by the US Geological Survey for Spooner Lake District as a part of the program that was partially funded by Wisconsin Department of Natural Resources lake planning grant LPL-814. Much of these data have been or will be published in two annual data reports of the Wisconsin District of the U.S. Geological Survey. These reports are "Water-quality and lake-stage data for Wisconsin Lakes, water years 2002 and 2003 and "Water Resources data –Wisconsin, Water year 2002 and 2003". In addition, the data are archived in the U.S. Geological Survey's national stream flow and water-quality databases.

United States Geological Survey
Madison, Wisconsin

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June 14, 2003

Lake description and sampling locations:

Spooner Lake is classified as a drainage lake, having one main inlet (Crystal Brook) and an outlet (Yellow River). The average depth of the lake is 7 feet and maximum depth is 17 feet, and surface area is 1092 acres ("Wisconsin Lakes" Wisconsin Department of Natural Resources, PUB-FH-800, 2001). The Lake's watershed area, including the lake, is 31.1 square miles, (Drainage Area Data for Wisconsin Streams", Henrich and Daniel, 1983, USGS Open-File Report 83-933).

Two sites in the lake were sampled for water quality and six sites were sampled for bed sediment quality. Crystal Brook was measured and sampled at the Highway 70 crossing southeast of the lake. Lake stage was measured at the dam at the lake's outlet. Locations of these sites are shown in Figure 1.

Lakebed sediment:

Bed sediment analyses are summarized in table 1 and a series of graphs (figs 2a-f). Sampling sites are approximately evenly distributed from the Crystal Brook inlet to the deep hole. The sites are numbered 1 – 6, with Site 1 being near the inlet and Site 6 being at the deep hole.

Lake water quality:

Lake-depth profiles:

Vertical profiles of water temperature, dissolved oxygen, pH, and specific conductance are typical of those for a shallow lake. Profile data in Tables 2a and 2b indicate there was little thermal stratification. However, as shown in figures 3a and 3b there was strong oxygen stratification and oxygen depletion in the lower 10 feet at the deep-hole sampling site by late summer. There was little oxygen depletion at the southeast sampling site (figs. 4a and 4b). Water was well mixed from top to bottom at both sampling sites at the spring turnover sampling on April 29, 2003.

Chemical constituents:

Analyses of water samples collected in April 2003 during spring turnover for selected chemical constituents for chemical characterization of the lake are given in Tables 3a and 3b. The constituent values were within regional values for northwestern Wisconsin as described by Lillie and Mason in "Limnological Characteristics of Wisconsin Lakes," 1983, Technical Bulletin No. 138, Department of Natural Resources.

Three common measures of water quality, which are used as indices, are concentrations of near-surface total phosphorus and chlorophyll a, and Secchi depth. These data are given in tables 4a and 4b and graphed in figures 5-7. The data indicate significant decline in quality from June through August at the deep-hole site. Water quality as indicated by Secchi depth and chlorophyll a was considerably better at the southeastern sampling site than at the deep-hole site.

Trophic status:
Another means of assessing the nutrient, or trophic, status of a lake is to compute trophic state indices (TSIs). The TSIs were developed to place phosphorus and chlorophyll a concentration and Secchi depth data on a common scale. TSI equations for Wisconsin Lakes developed by Lillie and others in "Trophic State Index Equations and regional predictive equations for Wisconsin Lakes," WDNR Management Findings, no. 35, 1993. These data are summarized in tables 4a and 4b and graphed in figure 8 show Spooner Lake to be solidly in the eutrophic range.

Crystal Brook:

Crystal Brook flow, which was measured on seven different dates, was fairly constant, ranging from 18.1 to 20.1 cubic feet per second. Concentrations of total phosphorus at the time of measurements ranged from 0.036 – 0.051 mg/L and averaged 0.044 mg/L. About 72 percent of the phosphorus was in the dissolved form. These data are summarized in table 5 and figures 9a and 9b.

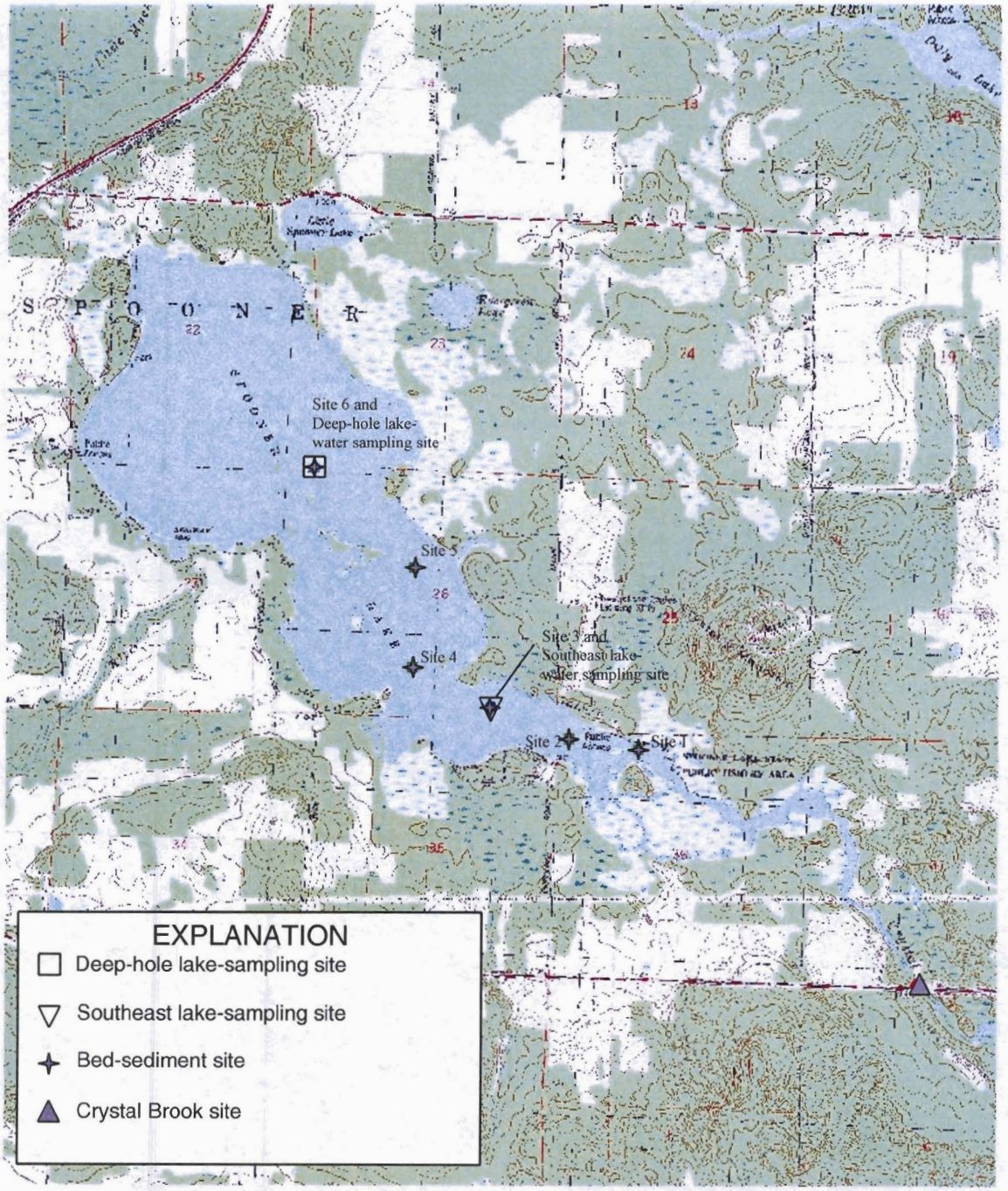

Figure 1. Locations of monitoring sites in and near Spooner Lake.

Table 1. Analyses of surfacial bed sediment from six sites in Spooner Lake near Spooner Lake, Wisconsin

field number	Distance from hwy 70 (feet)	Water depth at site (feet)	tot kjeldahl nitrogen dry wt (MG/KG)	Total Phosphorus Dry wt (MG/KG)	phosphate FE & AL bound NAOH Ext (MG P/KG)	Percent volatile solids (%)	Percent solids (%)
1	9,600	3	16,800	10	131	32.6	8.2
2	11,100	5	20,100	1,320	187	35.6	6
3	12,800	8	28,200	1,060	202	44	4.7
4	14,800	6	23,200	696	170	46.2	5
5	16,800	5	28,900	1,190	703	53	3.4
6	19,800	17	21,400	801	226	47.2	6.6

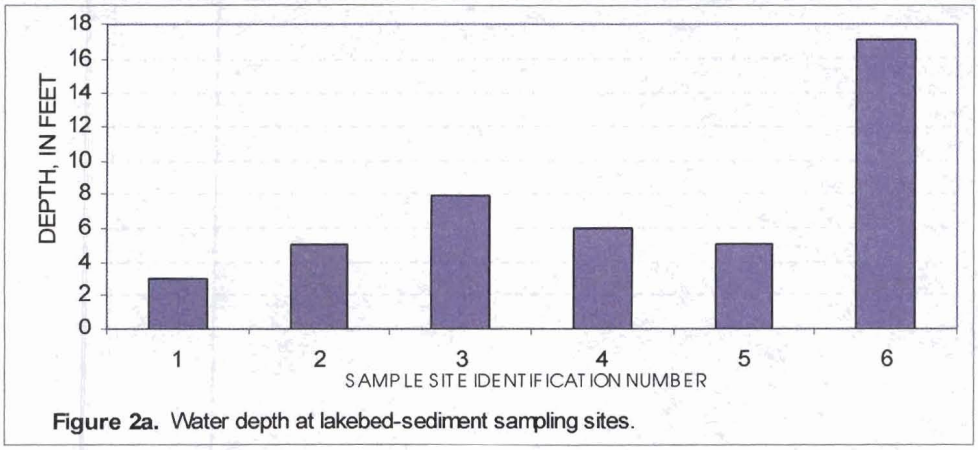

Figure 2a. Water depth at lakebed-sediment sampling sites.

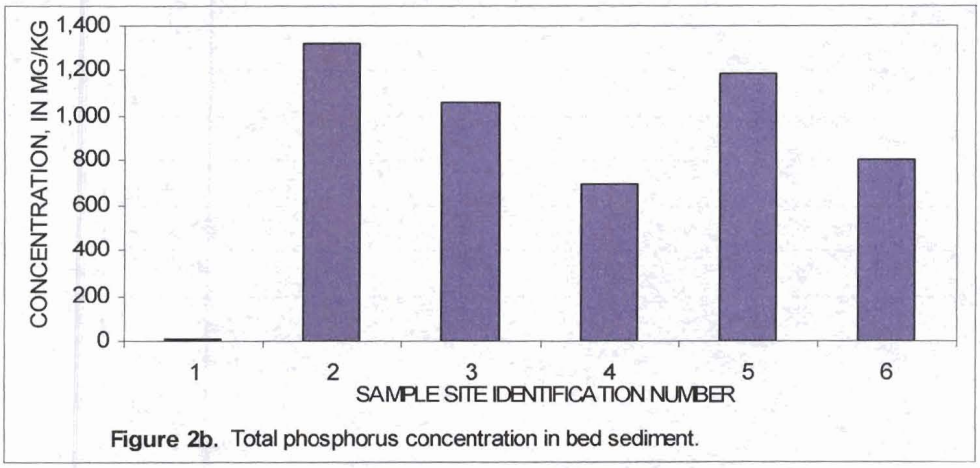

Figure 2b. Total phosphorus concentration in bed sediment.

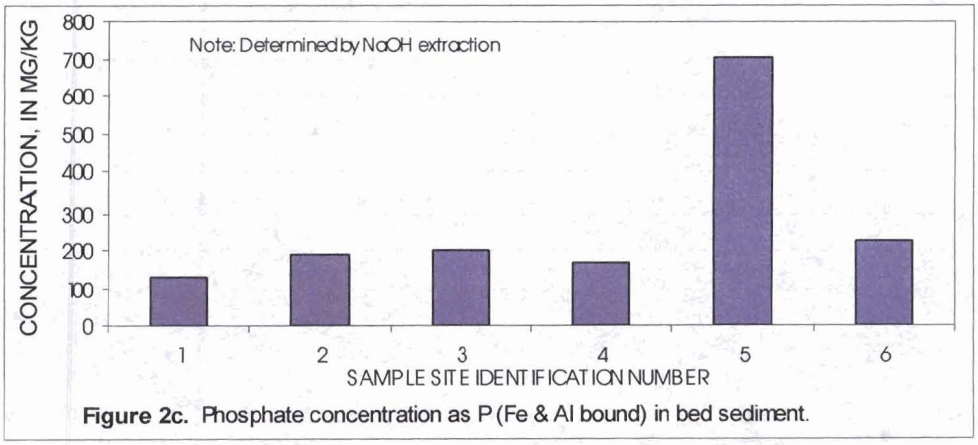

Figure 2c. Phosphate concentration as P (Fe & Al bound) in bed sediment.

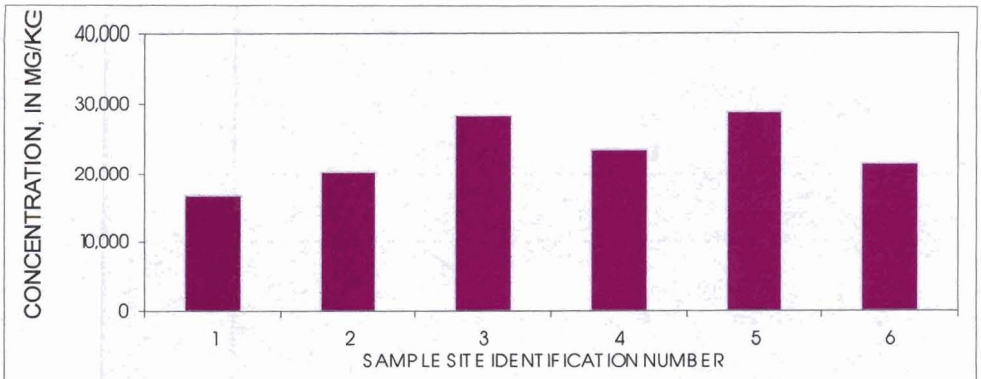

Figure 2d. Total Kjeldahl nitrogen in bed sediment (Based on dry weight.

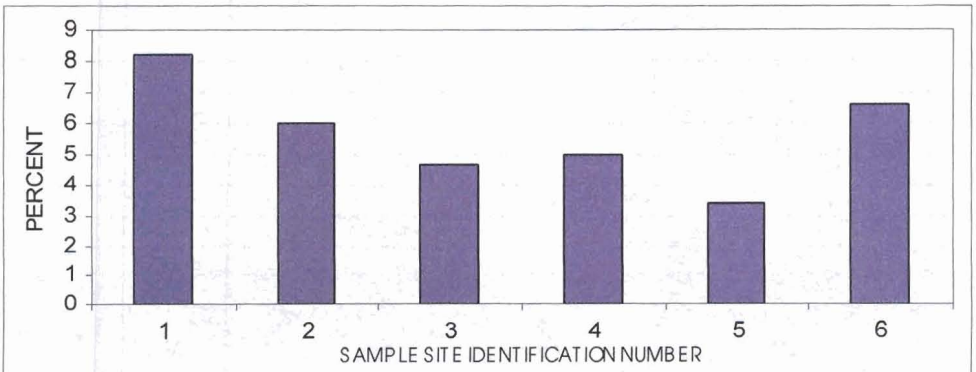

Figure 2e. Solids as a percentage of total bed sediment sample.

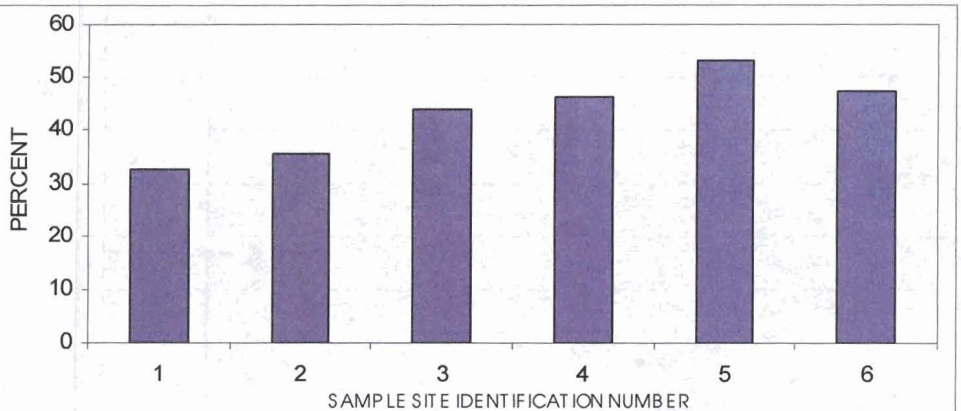

Figure 2f. Volatile solids as a percentage of total solids in bed sediment.

Table 2a. Lake-depth profiles for Spoooner Lake, Deep hole Site, near Spooner, Wisconsin, June 2002 - April 2003

[mg/L, milligrams per liter; µS/cm, microsiemans per centimeter; °C, degrees celsius]

Date and time	Sampling depth (meters)	Dissolved oxygen (mg/L)	pH	Specific conductance (µS/cm)	Temperature (°C)
6/27/02 10:58	0.5	8.9	8.3	170	24.5
6/27/02 11:00	1	8.8	8.3	171	24.4
6/27/02 11:02	1.5	8.6	8.3	171	24.2
6/27/02 11:03	2	7.5	8.1	172	24.2
6/27/02 11:05	2.5	7.0	7.9	173	24.1
6/27/02 11:07	3	5.9	7.8	175	24.0
6/27/02 11:09	3.5	4.2	7.4	177	23.7
6/27/02 11:11	4	1.5	7.1	178	23.0
6/27/02 11:12	4.5	0.1	7.0	180	22.4
6/27/02 11:13	5	0.1	7.0	187	21.8

Date and time	Sampling depth (meters)	Dissolved oxygen (mg/L)	pH	Specific conductance (µS/cm)	Temperature (°C)
7/30/02 8:25	0.5	7.7	8.9	160	25.7
7/30/02 8:26	1	7.6	8.9	160	25.7
7/30/02 8:27	1.5	7.5	8.9	160	25.7
7/30/02 8:28	2	0.3	8.0	172	24.9
7/30/02 8:29	2.5	0.1	7.8	172	24.3
7/30/02 8:30	3	0.1	7.7	173	24.1
7/30/02 8:31	3.5	0.1	7.7	174	23.9

Date and time	Sampling depth (meters)	Dissolved oxygen (mg/L)	pH	Specific conductance (µS/cm)	Temperature (°C)
8/29/02 8:55	0.5	10.3	9.1	167	23.0
8/29/02 8:56	1	10.3	9.2	167	23.0
8/29/02 8:57	1.5	8.5	8.9	174	22.5
8/29/02 8:58	2	0.9	8.4	181	22.1
8/29/02 8:59	2.5	0.6	8.0	185	21.4
8/29/02 9:00	3	0.4	7.9	184	21.1
8/29/02 9:01	3.5	0.3	7.8	184	20.8
8/29/02 9:02	4	0.2	7.7	188	20.7
8/29/02 9:03	4.5	0.2	7.6	190	20.6
8/29/02 9:04	5	0.2	7.5	191	20.6

Table 2a. Lake-depth profiles for Spoooner Lake, Deep hole Site, near Spooner, Wisconsin, June 2002 - April 2003--continured

[mg/L, milligrams per liter; µS/cm, microsiemans per centimeter; °C, degrees celsius]

Date and time	Sampling depth (meters)	Dissolved oxygen (mg/L)	pH	Specific conductance (µS/cm)	Temperature (°C)
3/18/03 9:40	0.5	11.2	7.4	169	0.8
3/18/03 9:41	1	11.2	7.4	169	4.6
3/18/03 9:42	1.5	10.0	7.4	242	5.1
3/18/03 9:43	2	8.9	7.4	254	5.4
3/18/03 9:44	2.5	6.8	7.3	270	5.4
3/18/03 9:45	3.0	6.1	7.3	273	5.4
3/18/03 9:46	3.5	5.2	7.3	275	5.2
3/18/03 9:47	4.0	4.5	7.2	275	5.3

Date and time	Sampling depth (meters)	Dissolved oxygen (mg/L)	pH	Specific conductance (µS/cm)	Temperature (°C)
4/29/03 9:30	0.5	11.6	8.7	166	13.1
4/29/03 9:31	1.0	11.2	8.8	166	13.1
4/29/03 9:32	1.5	11.3	8.8	166	13.1
4/29/03 9:33	2.0	11.2	8.8	166	13.1
4/29/03 9:34	2.5	11.0	8.8	167	13.0
4/29/03 9:35	3.0	10.9	8.8	167	13.0
4/29/03 9:36	3.5	10.9	8.8	166	12.9
4/29/03 9:37	4.0	10.8	8.8	167	12.8
4/29/03 9:38	4.5	10.8	8.8	167	12.8
4/29/03 9:39	5	10.8	8.8	167	12.8

Table 2b. Lake-depth profiles for Spoooner Lake, Southeast Site, near Spooner, Wisconsin, June 2002 - April 2003

[mg/L, milligrams per liter; µS/cm, microsiemans per centimeter; °C, degrees celsius]

Date and time	Sampling depth (meters)	Dissolved oxygen (mg/L)	pH	Specific conductance (µS/cm)	Temperature (°C)
6/27/02 12:23	0.25	9.4	8.3	181	25.5
6/27/02 12:24	0.5	9.2	8.2	183	25.2
6/27/02 12:26	0.75	9.1	8.1	185	24.4
6/27/02 12:27	1	9.0	8.1	185	24.5
6/27/02 12:28	1.25	8.9	8.1	185	24.1
6/27/02 12:29	1.5	8.5	8.0	185	24.0
6/27/02 12:30	1.75	8.2	7.9	186	23.9
6/27/02 12:31	2	7.7	7.8	187	23.9
6/27/02 12:32	2.25	5.6	7.4	189	23.6

Date and time	Sampling depth (meters)	Dissolved oxygen (mg/L)	pH	Specific conductance (µS/cm)	Temperature (°C)
7/30/02 9:25	0.25	9.9	8.7	190	25.2
7/30/02 9:26	0.5	9.9	8.7	190	25.2
7/30/02 9:27	0.75	9.8	8.7	190	25.2
7/30/02 9:28	1.0	9.8	8.7	190	25.1
7/30/02 9:29	1.25	9.9	8.6	190	25.0
7/30/02 9:30	1.5	10.9	8.2	192	24.2
7/30/02 9:31	1.75	10.4	7.8	192	23.2
7/30/02 9:32	2	10.0	7.8	191	22.9

Date and time	Sampling depth (meters)	Dissolved oxygen (mg/L)	pH	Specific conductance (µS/cm)	Temperature (°C)
8/29/02 10:05	0.5	10.2	8.8	188	22.3
8/29/02 10:06	1	10.0	8.8	188	22.3
8/29/02 10:07	1.5	8.6	8.6	191	21.9
8/29/02 10:08	2	8.4	8.3	195	21.8
8/29/02 10:09	2.3	7.6	8.2	195	21.8

Table 2b. Lake-depth profiles for Spoooner Lake, Southeast Site, near Spooner, Wisconsin, June 2002 - April 2003--continued

[mg/L, milligrams per liter; µS/cm, microsiemans per centimeter; °C, degrees celsius]

Date and time	Sampling depth (meters)	Dissolved oxygen (mg/L)	pH	Specific conductance (µS/cm)	Temperature (°C)
3/18/03 10:20	1	9.4	7.4	101	0.2
3/18/03 10:21	0.75	10.3	7.4	101	0.7
3/18/03 10:22	1	10.0	7.3	183	3.6
3/18/03 10:23	1.25	9.1	7.3	214	4.4
3/18/03 10:24	1.5	8.8	7.3	219	4.5
3/18/03 10:25	1.75	8.3	7.3	225	4.8
3/18/03 10:26	2	8.2	7.2	233	4.9
3/18/03 10:27	2.25	7.8	7.2	336	5.0

Date and time	Sampling depth (meters)	Dissolved oxygen (mg/L)	pH	Specific conductance (µS/cm)	Temperature (°C)
4/29/03 10:30	0.5	12.0	9.1	168	13.7
4/29/03 10:31	0.75	12.0	9.1	167	13.7
4/29/03 10:32	1	12.0	9.1	167	13.7
4/29/03 10:33	1.25	11.9	9.1	167	13.7
4/29/03 10:34	1.5	11.8	9.1	167	13.6
4/29/03 10:35	1.75	11.6	9.1	167	13.6
4/29/03 10:36	2	11.7	9.1	166	13.5
4/29/03 10:37	2.25	11.9	9.1	166	13.5
4/29/03 10:38	2.5	9.1	8.8	171	13.3

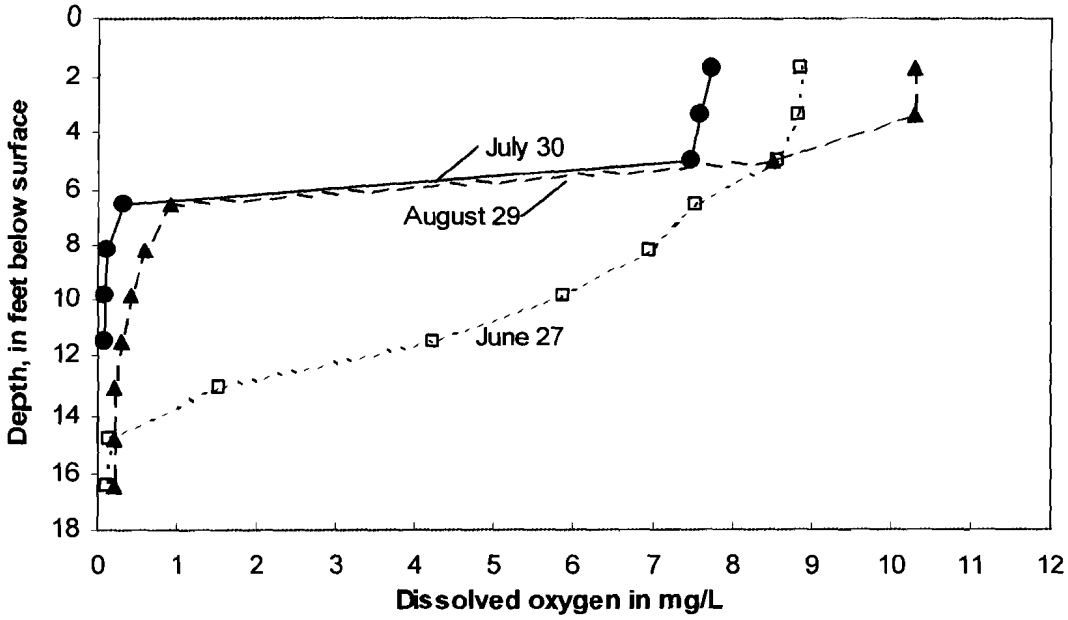

Figure 3a. Dissolved oxygen profiles for deep hole, Spooner Lake, 2002.

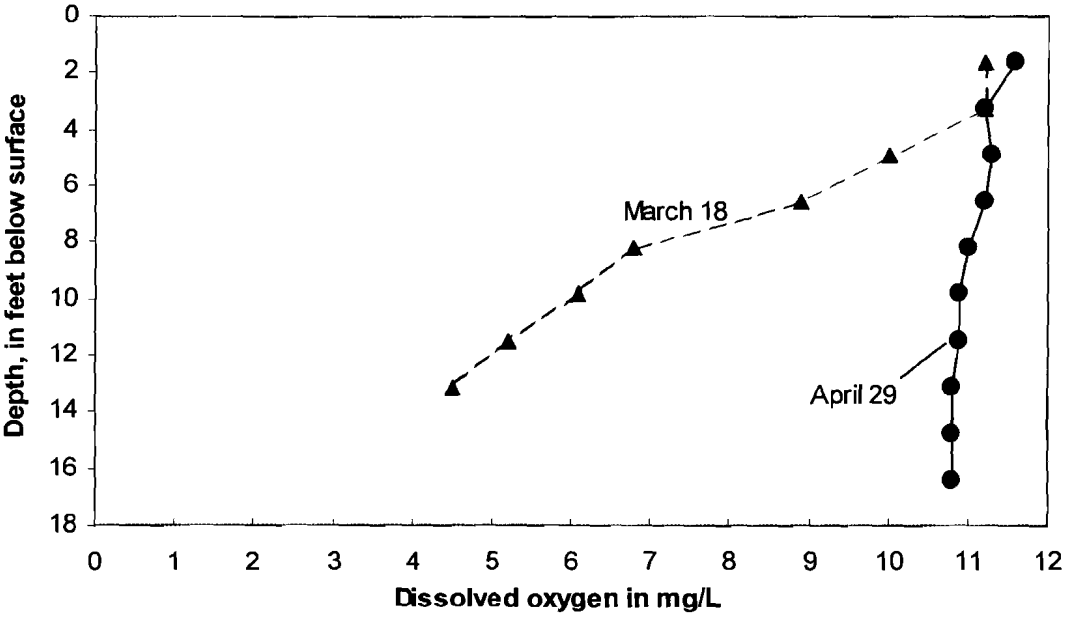

Figure 3b. Dissolved oxygen profiles for deep hole, Spooner Lake, 2003.

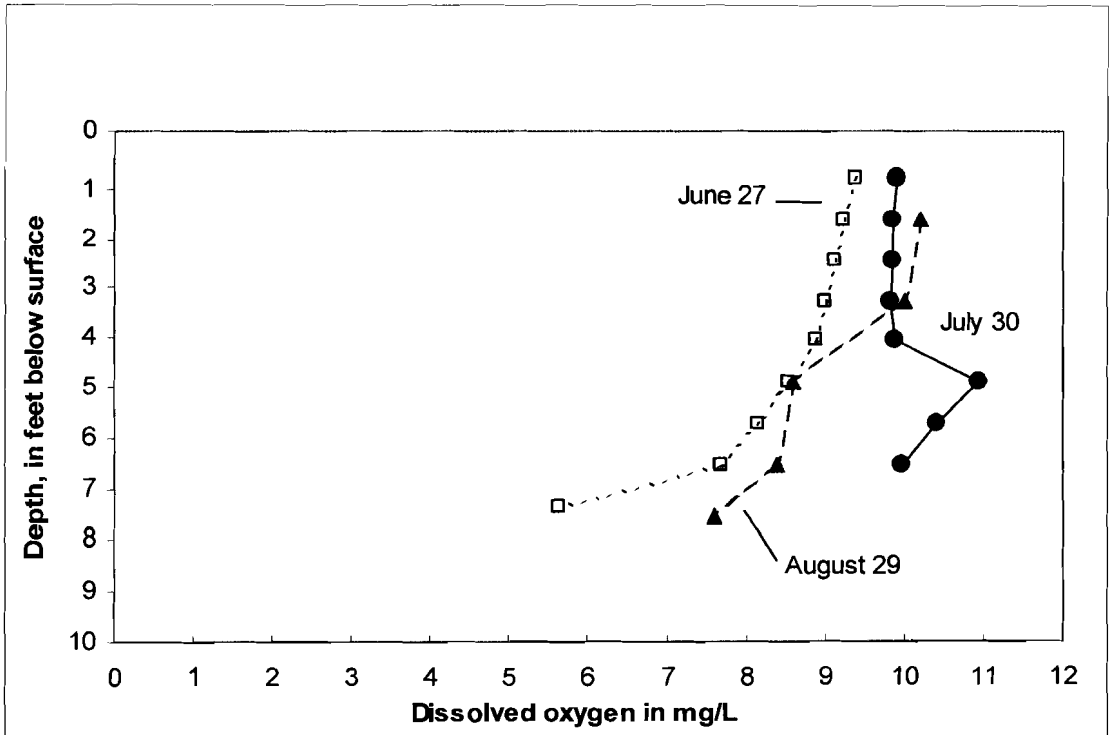

Figure 4a. Dissolved oxygen profiles for southeast site, Spooner Lake, 2002.

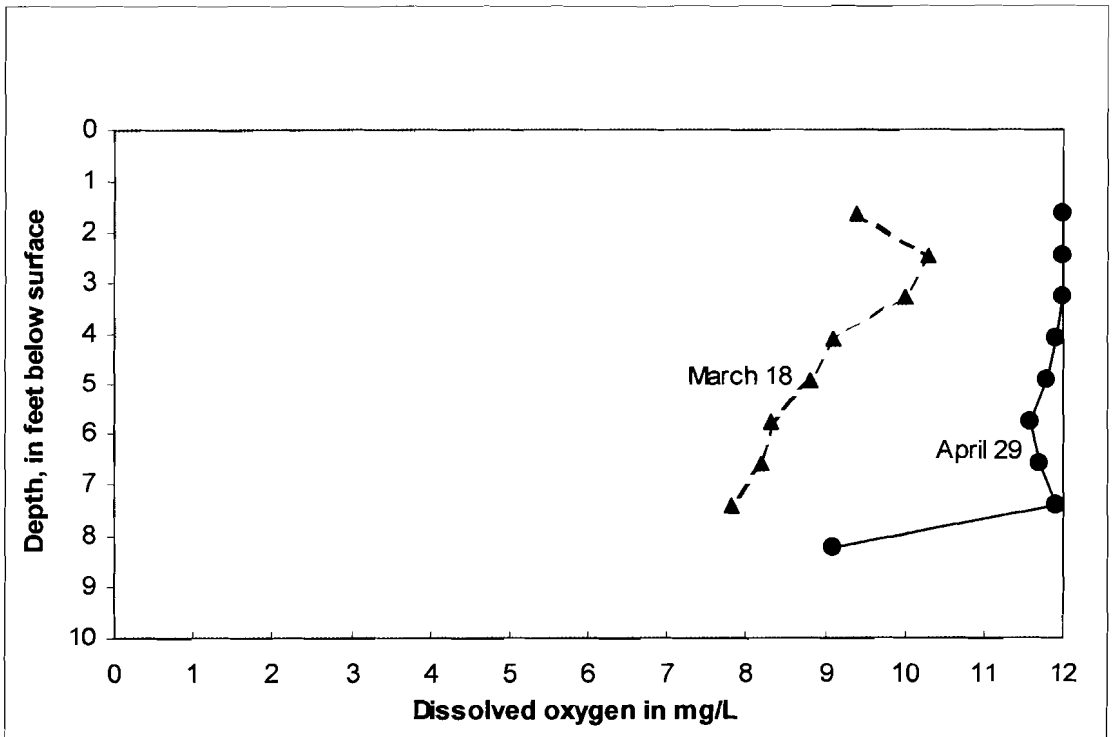

Figure 4b. Dissolved oxygen profiles for southeast site, Spooner Lake, 2003.

Table 3a. Summary of analyses of water in Spooner Lake, deep hole, June 2002 - April 2003
[Units are milligrams per liter unless otherwise indicated]

	June 27, 2002		July 30, 2002		Aug. 29, 2002			Mar. 18, 2003		Apr. 29, 2003	
Lake stage, (ft)	7.05		6.97		6.92			6.75		6.88	
Secchi depth (m)	1.4		0.7		0.8			--		2.7	
Chlorophyll a, phytoplankton (µg/L)	15.3		49.3		48.4			--		5.68	
Depth of sample (m)	0.5	4.5	0.5	3.5	0.5	2.0	4.5	0.5	4.0	0.5	4.5
Water temperature (°C)	24.5	22.4	25.7	23.9	23	22.1	20.6	0.8	5.3	13.1	12.8
Specific conductance (µS/cm)	170	180	160	174	167	181	190	169	275	166	167
pH (units)	8.3	7.0	8.9	7.7	9.1	8.4	7.6	7.4	7.2	8.7	8.8
Dissolved oxygen (mg/L)	8.9	0.1	7.7	0.1	10.3	0.9	0.2	11.2	4.5	11.6	10.8
Phosphorus, total (as P)	0.028	0.039	0.070	0.058	0.078	0.093	0.066	0.042	0.037	0.026	0.021
Phosphorus, ortho, dissolved (as P)	--	--	0.004	--	--	--	--	--	--	0.003	--
Nitrogen, NO_2 + NO_3, dissolved (as N)	--	--	0.012	--	--	--	--	--	--	0.02	--
Nitrogen, ammonia, dissolved (as N)	--	--	0.033	--	--	--	--	--	--	<.013	--
Nitrogen, amm. + org., total (as N)	--	--	1.4	--	--	--	--	--	--	0.39	--
Nitrogen, dissolved (as N)	--	--	1.4	--	--	--	--	--	--	--	--
Nitrogen, total (as N)	--	--	--	--	--	--	--	--	--	0.41	--
Color (Pt-Co. scale)	--	--	--	--	--	--	--	--	--	5	--
Turbidity (NTU)	--	--	--	--	--	--	--	--	--	4.2	--
Hardness, as $CaCO_3$	--	--	--	--	--	--	--	--	--	84	--
Calcium, dissolved (Ca)	--	--	--	--	--	--	--	--	--	23.6	--
Magnesium, dissolved (Mg)	--	--	--	--	--	--	--	--	--	6.2	--
Sodium, dissolved (Na)	--	--	--	--	--	--	--	--	--	13.6	--
Potassium, dissolved (K)	--	--	--	--	--	--	--	--	--	<1	--
Alkalinity as $CaCO_3$	--	--	--	--	--	--	--	--	--	82	--
Sulfate, dissolved (SO_4)	--	--	--	--	--	--	--	--	--	<4.5	--
Chloride, dissolved (Cl)	--	--	--	--	--	--	--	--	--	2.4	--
Silica, dissolved (SiO_2)	--	--	--	--	--	--	--	--	--	8.76	--
Solids, dissolved, at 180oC	--	--	--	--	--	--	--	--	--	102	--
Iron, dissolved (Fe) µg/L	--	--	--	--	--	--	--	--	--	<100	--
Manganese, dissolved (Mn) µg/L	--	--	--	--	--	--	--	--	--	<1	--

Table 3b. Summary of analyses of water in Spooner Lake, Southeast Site, June 2002 - April 2003
[Units are milligrams per liter unless otherwise indicated]

	June 27, 2002	July 30, 2002	Aug. 29, 2002	Mar. 18, 2003	Apr. 29, 2003
Lake stage, (ft)	7.05	6.97	6.92	6.75	6.88
Secchi depth (m)	2.0	1.8	1.7	--	1.7
Chlorophyll a, phytoplankton (µg/L)	8.57	9.84	19.6	--	8.52
Depth of sample (m)	0.25	0.25	0.5	0.5	0.5
Water temperature (°C)	25.5	25.2	22.3	0.2	13.7
Specific conductance (µS/cm)	183	190	188	101	168
pH (units)	8.2	8.7	8.8	7.4	9.1
Dissolved oxygen (mg/L)	9.2	9.9	10.2	9.4	12.0
Phosphorus, total (as P) (mg/L)	0.068	0.046	0.034	0.056	0.040

Table 4a. Water clarity and water-quality analyses and their associated Trophic State Indices (TSI) for Spooner Lake, deep hole

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

Date	Secchi Disk			Sampling	Total Phosphorus			Chlorophyll a		Dissolved Ortho-phosphate Phosphorus
	Depth (meters)	Depth (feet)	TSI	Depth (meters)	Conc. (mg/L)	Conc. (ug/L)	TSI	Conc. (ug/L)	TSI	Conc. (mg/L)
6/27/2002	1.4	4.6	55	0.5	0.028	28	54	15.3	55	--
	-	-	-	4.5	0.039	39	--	-	-	--
7/30/2002	0.7	2.3	65	0.5	0.070	70	61	49.3	64	0.004
	-	-	-	3.5	0.058	58	--	-	-	--
8/29/2002	0.85	2.8	62	0.5	0.078	78	62	48.4	64	--
	-	-	-	2	0.093	93	-	-	-	--
	-	-	-	4.5	0.066	66	-	-	-	--
3/18/2003	--	--	--	0.5	0.042	42	57	--	--	--
				4	0.037	37	-	-	-	--
4/29/2003	2.7	8.9	46	0.5	0.026	26	53	5.68	48	0.003
				4.5	0.021	-	-	-	-	

Table 4b. Water clarity and water-quality analyses and their associated Trophic State Indices (TSI) for Spooner Lake, southeast site

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

Date	Secchi Disk			Sampling	Total Phosphorus			Chlorophyll a		Dissolved Ortho-phosphate Phosphorus
	Depth (meters)	Depth (feet)	TSI	Depth (meters)	Conc. (mg/L)	Conc. (ug/L)	TSI	Conc. (ug/L)	TSI	Conc. (mg/L)
6/27/2002	2	6.6	50	0.5	0.068	68.0	61	8.57	51	--
7/30/2002	1.75	5.7	52	0.5	0.046	46.0	58	9.84	52	--
8/29/2002	1.65	5.4	53	0.5	0.034	34.0	56	19.6	57	--
3/18/2003	-	-	-	0.5	0.056	56.0	59	-	-	--
4/29/2003	1.7	5.6	52	0.5	0.040	40.0	57	8.52	51	--

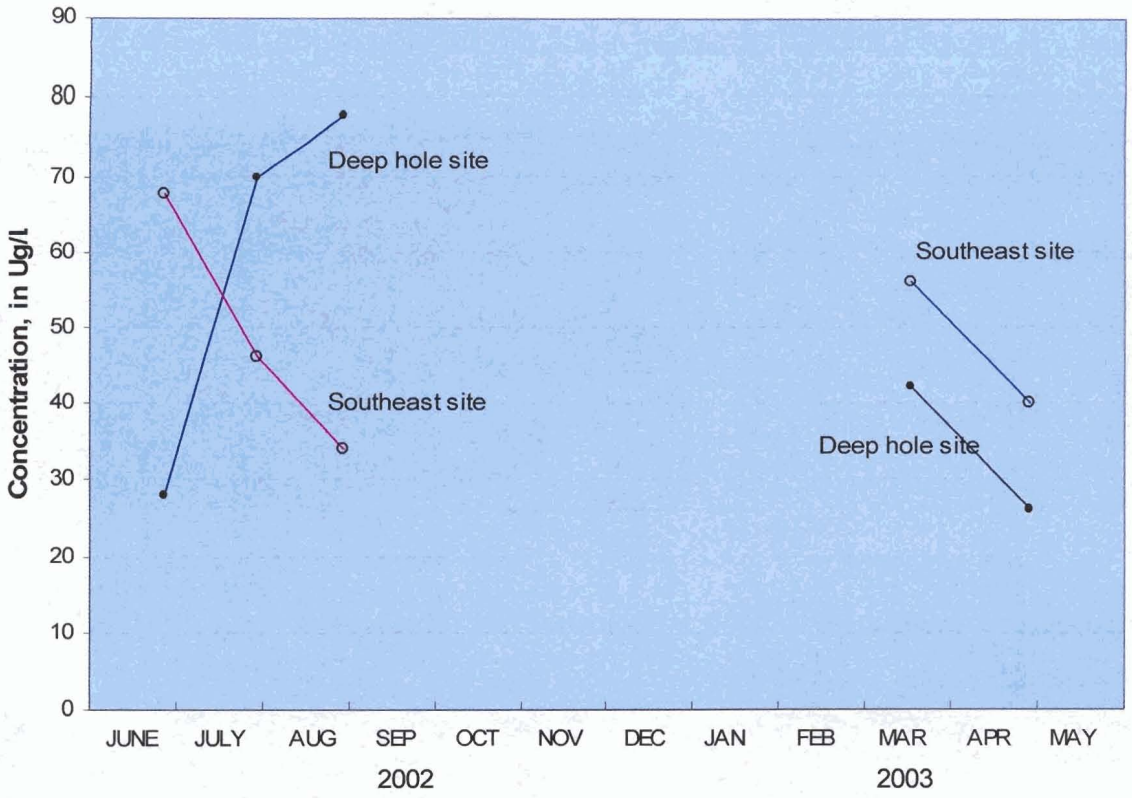

Figure 5. Total phosphorus concentration for Spooner Lake, June 2002 - April 2003.

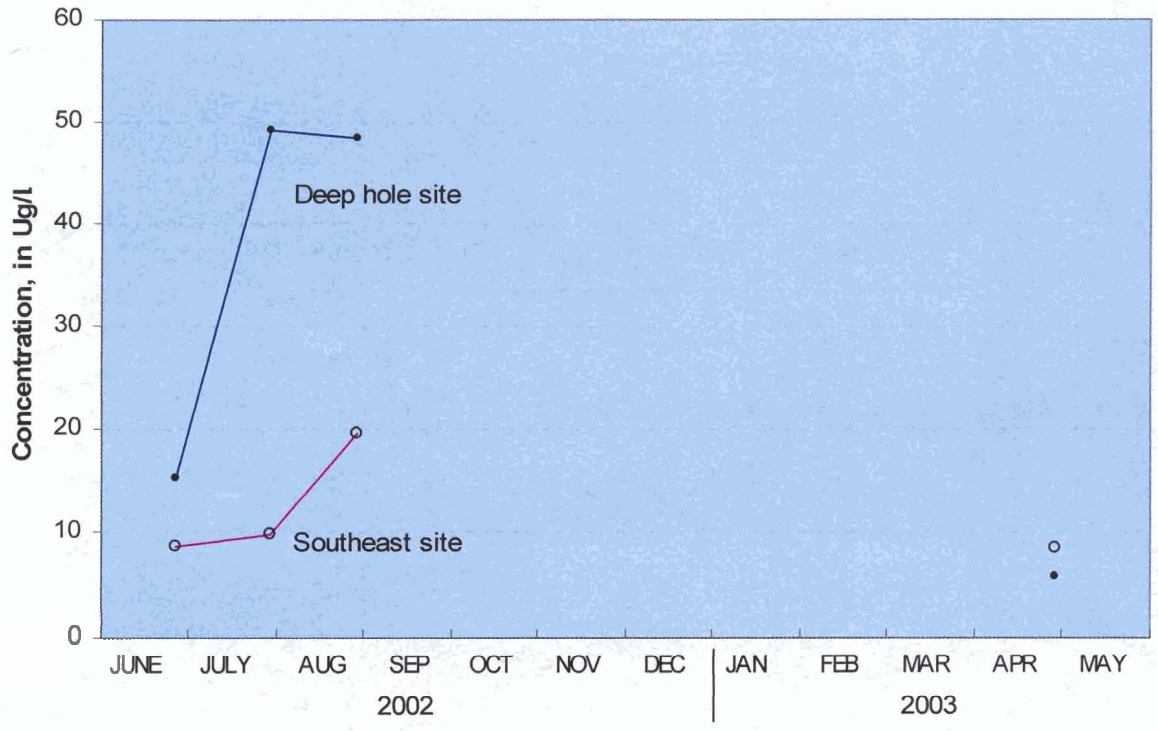

Figure 6. Chlorophyll a concentration for Spooner Lake, June 2002 - April 2003.

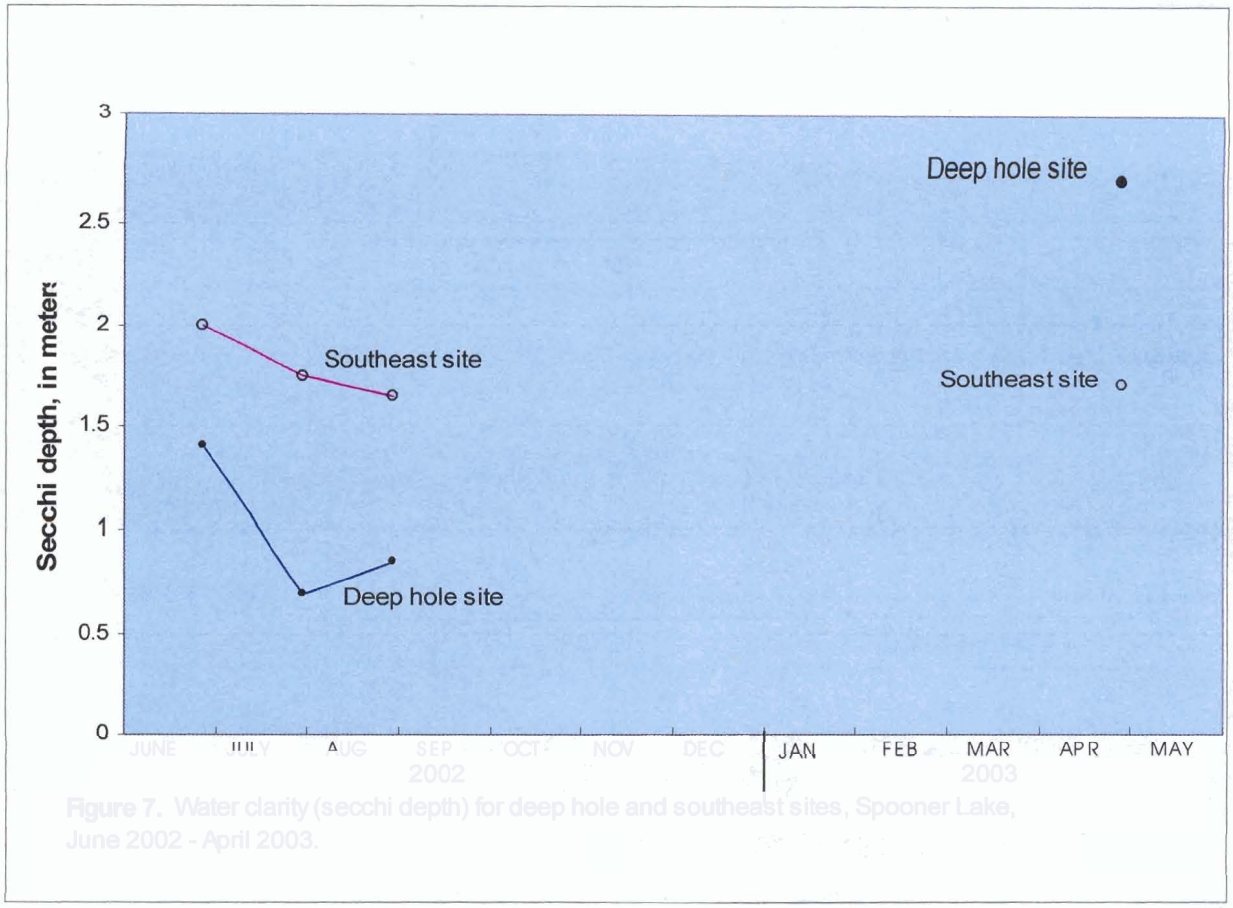

Figure 7. Water clarity (secchi depth) for deep hole and southeast sites, Spooner Lake, June 2002 - April 2003.

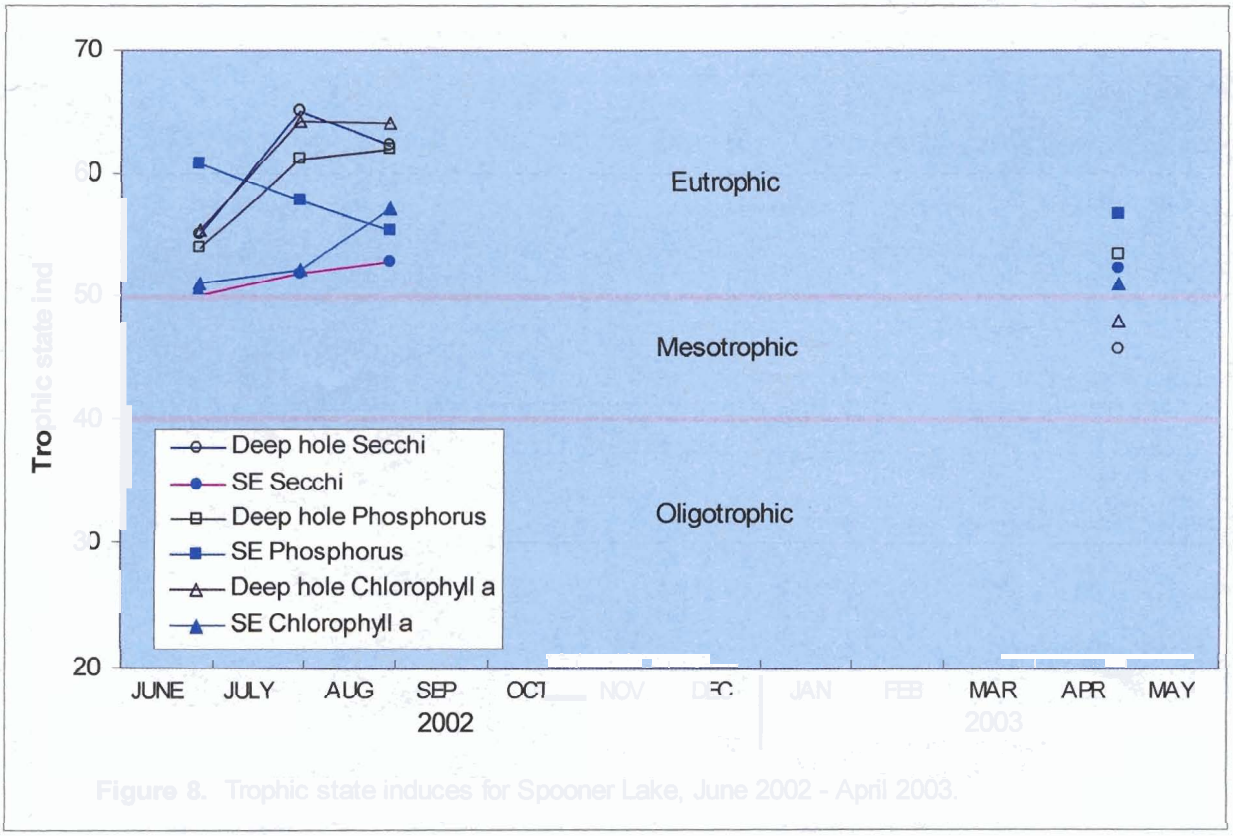

Figure 8. Trophic state induces for Spooner Lake, June 2002 - April 2003.

Table 5. Flow and phosphorus data for Crystal Brook at Highway 70 near Spooner, Wisconsin, June 2002 - April 2003

Date	Time	Discharge (ft^3/s)	Dissolved phosphorus (mg/L)	Total phosphorus (mg/L)	Dissolved phosphorus transport rate (pounds/day)	Total phosphorus transport rate (pounds/day)
6/27/02	1700	19.8	0.039	0.050	4.2	5.3
7/30/02	1045	18.9	0.030	0.040	3.1	4.1
8/29/02	1130	18.6	0.030	0.036	3.0	3.6
10/24/02	1450	20.1	0.033	0.041	3.6	4.5
12/20/02	0910	18.9	--	0.051	--	5.2
3/18/03	1140	18.7	0.03	0.049	3.0	4.9
4/29/03	1250	18.1	0.027	0.041	2.6	4.0
	Average	19.0	0.032	0.044	3.2	4.5

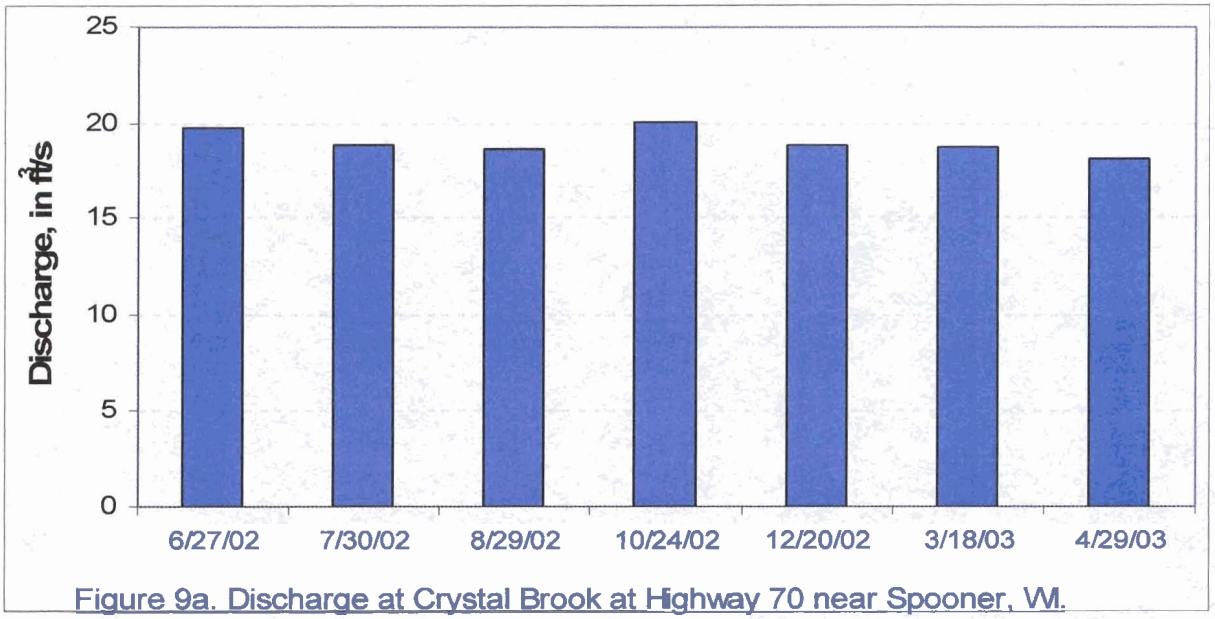

Figure 9a. Discharge at Crystal Brook at Highway 70 near Spooner, WI.

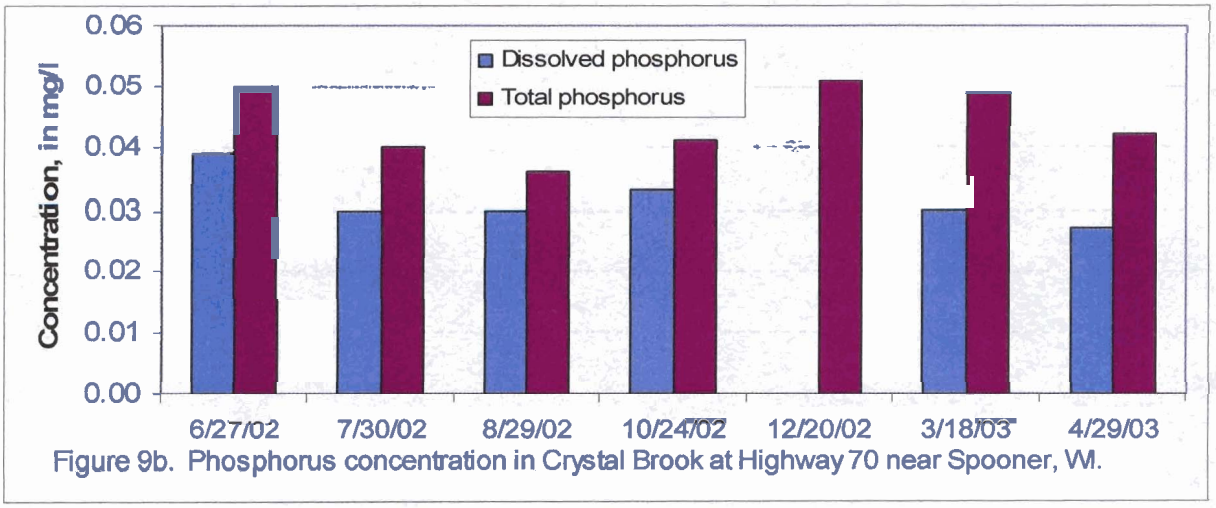

Figure 9b. Phosphorus concentration in Crystal Brook at Highway 70 near Spooner, WI.