LAKE MANITOU
BENNINGTON TOWNSHIP
SHIAWASSEE COUNTY
1993-2002
WATER QUALITY STUDIES

LAKE MANITOU DATA

Lake Manitou is a 94-acre natural moderately hard water to hard water reservoir located in Sections 10 and 11, Bennington Township (T6N R2E), Shiawassee County, Michigan. There are two islands totaling less than two acres in the lake. Hence the surface area is about 92 acres. The lake has a maximum depth of 19 feet (in the old stream bed), a water volume of 1029 acre-feet, and a mean depth of 11.2 feet. It has 16,526 feet of shoreline, not including the island shorelines. The elevation of the lake is 781 feet above sea level.

The lake was formed in 1958 when a 385-foot long earthen dam was constructed across the outlet of the Hardy-Jennings Drain.

The lake has three inlets. The Hardy-Jennings Drain enters the lake through the Waugh Road arm on the east side (Inlet 3). Mirror Lake (Inlet 1) drains into Lake Manitou from the south under Garrison Road, as does water from Forrest Lake (Inlet 2).

The outlet is located on the north side.

The size of the watershed, which is the land area that contributes water to the lake, but does not include the lake, is 3206 acres. The drainage area, which includes the lake and the watershed, is 3300 acres. The watershed to lake ratio is 34.8 to 1, which is high for a Michigan inland lake but normal for a lake formed by damming a stream. Because of this high ratio, the lake flushes rapidly, about once every 0.45 years (or 165 days), on an average.

The drainage area of the Hardy-Jennings Drain is 2026 acres. The drainage area for the Cummings Lakes is 1042 acres. The immediate drainage area of Lake Manitou (including the lake) is 232 acres.

Based on the above drainage areas, the average flow from the 3300-acre Lake Manitou drainage area is 3.17 cubic feet per second or 6.24 billion pounds per year.

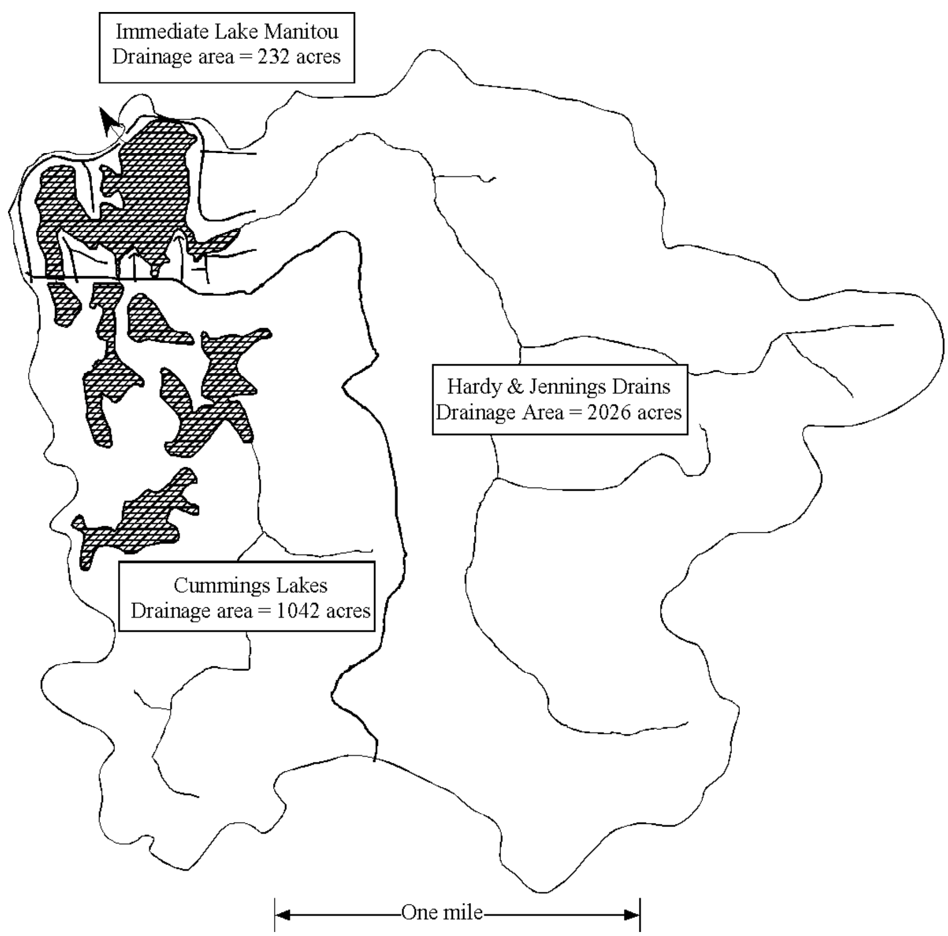
The average flow from the 2026-acre Hardy-Jennings Drain drainage area is 1.95 CFS or 3.83 billion pounds per year.

The average flow from the 1042-acre Cummings Lakes drainage area is 1.00 CFS or 1.97 billion pounds per year.

Water from Lake Manitou flows into the Willow Brook Drain, then into the Maple River, and then into the Grand River. The Grand River discharges into Lake Michigan at Grand Haven.

The longitude and latitude of the 19-foot deep hole is 84° 12.188W and 42° 55.479N.

MAP OF 3300 ACRE LAKE MANITOU DRAINAGE AREA SHOWING CUMMINGS LAKES AND HARVEY-JENNINGS DRAINS



THE SAMPLE DATES

Lake Manitou was sampled on an irregular basis.

1993

WQI limnologists sampled the lake for water quality testing at ten surface stations, plus top to bottom at Station 10, the 19-foot deep hole on April 27, 1993 and August 8, 1993. Samples from the inlets were also collected on these dates. Ten bottom sediment samples were collected during the spring sampling period.

1995-96

Jerry Meyer and Lloyd Sutliff sampled the drains several times during 1995-96, with an emphasis on the Harding-Jennings Drain.

WQI limnologists visited the lake in late summer 1995 and took three surface samples for water quality testing. Top to bottom dissolved oxygen and temperature profile data were also collected at this time.

1999

Jerry Meyer took 6 surface samples for water quality testing on May 15, 1999.

MAP OF LAKE MANITOU SHOWING BOTTOM CONTOURS AND SAMPLES STATIONS

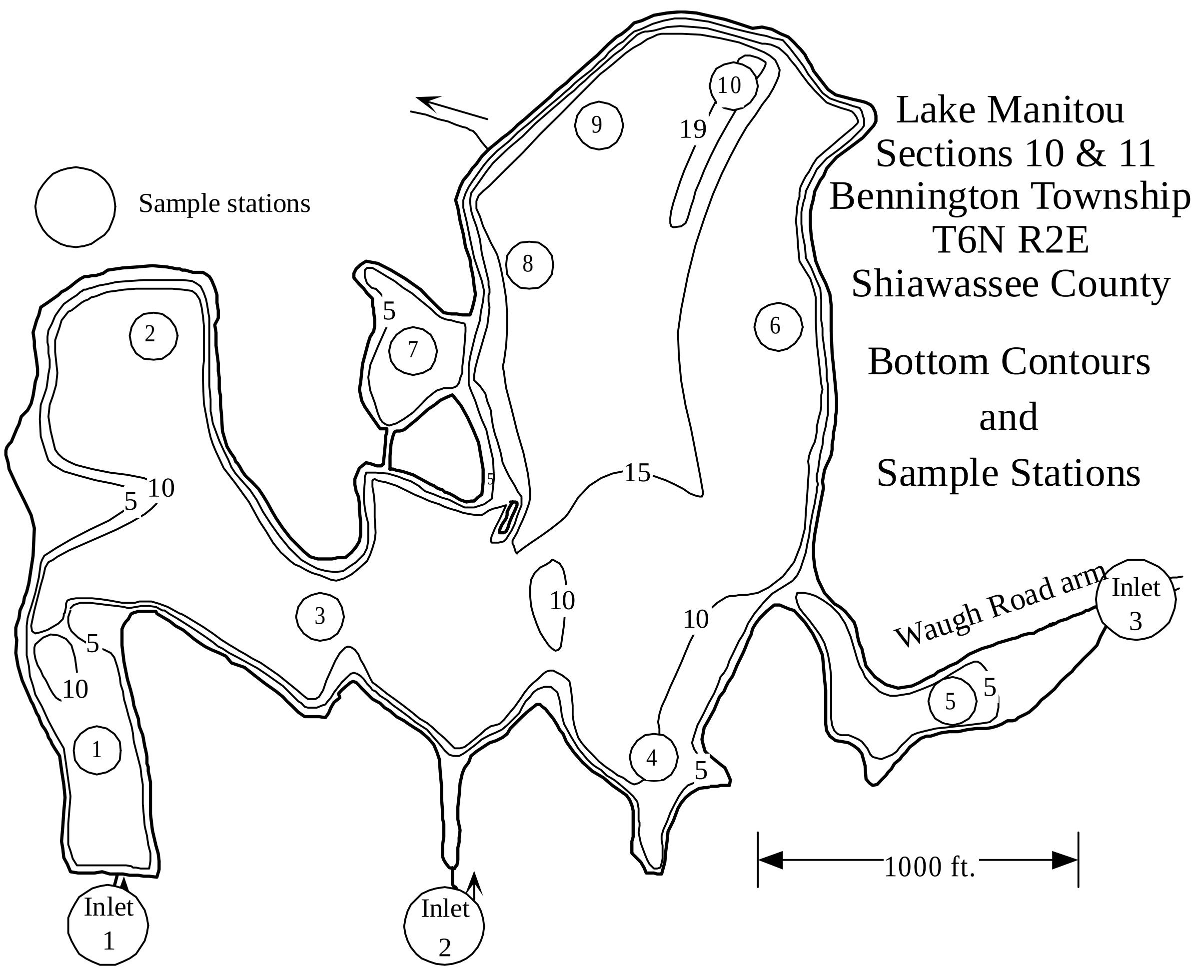
WQI limnologists collected six surface samples for water quality testing on August 22, 1999. Top to bottom dissolved oxygen and temperature profile data were collected at this time.

2000

WQI limnologists collected six surface samples for water quality testing on September 13, 2000. Top to bottom dissolved oxygen and temperature profile data were collected at this time. Three samples for algal analysis were also taken on this date.

2002

In 2002 WQI limnologists collected ten surface samples for water quality testing on May 22 and another ten on August 17. Top to bottom samples were collected every five feet at Station 10, the deep hole each time the lake was sampled. Dissolved oxygen and temperature top to bottom profile data were collected at Station 10 in both spring and summer. Ten bottom sediment samples were also collected this year.



The three inlets were also sampled in both spring and summer.

THE SAMPLE STATIONS

The locations of the various sample stations are shown as circles on the map of the lake.

THE ANALYSES

The tests performed on the samples included total phosphorus, total nitrate nitrogen, total alkalinity, pH, conductivity, chlorophyll a, Secchi disk depth, temperature and dissolved oxygen.

Temperature, dissolved oxygen and Secchi disk depths were measured in the field. Chlorophyll a, phosphorus, nitrate nitrogen, alkalinity, pH and conductivity tests were performed at the Water Quality Investigators laboratory in Dexter, Michigan. All test procedures followed those outlined in *APHA's Standard Methods for the Examination of Water and Wastewater* (1985).

THE TEST RESULTS

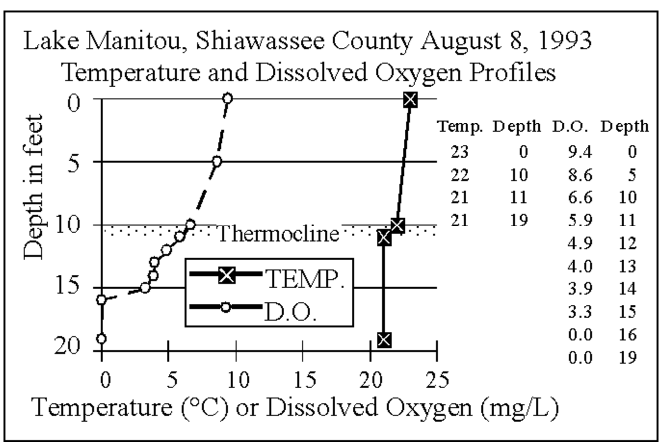
The results of the tests are found on the graphs below, in the tables at the end of this report, and on the enclosed atlas pages.

TEMPERATURE AND DISSOLVED OXYGEN

Temperature exerts a wide variety of influences on most lakes, such as the separation of layers of water (stratification), solubility of gasses and biological activity.

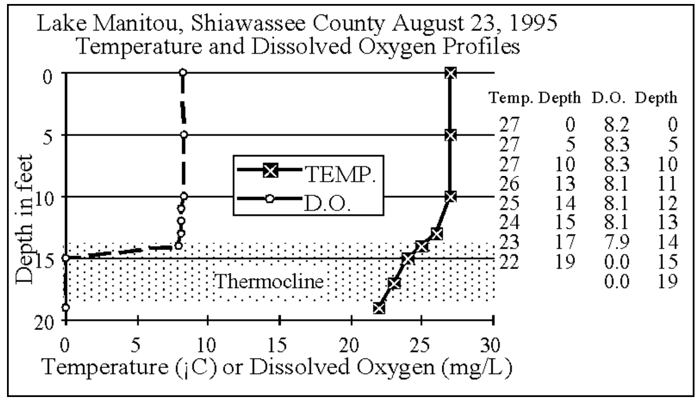
Dissolved oxygen is the test most often selected by lake scientists as being important. Besides its importance in providing oxygen for aquatic organisms to use, in natural lakes oxygen is involved in the capture and release of various chemicals, such as iron and phosphorus.

1993



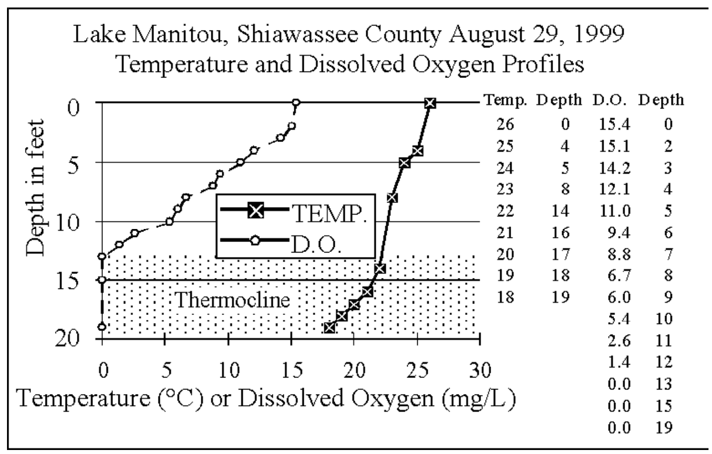
In late summer 1993 the lake formed a one-foot-thick thermocline (a thermocline is defined as a layer of water in a lake where the temperature changes more than one degree C per meter of depth and is shown shaded on the temperature and dissolved oxygen profile graphs) from 10 to 11 feet. The dissolved oxygen concentration at the surface was 9.4 milligrams per liter. From there, it dropped continuously until it was zero at 16 feet. That condition remained to the bottom at 19 feet. The hypsographic (depth-area) graph shows about 14 percent of the lake is deeper than 16 feet.

1995



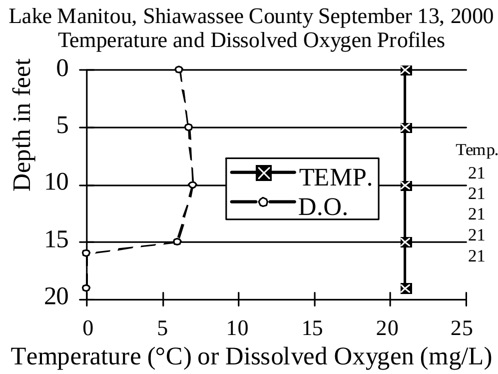
In late summer 1995 Lake Manitou formed a five-foot-thick thermocline from 14 to 19 feet. This year the lake ran out of dissolved oxygen at 15 feet, and that condition remained to the bottom. About 20 percent of the lake is deeper than 15 feet.

1999



In late summer 1999 the lake formed a 6-foot-thick thermocline from 13 to 19 feet. The dissolved oxygen concentration at the surface was high (supersaturated) at 15.14 milligrams per liter. From there it continually dropped, until it was zero at 13 feet. About 34 percent of the lake is deeper than 13 feet.

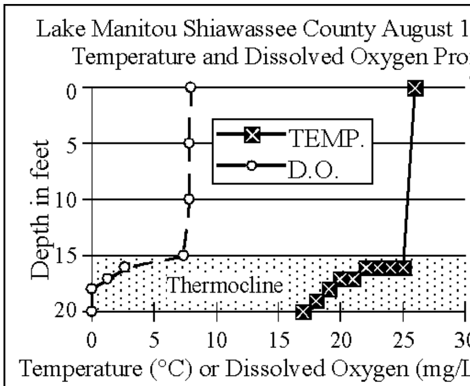
2000



Temp.	Depth	D.O.	Depth
21	0	6.1	0
21	5	6.7	5
21	10	7.0	10
21	15	6.0	15
21	19	0.0	16
		0.0	19

In late summer 2000, temperature was uniform top to bottom. Dissolved oxygen concentrations were essentially uniform to 15 feet. D.O. dropped to zero at 16 feet, and that condition remained to the bottom.

2002



Temp.	Depth	D.O.	Depth
26	0	8.0	0
25	16	7.9	5
24	16	7.8	10
23	16	7.4	15
22	16	2.7	16
21	17	1.3	17
20	17	0.0	18
19	18	0.0	20
18	19		
17	20		

In late summer 2002, the lake formed a 4-foot-thick thermocline from 15 to 19 feet. Dissolved oxygen was again essentially uniform in the top 15 feet. It dropped to zero at 18 feet.

DISSOLVED OXYGEN, PERCENT SATURATION

The dissolved oxygen saturation graph below shows dissolved oxygen saturation in spring and summer 1993 and summer 1995 near 100 percent, which is ideal. (Spring dissolved oxygen concentrations and temperatures were not measured.)

1999 summer dissolved oxygen concentrations were near or above 180 percent saturation. These data indicate that year, algal blooms in the lake were producing significant amounts of dissolved oxygen during the day.

In summer 2000 dissolved oxygen was about 80% of saturation. Best is near saturation (100%). In 2002 dissolved oxygen saturation was near 100 percent which is good.

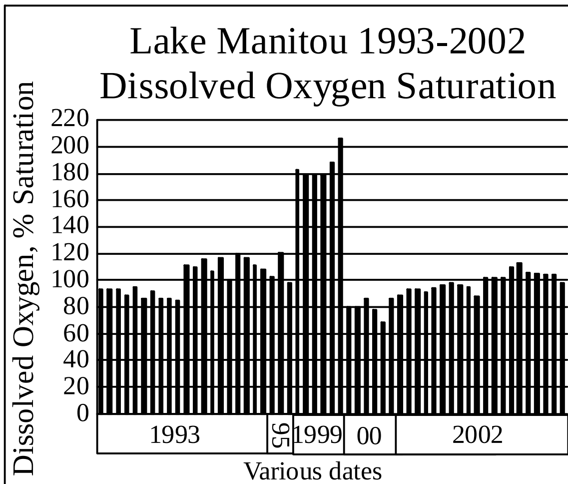
CONDUCTIVITY

Conductivity, measured with a meter, detects the capacity of a water to conduct an electric current. More importantly however, it measures the amount of materials dissolved in the water, since only dissolved materials will permit an electric current to flow. Theoretically, pure water will not conduct an electric current.

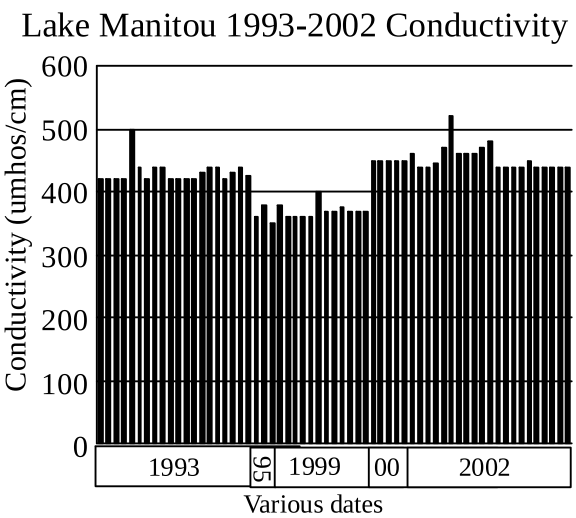
It is the perception of the experts that poor quality water has more dissolved materials than good quality water. I agree. Lower is usually better.

The graph shows the conductivity of Lake Manitou ranges from 350 to 520 micromhos per centimeter. The conductivity measurements for Lake Manitou are normal for a moderately hard water Michigan inland lake.

The graph also shows conductivity may be increasing. Usually the source of most salts around a lake are water softeners or winter road salting activities.



4/27/93	1	93	8/8/93	10	108	5/22/02	4	91
4/27/93	2	93	8/22/95	1	103	5/22/02	5	94
4/27/93	3	93	8/22/95	2	121	5/22/02	6	96
4/27/93	4	89	8/22/95	3	98	5/22/02	7	98
4/27/93	5	95	8/22/99	1	183	5/22/02	8	96
4/27/93	6	86	8/22/99	3	179	5/22/02	9	95
4/27/93	7	92	8/22/99	4	179	5/22/02	10	88
4/27/93	8	86	8/22/99	7	179	8/17/02	1	102
4/27/93	9	86	8/22/99	10	188	8/17/02	2	102
4/27/93	10	85	8/22/99	5	206	8/17/02	3	102
8/8/93	1	111	9/13/00	1	80	8/17/02	4	110
8/8/93	2	110	9/13/00	3	80	8/17/02	5	113
8/8/93	3	116	9/13/00	4	86	8/17/02	6	106
8/8/93	4	107	9/13/00	7	78	8/17/02	7	105
8/8/93	5	117	9/13/00	10	68	8/17/02	8	104
8/8/93	6	100	9/13/00	5	86	8/17/02	9	104
8/8/93	7	120	5/22/02	1	89	8/17/02	10	98
8/8/93	8	117	5/22/02	2	93			
8/8/93	9	111	5/22/02	3	93			



4/27/93	1	420	8/22/95	2	380	5/22/02	2	440
4/27/93	2	420	8/22/95	3	350	5/22/02	3	445
4/27/93	3	420	5/15/99	1	380	5/22/02	4	470
4/27/93	4	420	5/15/99	3	360	5/22/02	5	520
4/27/93	5	500	5/15/99	4	360	5/22/02	6	460
4/27/93	6	440	5/15/99	7	360	5/22/02	7	460
4/27/93	7	420	5/15/99	10	360	5/22/02	8	460
4/27/93	8	440	5/15/99	5	400	5/22/02	9	470
4/27/93	9	440	8/22/99	1	370	5/22/02	10	480
4/27/93	10	420	8/22/99	3	370	8/17/02	1	440
8/8/93	1	420	8/22/99	4	375	8/17/02	2	440
8/8/93	2	420	8/22/99	7	370	8/17/02	3	440
8/8/93	3	420	8/22/99	10	370	8/17/02	4	440
8/8/93	4	430	8/22/99	5	370	8/17/02	5	450
8/8/93	5	440	9/13/00	1	450	8/17/02	6	440
8/8/93	6	440	9/13/00	3	450	8/17/02	7	440
8/8/93	7	420	9/13/00	4	450	8/17/02	8	440
8/8/93	8	430	9/13/00	7	450	8/17/02	9	440
8/8/93	9	440	9/13/00	10	450	8/17/02	10	440
8/8/93	10	425	9/13/00	5	460			
8/22/95	1	360	5/22/02	1	440			

TOTAL ALKALINITY

Alkalinity measures carbonates and bicarbonates in water. Soft water lakes have alkalinities below 75 milligrams per liter. Moderately hard water lakes have alkalinities between 75 and 150 milligrams per liter. Hard water lakes have alkalinities above 150 milligrams per liter.

The graph of 1993-2002 Lake Manitou surface alkalinity concentrations shows three things.

First, spring alkalinities are higher than summer alkalinities. That's normal because carbonates (which is what the alkalinity test measures) precipitate to the bottom sediments as the water warms in summer.

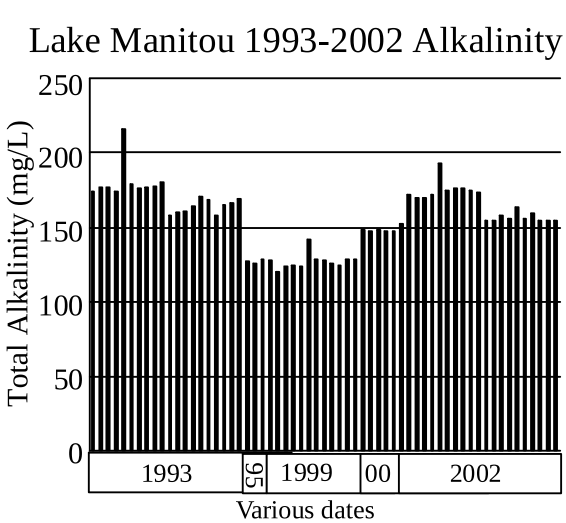
Second, the alkalinity in Lake Manitou ranges from about 174 to 216 milligrams per liter in spring, and from 125 to 171 milligrams per liter in summer. These data indicate Lake Manitou is a moderately hard water to hard water lake. Hard water lakes are tougher than soft water lakes because they have the ability to precipitate some phosphorus to the bottom sediments as calcium phosphate.

Third, the graph shows alkalinity seems to be decreasing. The reason for this is unknown.

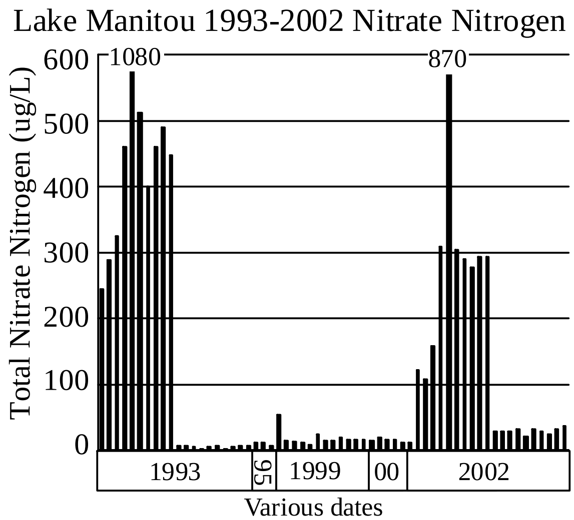
NITRATE NITROGEN

Most Michigan inland lakes have spring nitrate nitrogen concentrations around 200 micrograms per liter (or parts per billion). Summer nitrate nitrogen concentrations are generally much lower, in the 10 to 40 micrograms per liter range.

The 1993 spring nitrate nitrogen concentrations were higher than normal (248-1080 micrograms per liter, with the 1080 microgram per liter sample taken from the Waugh Road arm) for a Michigan inland lake. The 1995, 1999 and 2000 nitrate nitrogen concentrations were low, even the spring 1999 samples, but in 1999 spring came early, so nitrate nitrogen concentrations probably dropped to their warm water levels when the samples were collected in mid-May.



4/27/93	1	174	8/22/95	2	126	5/22/02	2	170
4/27/93	2	177	8/22/95	3	129	5/22/02	3	170
4/27/93	3	177	5/15/99	1	128	5/22/02	4	172
4/27/93	4	174	5/15/99	3	120	5/22/02	5	193
4/27/93	5	216	5/15/99	4	124	5/22/02	6	175
4/27/93	6	179	5/15/99	7	125	5/22/02	7	176
4/27/93	7	176	5/15/99	10	124	5/22/02	8	176
4/27/93	8	177	5/15/99	5	142	5/22/02	9	175
4/27/93	9	178	8/22/99	1	129	5/22/02	10	173
4/27/93	10	180	8/22/99	3	128	8/17/02	1	155
8/8/93	1	158	8/22/99	4	126	8/17/02	2	155
8/8/93	2	160	8/22/99	7	125	8/17/02	3	158
8/8/93	3	161	8/22/99	10	129	8/17/02	4	156
8/8/93	4	164	8/22/99	5	129	8/17/02	5	163
8/8/93	5	171	9/13/00	1	148	8/17/02	6	156
8/8/93	6	168	9/13/00	3	147	8/17/02	7	159
8/8/93	7	158	9/13/00	4	148	8/17/02	8	155
8/8/93	8	165	9/13/00	7	147	8/17/02	9	155
8/8/93	9	167	9/13/00	10	147	8/17/02	10	155
8/8/93	10	169	9/13/00	5	152			
8/22/95	1	127	5/22/02	1	172			



4/27/93	1	244	8/22/95	2	10	5/22/02	2	107
4/27/93	2	288	8/22/95	3	6	5/22/02	3	156
4/27/93	3	325	5/15/99	1	54	5/22/02	4	308
4/27/93	4	460	5/15/99	3	13	5/22/02	5	870
4/27/93	5	1080	5/15/99	4	11	5/22/02	6	303
4/27/93	6	510	5/15/99	7	10	5/22/02	7	290
4/27/93	7	400	5/15/99	10	8	5/22/02	8	277
4/27/93	8	460	5/15/99	5	24	5/22/02	9	294
4/27/93	9	490	8/22/99	1	14	5/22/02	10	294
4/27/93	10	447	8/22/99	3	14	8/17/02	1	28
8/8/93	1	6	8/22/99	4	18	8/17/02	2	28
8/8/93	2	5	8/22/99	7	16	8/17/02	3	28
8/8/93	3	4	8/22/99	10	16	8/17/02	4	32
8/8/93	4	1	8/22/99	5	16	8/17/02	5	20
8/8/93	5	4	9/13/00	1	13	8/17/02	6	32
8/8/93	6	6	9/13/00	3	18	8/17/02	7	28
8/8/93	7	2	9/13/00	4	16	8/17/02	8	24
8/8/93	8	4	9/13/00	7	16	8/17/02	9	32
8/8/93	9	5	9/13/00	10	10	8/17/02	10	36
8/8/93	10	6	9/13/00	5	10			
8/22/95	1	10	5/22/02	1	120			

In 2002, spring nitrate nitrogen ranged from 107 to 870 micrograms per liter, with most samples being 300 micrograms per liter or less. These are slightly higher than normal spring nitrate nitrogen concentrations.

Summer nitrate nitrogen concentrations were low (but normal), every year.

The lake appears to be nitrogen limited in summer, so any nitrogen added to the lake during the year is not recommended. Lawn fertilizers containing either nitrogen or phosphorus should not be used on lawns near (within 400 feet of) the lake.

The inlet nitrate nitrogen concentrations were another story. Jerry Meyer and Lloyd Sutliff sampled the inlets in 1995 and 1996, plus WQI sampled the inlets in both spring and summer in 1993 and 2002.

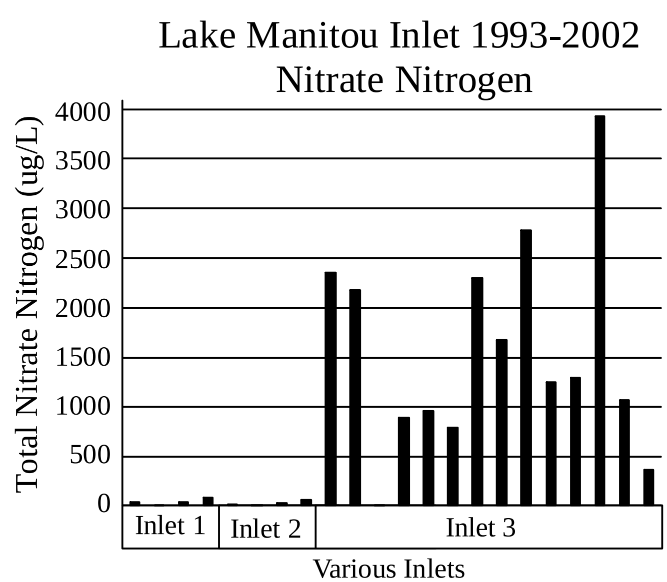
Based on four samples collected by WQI limnologists in 1993 and 2002 from Inlets 1 and 2, nitrate nitrogen concentrations were low at these two stations, ranging from 6 to 84 micrograms per liter and averaging 35 micrograms per liter. These low nitrate nitrogen concentrations may be the result of the water flowing through the Mirror and Forrest Lakes, which are acting as retention basins, before it reaches Lake Manitou.

WQI limnologists collected three samples from Inlet 3 (which discharges into the Waugh Road arm of the lake) in 1993 and two samples in 2002.

14 Nitrate nitrogen from Station 3 ranged from 7 to 3968 micrograms per liter and averaged 1561 micrograms per liter. These are high nitrate nitrogen concentrations for a Michigan inland lake. The graph below shows these data.

These data indicate a major source of nitrates for Lake Manitou is somewhere upstream on the Hardy-Jennings Drain.

Based on the average flow of the inlets (Cummings Lakes inlets = 1.97 billion pounds of water per year and the Hardy-Jennings Drain = 3.83 billion pounds per year) and averaged nitrate nitrogen concentrations, Cummings Lake inlets add 69 pounds of nitrate nitrogen per year to Lake Manitou,



4/27/93	39
8/8/93	6
5/22/02	36
8/17/02	84
4/27/93	16
8/8/93	6
5/22/02	31
8/17/02	60
4/23/93	2350
4/27/93	2180
8/8/93	7
5/10/95	895
5/23/95	947
7/25/95	784
8/4/95	2293
8/17/95	1673
4/12/96	2784
5/9/96	1248
5/20/96	1296
6/17/96	3936
5/22/02	1061
8/17/02	360

while the Hardy-Jennings Drain adds 5979 pounds of nitrate nitrogen per year to the lake.

These data indicate the lake gets more than 85 times more nitrogen from the Hardy-Jennings Drain than it gets from the Cummings Lake inlets. In terms of nitrogen additions, the Hardy-Jennings Drain is by far the bigger problem.

CHLOROPHYLL A

Chlorophyll a, reported in micrograms per liter (or parts per billion) generally gives an estimate of algal densities. Best is below 1 microgram per liter.

The graph shows Lake Manitou had significant algae blooms each time the lake was sampled. The graph also shows chlorophyll a concentrations range from a low of 3.5 micrograms per liter, to a high of 80.5 micrograms per liter, and average 23.3 micrograms per liter.

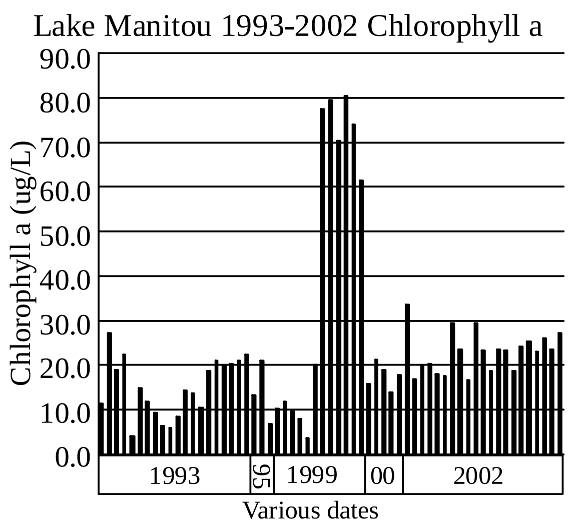
In summer 1999, chlorophyll a concentrations were very high, ranging from 70.5 to 80.5 micrograms per liter. This indicates the lake had an intense algal bloom at the time it was sampled.

In summer 2000 and 2002, chlorophyll a concentrations dropped considerably. They ranged from 13.9 to 33.5 micrograms per liter in 2000 and from 16.6 to 29.4 in 2002. Although lower than the summer 1999 chlorophyll a concentrations, these are still considered high chlorophyll a concentrations.

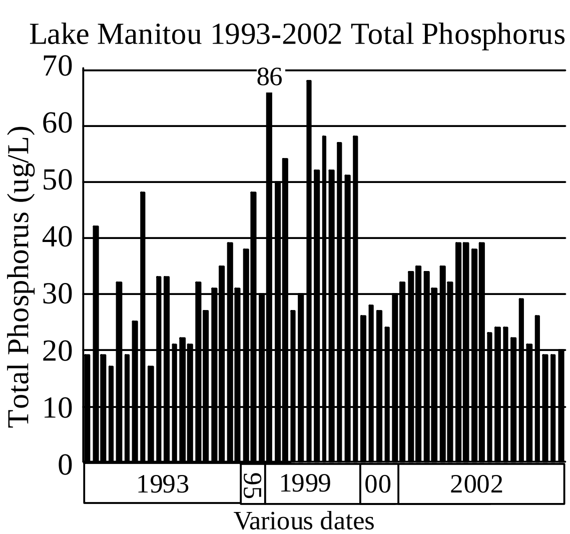
In 1993, the average chlorophyll a concentration of the 20 samples was 15.1 micrograms per liter. In 2002, it was 22.4 micrograms per liter. The graph and data seem to show chlorophyll a concentrations are increasing.

pH (Hydrogen ion concentration) (No graph)

pH values ranged between 8.0 and 9.2, with values in the higher range in 1999 when the lake had an intense algal bloom. In most cases, these are low pH values for a southeast Michigan inland lake with intense algal blooms. The high flushing rate probably had something to do with this.



4/27/93	1	11.3	8/22/95	2	21.0	5/22/02	2	19.8
4/27/93	2	27.1	8/22/95	3	6.6	5/22/02	3	20.4
4/27/93	3	19.0	5/15/99	1	10.1	5/22/02	4	18.1
4/27/93	4	22.4	5/15/99	3	11.9	5/22/02	5	17.6
4/27/93	5	4.1	5/15/99	4	9.5	5/22/02	6	29.4
4/27/93	6	15.0	5/15/99	7	7.9	5/22/02	7	23.7
4/27/93	7	11.9	5/15/99	10	3.5	5/22/02	8	16.6
4/27/93	8	9.2	5/15/99	5	20.0	5/22/02	9	29.4
4/27/93	9	6.4	8/22/99	1	77.5	5/22/02	10	23.2
4/27/93	10	5.8	8/22/99	3	79.5	8/17/02	1	18.6
8/8/93	1	8.4	8/22/99	4	70.5	8/17/02	2	23.7
8/8/93	2	14.2	8/22/99	7	80.5	8/17/02	3	23.2
8/8/93	3	13.8	8/22/99	10	74.0	8/17/02	4	18.6
8/8/93	4	10.5	8/22/99	5	61.5	8/17/02	5	24.3
8/8/93	5	18.5	9/13/00	1	15.8	8/17/02	6	25.4
8/8/93	6	21.1	9/13/00	3	21.3	8/17/02	7	23.1
8/8/93	7	19.7	9/13/00	4	18.8	8/17/02	8	25.9
8/8/93	8	20.3	9/13/00	7	13.9	8/17/02	9	23.7
8/8/93	9	21.1	9/13/00	10	17.8	8/17/02	10	27.1
8/8/93	10	22.3	9/13/00	5	33.5			
8/22/95	1	13.2	5/22/02	1	16.9			



4/27/93	1	19	8/22/95	2	48	5/22/02	2	35
4/27/93	2	42	8/22/95	3	30	5/22/02	3	34
4/27/93	3	19	5/15/99	1	70	5/22/02	4	31
4/27/93	4	17	5/15/99	3	50	5/22/02	5	35
4/27/93	5	32	5/15/99	4	54	5/22/02	6	32
4/27/93	6	19	5/15/99	7	27	5/22/02	7	39
4/27/93	7	25	5/15/99	10	30	5/22/02	8	39
4/27/93	8	48	5/15/99	5	68	5/22/02	9	38
4/27/93	9	17	8/22/99	1	52	5/22/02	10	39
4/27/93	10	33	8/22/99	3	58	8/17/02	1	23
8/8/93	1	33	8/22/99	4	52	8/17/02	2	24
8/8/93	2	21	8/22/99	7	57	8/17/02	3	24
8/8/93	3	22	8/22/99	10	51	8/17/02	4	22
8/8/93	4	21	8/22/99	5	58	8/17/02	5	29
8/8/93	5	32	9/13/00	1	26	8/17/02	6	21
8/8/93	6	27	9/13/00	3	28	8/17/02	7	26
8/8/93	7	31	9/13/00	4	27	8/17/02	8	19
8/8/93	8	35	9/13/00	7	24	8/17/02	9	19
8/8/93	9	39	9/13/00	10	30	8/17/02	10	20
8/8/93	10	31	9/13/00	5	32			
8/22/95	1	38	5/22/02	1	34			

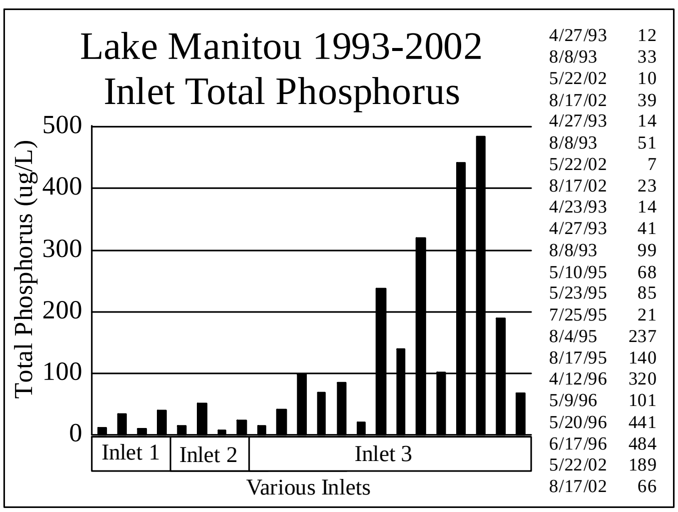
Lakes with extensive plant and/or algal communities often have high summer pH values (greater than 9) because the plants use the carbonates in the water as a carbon source. This causes a decrease in the buffering capacity of the water, and allows the pH to rise.

TOTAL PHOSPHORUS

The graph shows Lake Manitou has phosphorus concentrations in the 20 to 86 micrograms per liter range. (1999 seemed to be a particularly bad year in terms of in-lake phosphorus concentrations.) At these concentrations, the lake can and does support intense algal blooms. Best is below 10 micrograms per liter.

The inlet phosphorus data reveals the amount of phosphorus entering Lake Manitou from the Cummings Lakes is small (average 24 micrograms per liter, range 7-51 micrograms per liter) compared to the amount entering from the Hardy-Jennings Drain (average 154 micrograms per liter, range 14-484 micrograms per liter).

Based on average flow from the two drains, and average phosphorus concentrations, the amount of phosphorus discharged into Lake Manitou from the Cummings Lakes inlets is 46 pounds per year. The amount of phosphorus discharged from the Hardy-Jennings Drain is 590 pounds. Hence Hardy-Jennings Drain contributes more than 12 times more phosphorus to Lake Manitou than the Cummings Lake inlets do.



SECCHI DISK TRANSPARENCY (originally Secchi's disk)

In 1865, Angelo Secchi of Rome, Italy devised a 20 centimeter (8 inch) white disk for studying the transparency of the water in the Mediterranean Sea. Later an American limnologist (lake scientist) named Whipple divided the disk into black and white quadrants, which many are familiar with today.

The Secchi disk transparency is a lake test widely used and accepted by limnologists. The experts generally felt the greater the Secchi disk depth, the better quality the water. However, one Canadian scientist pointed out acid lakes have very deep Secchi disk readings. (Would you consider a very clear lake a good quality lake, even if it had no fish in it? It would be almost like a swimming pool.) Most lakes in southeast Michigan have Secchi disk transparencies of less than ten feet. On the other hand, Elizabeth Lake in Oakland County had 34 foot Secchi disk readings in summer 1996, evidently caused by a zebra mussel invasion a couple of years earlier.

Most limnology texts recommend the following: to take a Secchi disk transparency reading, lower the disk into the water on the shaded side of an anchored boat to a point where it disappears. Then raise it to a point where it's visible. The average of these two readings is the Secchi disk transparency depth.

We do it slightly differently. We lower the disk on the shaded side of an anchored boat until the disk disappears, and note the depth, then report the depth to the next deepest foot. For example if the disk disappears at six and a half feet, we report the Secchi disk depth as 7 feet. The reason we do this is that some suggest using a water telescope (a device that works like an underwater mask and eliminates water roughness) to view the disk as it disappears. Since we don't use this device, we compensate for it by noting the slightly deeper depth.

We feel it is only necessary to report Secchi disk measurements to the closest foot. Secchi disk measurements should be taken between 10 AM and 4 PM. Rough water will give slightly shallower readings than smooth water. Sunny days will give slightly deeper readings than cloudy days. However, roughness influences the visibility of the disk more than sunny or cloudy days. Furthermore, it's been reported that most adults can see the Secchi disk disappear at about the same depth, but grandchildren see it disappear 3-4 feet deeper than grand-parents.

If there are sample sites where the lake is too shallow and the disk is visible when resting on the bottom, the reading should be taken at a nearby deeper site. Since the sampling procedure is designed to obtain "representative samples" moving the boat to an area where a Secchi disk transparency reading can be properly taken is appropriate. In the case of Secchi disk readings, this procedure is more valid than reporting the disk is visible on the lake bottom.

LAKE MANITOU SECCHI DISK DATA

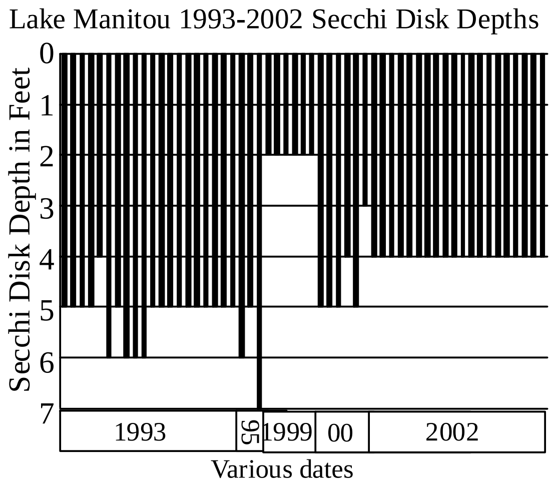
WQI limnologists collected Secchi disk data each time they sampled the lake. The graph below shows their data.

The graph shows in 1993 Secchi disk readings ranged from 4 to 6 feet, while in 2002, they were all four feet. The 2-foot 1999 readings show the intensity of the algal bloom that year. In any case, the Secchi disk readings collected by WQI show the clarity of the lake rarely exceeds 5 feet.

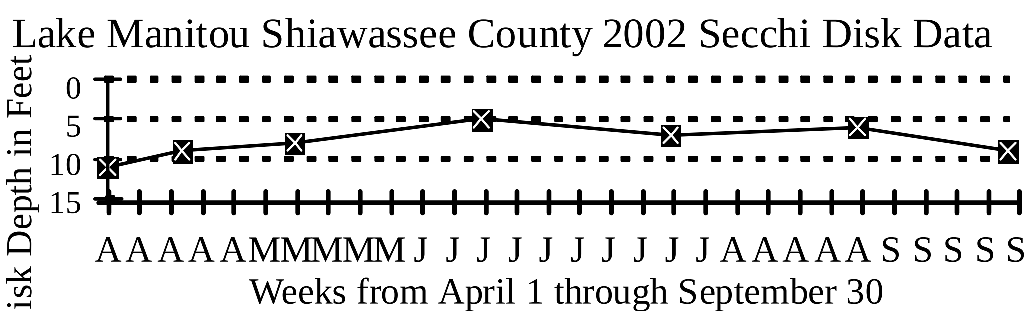
Jerry Meyer provided monthly 2002 Secchi disk data. These data are shown below. They range from 5 to 11 feet and are the best readings we've seen on the lake.

Secchi disk readings should be taken on a weekly basis through the warm months to follow what is happening in the lake.

Development of the index involved the use of two questionnaires sent to a panel of 555 lake scientists who were members of the American Society of Limnology and Oceanography. The panel was specifically selected because they were chemists and biologists with advanced degrees who studied lake water quality.



4/27/93	1	5	8/8/93	10	5	5/22/02	4	4
4/27/93	2	5	8/22/95	1	6	5/22/02	5	4
4/27/93	3	5	8/22/95	2	5	5/22/02	6	4
4/27/93	4	5	8/22/95	3	7	5/22/02	7	4
4/27/93	5	4	8/22/99	1	2	5/22/02	8	4
4/27/93	6	6	8/22/99	3	2	5/22/02	9	4
4/27/93	7	5	8/22/99	4	2	5/22/02	10	4
4/27/93	8	6	8/22/99	7	2	8/17/02	1	4
4/27/93	9	6	8/22/99	10	2	8/17/02	2	4
4/27/93	10	6	8/22/99	5	2	8/17/02	3	4
8/8/93	1	5	9/13/00	1	5	8/17/02	4	4
8/8/93	2	5	9/13/00	3	5	8/17/02	5	4
8/8/93	3	5	9/13/00	4	5	8/17/02	6	4
8/8/93	4	5	9/13/00	7	4	8/17/02	7	4
8/8/93	5	5	9/13/00	10	5	8/17/02	8	4
8/8/93	6	5	9/13/00	5	3	8/17/02	9	4
8/8/93	7	5	5/22/02	1	4	8/17/02	10	4
8/8/93	8	5	5/22/02	2	4			
8/8/93	9	5	5/22/02	3	4			



APR	11		.AUG	7
MAY	9		SEP	6
JUN	8		OCT	9
JUL	5.			

AVERAGE SECCHI DISK DATA

Not enough data is available to create a graph showing the Secchi disk trend over the years. This is unfortunate.

THE LAKE WATER QUALITY INDEX

The Lake Water Quality Index used in this study to define the water quality of Lake Manitou was developed for two reasons. First, there was no agreement among lake scientists regarding which tests should be used to define the water quality of lakes, and second, there was no agreement among lake scientists regarding what the results of various tests meant in terms of lake water quality.

The first questionnaire asked the scientists to select tests which they felt should be used to define lake water quality. The tests most often selected by the panel became the index parameters (or tests). They were:

- Total phosphorus
- Chlorophyll a
- Secchi disk depth
- Total nitrate nitrogen
- Dissolved oxygen (percent saturation)
- Total alkalinity
- Temperature
- Conductivity
- pH

The second questionnaire, sent out after the first was returned, asked the scientists what the results of the tests they selected as good indicators of lake water quality meant.

After the responses to the second questionnaire were returned and tabulated, the nine parameters and the accompanying rating curves were combined into a Lake Water Quality Index.

The index ranges from 1 to 100 and rates lakes about the same way professors rate students: 90-100=A, 80-90=B, 70-80=C, 60-70=D, and below 60 = E. The lake with the highest LWQI was Long Lake in Grand Traverse County, with a spring LQWI of 100. The lowest was 16 at an Ottawa County lake.

THE LAKE WATER QUALITY INDEX CALCULATION SHEETS

The Lake Water Quality Index calculation sheets which follow were developed to show graphically what the results of the nine different lake water quality tests mean in terms of lake water quality.

HOW TO READ THE LAKE WATER QUALITY INDEX CALCULATION SHEETS.

Listed across the top of the calculation sheets are the tests selected by the panel of experts as being good indicators of lake water quality. The results of the tests are entered into the square boxes immediately under the names of the tests.

The figures which look like thermometers are actually graphs which convert the test results (the numbers found outside the thermometer) to a uniform 1-100 lake water quality rating (found inside the thermometer).

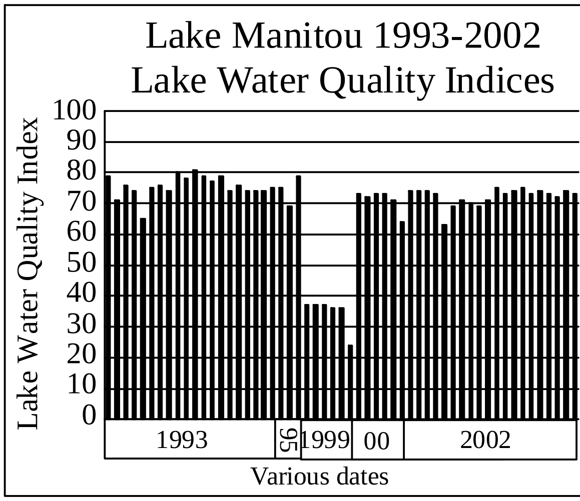
water quality problem. A glance at the top of the calculation sheet indicates the test and the actual test results.

The thermometer rating scales also allow you to determine what test results would be considered excellent in terms of lake water quality. They are the numbers found outside the thermometer near the top.

The index is shown three different ways, as a number between 1 and 100 in the circle marked LWQI, and by a color and position on the sheet edge scale. The purpose of the sheet edge scale is to review quickly large numbers of lakes or test sites within a lake, and determine how the water quality of the various lakes, or test sites within a lake compare.

THE 1993 -2002 LAKE WATER QUALITY INDICES FOR LAKE MANITOU

The graph below shows the water quality of Lake Manitou is generally below 80, ranging from a low of 24 (E) in summer 1999 to a high of 81 (B) in summer 1993. A majority of the Lake Water Quality Indices are in the 70s, or C range. However, the summer 1999 LWQIs were very low, ranging from 24 to 37 (E). The causes of these low LWQIs were the intense algal bloom, shallow Secchi disk readings, and very high dissolved oxygen saturation values.



4/27/93	1	79	8/8/93	10	75	5/22/02	4	73
4/27/93	2	71	8/22/95	1	75	5/22/02	5	63
4/27/93	3	76	8/22/95	2	69	5/22/02	6	69
4/27/93	4	74	8/22/95	3	79	5/22/02	7	71
4/27/93	5	65	8/22/99	1	37	5/22/02	8	70
4/27/93	6	75	8/22/99	3	37	5/22/02	9	69
4/27/93	7	76	8/22/99	4	37	5/22/02	10	71
4/27/93	8	74	8/22/99	7	36	8/17/02	1	75
4/27/93	9	80	8/22/99	10	36	8/17/02	2	73
4/27/93	10	78	8/22/99	5	24	8/17/02	3	74
8/8/93	1	81	9/13/00	1	73	8/17/02	4	75
8/8/93	2	79	9/13/00	3	72	8/17/02	5	73
8/8/93	3	77	9/13/00	4	73	8/17/02	6	74
8/8/93	4	79	9/13/00	7	73	8/17/02	7	73
8/8/93	5	74	9/13/00	10	71	8/17/02	8	72
8/8/93	6	76	9/13/00	5	64	8/17/02	9	74
8/8/93	7	74	5/22/02	1	74	8/17/02	10	73
8/8/93	8	74	5/22/02	2	74			
8/8/93	9	74	5/22/02	3	74			

The calculation sheet permits calculation of the Lake Water Quality Index, using the results of all nine lake water quality tests.

The position of the red lines across the thermometer indicates how the results of each test compare in terms of lake water quality. Test results indicating excellent water quality are indicated by red lines near the top of the thermometer. Test results indicating poor water quality are indicated by red lines lower on the thermometer. And the lower the red line on the thermometer, the greater the

In 1993 the ten spring LWQIs averaged 75, while the ten summer LWQIs averaged 76. In 2002, the ten spring LWQIs averaged 71 and the ten summer LWQIs averaged 74.

THE LAKE WATER QUALITY INDEX CALCULATION SHEETS

Only two Lake Water Quality Index calculation sheets are included in this report, one for the ten spring 2002 samples, using averaged data, and a second for the ten summer 2002 samples. using averaged data.

In the report marked MASTER, all 20 of the 2002 LWQI calculation sheets are included. That is the only difference between the MASTER and the other reports.

LAKE BOTTOM SEDIMENTS

Many times bottom sediments tell us more about what is happening in a lake than the water quality tests do. That's because bottom sediments provide sort of a history of what's been happening in a lake, while water testing just provides a snapshot.

Bottom sediments are collected with a Pederson dredge, transferred to pint freezer containers and allowed to air dry. Once they are dry, the (usually) shrunken block of material is measured to determine volume, then ground, placed in porcelain dishes, dried at 100 degrees C, weighed, burned at 550 degrees C, and weighed again. Color after air-drying and after burning is also noted.

Bottom sediments almost always come up from the lake bottom black, and many people consider these black sediments “muck”. However that's not usually the case.

The bottom sediments are black because no oxygen penetrates them, so the decomposition processes which occur use sulfur rather than oxygen, and in this process, produce iron sulfides, which are black. However once the sediments are exposed to air, they usually turn some other color.

If the sediments remain black after air drying it usually means they are less than about 65 percent mineral (or more than 35% organic material). Sediments also remain black if they are from soft water lakes, but there's a reason for that.

If the sediments turn gray after air drying it usually means they are made up primarily of carbonates. This is what we usually see in moderately hard water and hard water lakes.

If the sediments turn tan, it usually means they are made up primarily of clays. Further evidence of this occurs when we burn the sediments at 550 degrees C.

If the gray bottom sediments remain gray after burning they are considered carbonates, and the loss of material during this process is considered organic material. The results are expressed in the percentage of minerals in the bottom sediments.

If the tan bottom sediments turn red after burning, it means the lake is filling with clay. Clay enters the lake from near-lake activities such as road building, home building or farming. Usually clay is not a material that makes up the bottom sediments of most Michigan inland lakes.

Highly organic sediments that remained black after air drying usually turn tan after burning, but the mineral content is usually quite low.

I consider high quality bottom sediments from natural lakes to be above 85 percent mineral. And I consider bottom sediments less than 50 percent mineral to be muck.

LAKE MANITOU BOTTOM SEDIMENTS

Ten bottom sediment samples were collected at the sample stations shown on the map in spring 1993 and again in spring 2002.

The graph below shows the data.

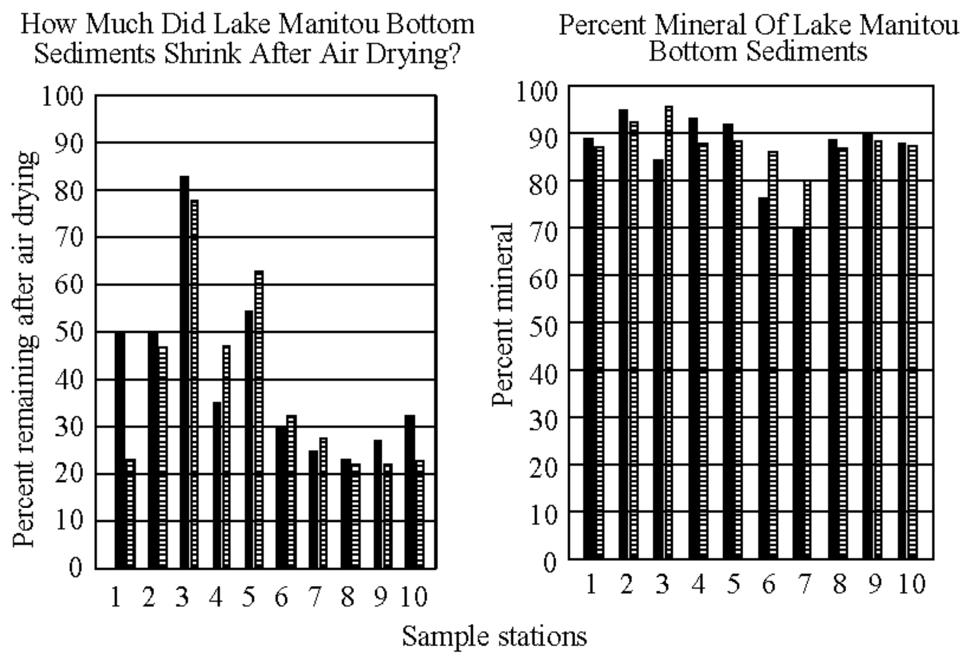
The graph shows the amount of shrinkage in Lake Manitou bottom sediments ranged from 17 to 78 percent in 1993, and from 22 to 77 percent in 2002. This amount of shrinkage is less than most bottom sediments, and indicates they are not light and fluffy, and easily mixed into the water column by boat or wind action.

The mineral content of the bottom sediments ranged from 70 to 94 percent and averaged 86 percent in 1993. In 2002, it ranged from 80 to 95 percent and averaged 88 percent. In other words, the data indicates the mineral content of Lake Manitou didn't change between 1993 and 2002.

This is a high mineral content for a Michigan inland lake and would normally be considered high quality.

However, in 1993 all samples turned red after burning at 550ºC, and in 2002 they either turned red or red gray after burning at 550ºC.

The red color after burning at 550ºC indicates either the lake bottom is made up primarily of clay or clay is being deposited on the lake bottom from the drains. Clay in lake bottom sediments usually comes from road building, home building or farming activities in the watershed.

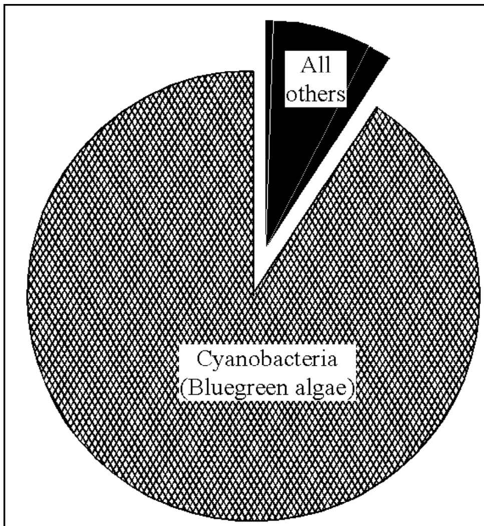


1994 Characteristics of Lake Manitou Bottom Sediments 2002

Sample I.D.	Percent Shrinkage		Percent Mineral		Dried at 100°C Color		Color after burning at 550°C		Depth of water (feet)	
	1994	2002	1994	2002	1994	2002	1994	2002	1994	2002
1	78	50	89	88	Tan	Gray	Red	Red gray	9	9
2	53	50	94	92	Tan	Gray	Red	Red	10	11
3	17	22	84	95	Tan	Gray	Red	Red gray	12	10
4	53	65	92	88	Tan	Gray	Red	Red	9	11
5	37	46	91	89	Tan	Gray	Red	Red	7	6
6	68	70	77	86	Tan	Gray	Red	Red	14	13
7	73	75	70	80	Gray black	Gray	Red	Red gray	9	8
8	78	77	89	87	Tan	Gray	Red	Red	18	17
9	78	73	90	88	Tan	Gray	Red	Red	18	18
10	78	68	88	88	Tan	Gray	Red	Red	19	19
			86%	88%	Average mineral content of bottom sediments					

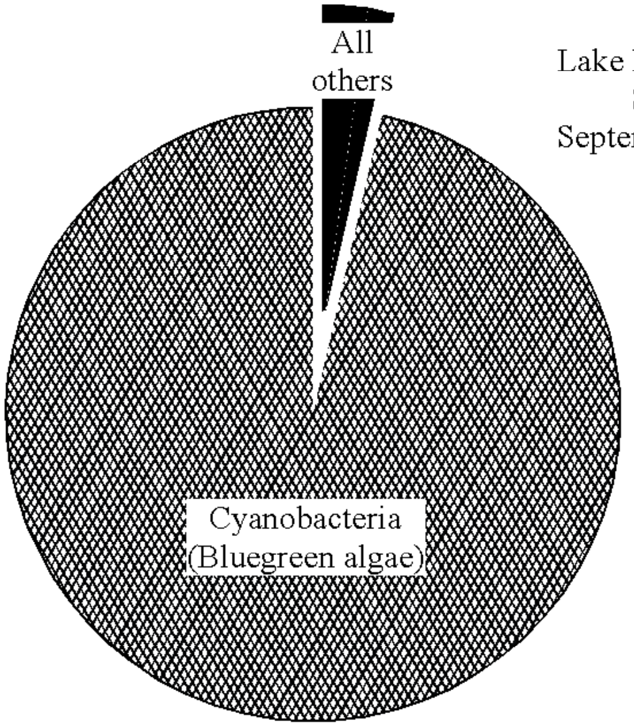
ALGAL ANALYSES

Three samples were collected in late summer 2000 for algal analysis. The results of those analyses are shown below.



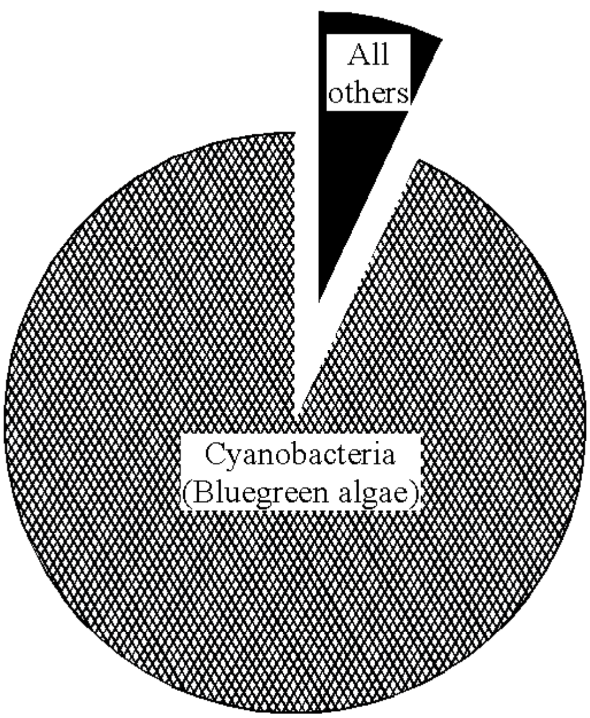
Lake Manitou algae
Station 6
September 13, 2000

Division	Number per liter	Percent
Pyrrophyta	13423	0.05
Chrysophyta	105787	0.4
Bacillariophyta	165364	0.6
Cryptophyta	357032	1.3
Chlorophyta	1850074	6.9
Cyanobacteria	24361697	90.7



Lake Manitou algae
Station 1
September 13, 2000

Division	Number per liter	Percent
Pyrrophyta	13223	0.0
Chlorophyta	206749	0.7
Chrysophyta	224798	0.7
Bacillariophyta	651802	2.1
Cyanobacteria	30270094	96.5



Lake Manitou algae
Station 5
September 13, 2000

Division	Percent	Number per liter
Euglenophyta	0.01	2856
Chrysophyta	0.3	85252
Bacillariophyta	3.1	899192
Chlorophyta	3.4	1000832
Cyanobacteria	93.2	27090433

The above graphs show the major division represented were the cyanobacteria, or blue-green algae. At Station 1 they made up 96.5 of the algal cells; at Station 5 they made up of 93.2 percent of the algal cells, and at Station 6 they made up 90.7 percent of the algal cells. In other words, the lake had a blue-green algal bloom at that time.

Wallace E. Fusilier, Ph.D.
Consulting Limnologist
Water Quality Investigators
Dexter, Michigan

Lake Manitou Water Quality Data (1993-2002)

Date	Sample Station Number	Temperature °C	Dissolved Oxygen (mg/L)	Dissolved Oxygen Percent Saturation	Chlorophyll a ug/L	Secchi Disk Depth (feet)	Total Nitrate Nitrogen ug/L	Alkalinity mg/L	pH	Conductivity umhos per cm at 25°C	Total Phosphorus ug/L	Lake Water Quality Index	Grade
4/27/93	1	11	10.3	93	11.3	5	244	174	8.3	420	19	79	C
4/27/93	2	11	10.3	93	27.1	5	288	177	8.2	420	42	71	C
4/27/93	3	11	10.3	93	19.0	5	325	177	8.1	420	19	76	C
4/27/93	4	11	9.9	89	22.4	5	460	174	8.1	420	17	74	C
4/27/93	5	11	10.6	95	4.1	4	1080	216	8.0	500	32	65	D
4/27/93	6	11	9.5	86	15.0	6	510	179	8.0	440	19	75	C
4/27/93	7	11	10.2	92	11.9	5	400	176	8.1	420	25	76	C
4/27/93	8	11	9.5	86	9.2	6	460	177	8.0	440	48	74	C
4/27/93	9	11	9.6	86	6.4	6	490	178	8.0	440	17	80	B
4/27/93	10	11	9.4	85	5.8	6	447	180	8.0	420	33	78	C
4/27/93	10-5	11	9.3	---	---	---	425	181	8.0	420	17	---	---
4/27/93	10-10	11	9.3	---	---	---	425	182	8.0	420	14	---	---
4/27/93	10-15	11	8.7	---	---	---	490	182	8.0	420	16	---	---
4/27/93	10-19	10	8.5	---	---	---	460	178	8.0	420	27	---	---
8/8/93	1	23	9.7	111	8.4	5	6	158	8.4	420	33	81	C
8/8/93	2	23	9.6	110	14.2	5	5	160	8.4	420	21	79	C
8/8/93	3	23	10.1	116	13.8	5	4	161	8.5	420	22	77	C
8/8/93	4	23	9.3	107	10.5	5	1	164	8.4	430	21	79	C
8/8/93	5	23	10.2	117	18.5	5	4	171	8.6	440	32	74	C
8/8/93	6	23	8.7	100	21.1	5	6	168	8.5	440	27	76	C
8/8/93	7	23	10.4	120	19.7	5	2	158	8.6	420	31	74	C
8/8/93	8	23	10.2	117	20.3	5	4	165	8.5	430	35	74	C
8/8/93	9	23	9.7	111	21.1	5	5	167	8.5	440	39	74	C
8/8/93	10	23	9.4	108	22.3	5	6	169	8.5	425	31	75	C
8/8/93	10-5	23	8.6		---	---	7	169	8.5	425	46	---	---
8/8/93	10-10	22	6.6		---	---	4	170	8.5	420	35	---	---
8/8/93	10-15	21	3.3	---	---	---	5	170	8.4	420	35	---	---
8/8/93	10-19	21	0.0	0	---	---	10	173	8.1	430	43	---	---
8/22/95	2	26	8.0	98	6.6	7	6	129	8.6	350	30	79	C
8/22/95	5	25	10.2	121	21.0	5	10	126	8.8	380	48	69	D
8/22/95	10	27	8.2	103	13.2	6	10	127	8.6	360	38	75	C
5/15/99	1	---	---	---	10.1	---	54	128	7.8	380	86	---	---
5/15/99	3	---	---	---	11.9	---	13	120	7.6	360	50	---	---
5/15/99	4	---	---	---	9.5	---	11	124	7.7	360	54	---	---
5/15/99	5	---	---	---	20.0	---	24	142	7.7	400	68	---	---
5/15/99	7	---	---	---	7.9	---	10	125	7.7	360	27	---	---
5/15/99	10	---	---	---	3.5	---	8	124	7.6	360	30	---	---
8/22/99	1	26	14.9	183	77.5	2	14	129	9.1	370	52	37	E
8/22/99	3	26	14.7	179	79.5	2	14	128	9.1	370	58	37	E
8/22/99	4	26	14.7	179	70.5	2	18	126	9.1	375	52	37	E
8/22/99	5	28	16.3	206	61.5	2	16	129	9.2	370	58	24	E
8/22/99	7	26	14.7	179	80.5	2	16	125	9.2	370	57	36	E
8/22/99	10	26	15.4	188	74.0	2	16	129	9.2	370	51	36	E
9/13/00	1	21	7.2	80	15.8	5	13	148	8.8	450	26	73	C
9/13/00	3	21	7.2	80	21.3	5	18	147	8.7	450	28	72	C
9/13/00	4	21	7.7	86	18.8	5	16	148	8.8	450	27	73	C
9/13/00	5	21	7.7	86	33.5	3	10	152	8.7	460	32	64	D
9/13/00	7	21	7.0	78	13.9	4	16	147	8.7	450	24	73	C
9/13/00	10	21	6.1	68	17.8	5	10	147	8.8	450	30	71	C

RESULTS OF ALGAL ANALYSIS OF SEPTEMBER 13, 2000 SAMPLES

Station 1	Division	No./L	%
Asterionella formossa	Bacillariophyta	158681	0.5
Cyclotella sp.	Bacillariophyta	52894	0.2
Cymbella sp.	Bacillariophyta	8568	0.0
Denticula sp.	Bacillariophyta	5712	0.0
Fragilaria capucinia	Bacillariophyta	51408	0.2
Melosiria granulata	Bacillariophyta	800	0.0
Melosira islandica	Bacillariophyta	79968	0.3
Navicula sp	Bacillariophyta	277692	0.9
Synedra delicatissima	Bacillariophyta	2856	0.0
Synedra ulna	Bacillariophyta	13223	0.0
Chlamydomonas sp.	Chlorophyta	66117	0.2
Gonium pectorate	Chlorophyta	51408	0.2
Pediastrum simplex	Chlorophyta	6400	0.0
Pleodorina illioisensis	Chlorophyta	74256	0.2
Staurastrum sp.	Chlorophyta	8568	0.0
Dinobryon sociale	Chrysophyta	224798	0.7
Anabaena plactonica	Cyanobacteria	157080	0.5
Anabaena sp.	Cyanobacteria	24132729	76.9
Aphanizomenon flos-aquae	Cyanobacteria	1250926	4.0
Gomphospheria lacustris	Cyanobacteria	8600	0.0
Oscillatoria limosa	Cyanobacteria	1877725	6.0
Oscillatoria sp.	Cyanobacteria	2843034	9.1
Ceratium hurundinella	Pyrrophyta	13223	0.04
Total number per liter		31366666	100.0

Station 5	Division	No./L.	%
Asterionella formossa	Bacillariophyta	1600	0.0
Cyclotella sp.	Bacillariophyta	198351	0.7
Fragilaria crorонensis	Bacillariophyta	423149	1.5
Gomphonema sp.	Bacillariophyta	200	0.0
Melosira granulata	Bacillariophyta	211575	0.7
Navicula sp.	Bacillariophyta	2856	0.0
Nedium sp.	Bacillariophyta	2856	0.0
Pinnularia sp.	Bacillariophyta	5712	0.0
Synedra delicatissima	Bacillariophyta	13223	0.0
Synedra ulna	Bacillariophyta	39670	0.1
Chlamydomonas sp.	Chlorophyta	26447	0.1
Cosmarium sp.	Chlorophyta	2856	0.0
Pleodorina illionisensis	Chlorophyta	581830	2.0
Quadrigulia lacustris	Chlorophyta	11424	0.0
Secenedesmus bijuga	Chlorophyta	105787	0.4
Sphaerocystus schroeteri	Chlorophyta	179928	0.6
Staurastrum sp.	Chlorophyta	92564	0.3
Dinobryon sociale	Chrysophyta	79340	0.3
Mallomonas pseudocoronota	Chrysophyta	200	0.0
Mallomonas sp.	Chrysophyta	5712	0.0
Anabaena plactonica	Cyanobacteria	9600	0.0
Anabaena circinalis	Cyanobacteria	6600	0.0
Anabaena sp.	Cyanobacteria	20892993	71.9
Aphanizomenon flos-aquae	Cyanobacteria	5157131	17.7
Gomphospheria lacustris	Cyanobacteria	114240	0.4
Microcystis aeruginosa	Cyanobacteria	63201	0.2
Oscillatoria limosa	Cyanobacteria	25000	0.1
Oscillatoria nigra	Cyanobacteria	22000	0.1
Oscillatoria sp.	Cyanobacteria	799678	2.8
Trachelomonas sp.	Euglenophyta	2856	0.0
Total number per liter		29078579	100.0

Station 6	Division	No./L.	%
Acnanthes sp.	Bacillariophyta	39984	0.1
Fragilaria crorонensis	Bacillariophyta	19992	0.1
Melosira islandica	Bacillariophyta	62832	0.2
Navicula sp.	Bacillariophyta	26477	0.1
Nedium sp.	Bacillariophyta	2856	0.0
Pinnularia sp.	Bacillariophyta	13223	0.0
Chlamydomonas sp.	Chlorophyta	1401682	5.2
Gonium pedtorale	Chlorophyta	194208	0.7
Pediastrum simples	Chlorophyta	91392	0.3
Sphaerocystus schroeteri	Chlorophyta	157080	0.6
Staurastrum sp.	Chlorophyta	5712	0.0
Dinobryon sociale	Chrysophyta	105787	0.4
Cryptomonas ovata	Cryptophyta	357032	1.3
Anabaena circinalis	Cyanobacteria	343809	1.3
Anabaena plactonica	Cyanobacteria	396702	1.5
Anabaena sp.	Cyanobacteria	18777247	69.9
Aphanizomenon flos-aquae	Cyanobacteria	3107502	11.6
Gomphospheria lacustris	Cyanobacteria	242760	0.9
Microcystis aeruginosa	Cyanobacteria	699719	2.6
Oscillatoria nigra	Cyanobacteria	422679	1.6
Oscillatoria sp.	Cyanobacteria	371279	1.4
Trachelomonas sp.	Euglenophyta	13223	0.0
Ceratium hurundinella	Pyrrophyta	200	0.0
Peridinium sp.	Pyrrophyta	13223	0.0
Total number per liter		26866600	100.0