UPPER LONG LAKE

WEST BLOOMFIELD AND

BLOOMFIELD TOWNSHIPS

OAKLAND COUNTY, MICHIGAN

1999-2010 WATER QUALITY STUDIES

UPPER LONG LAKE DATA

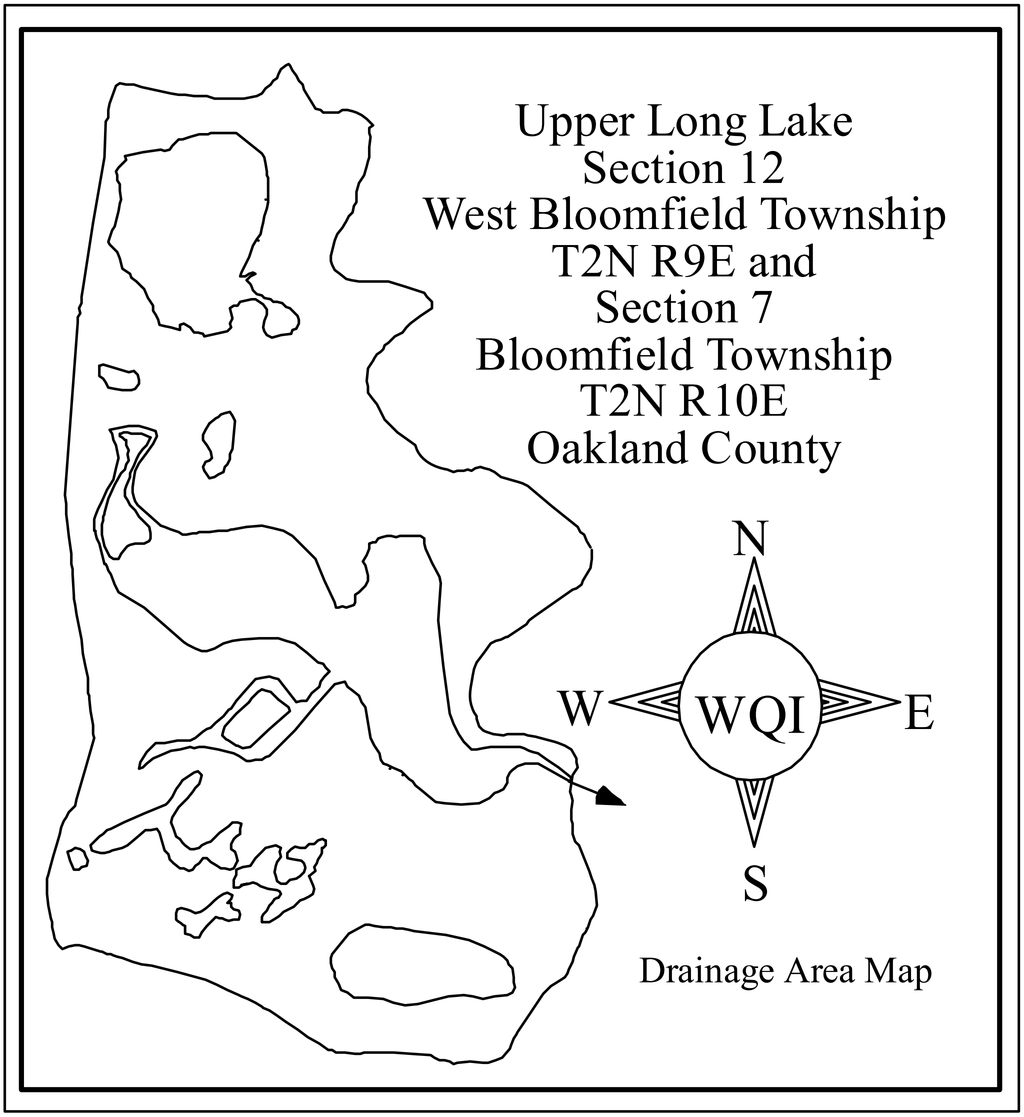
Upper Long Lake is a 128-acre natural moderately hard water to hard water kettle lake located in Section 7, Bloomfield Township (T2N R10E) and Section 12, West Bloomfield Township (T2N R9E), Oakland County, Michigan. The lake has a maximum depth of 22 feet, a water volume of 1174 acre-feet, and a mean depth of 9.7 feet. The lake has a seven-acre island; hence the surface area is 121 acres. The lake has 17059 feet of shoreline not including the shoreline of the island.

The size of the watershed, which is the land area that contributes water to the lake, but does not include the lake, is 779 acres. The drainage area, which includes the lake and the watershed, is 907 acres. (See map below) The watershed to lake ratio is 6.1 to 1. The lake flushes once every 1.65 years on an average.

The elevation of the lake is 911 feet above sea level. There is an inlet on the south side which drains a series of canals. Water also enters the lake from the north through wetland areas.

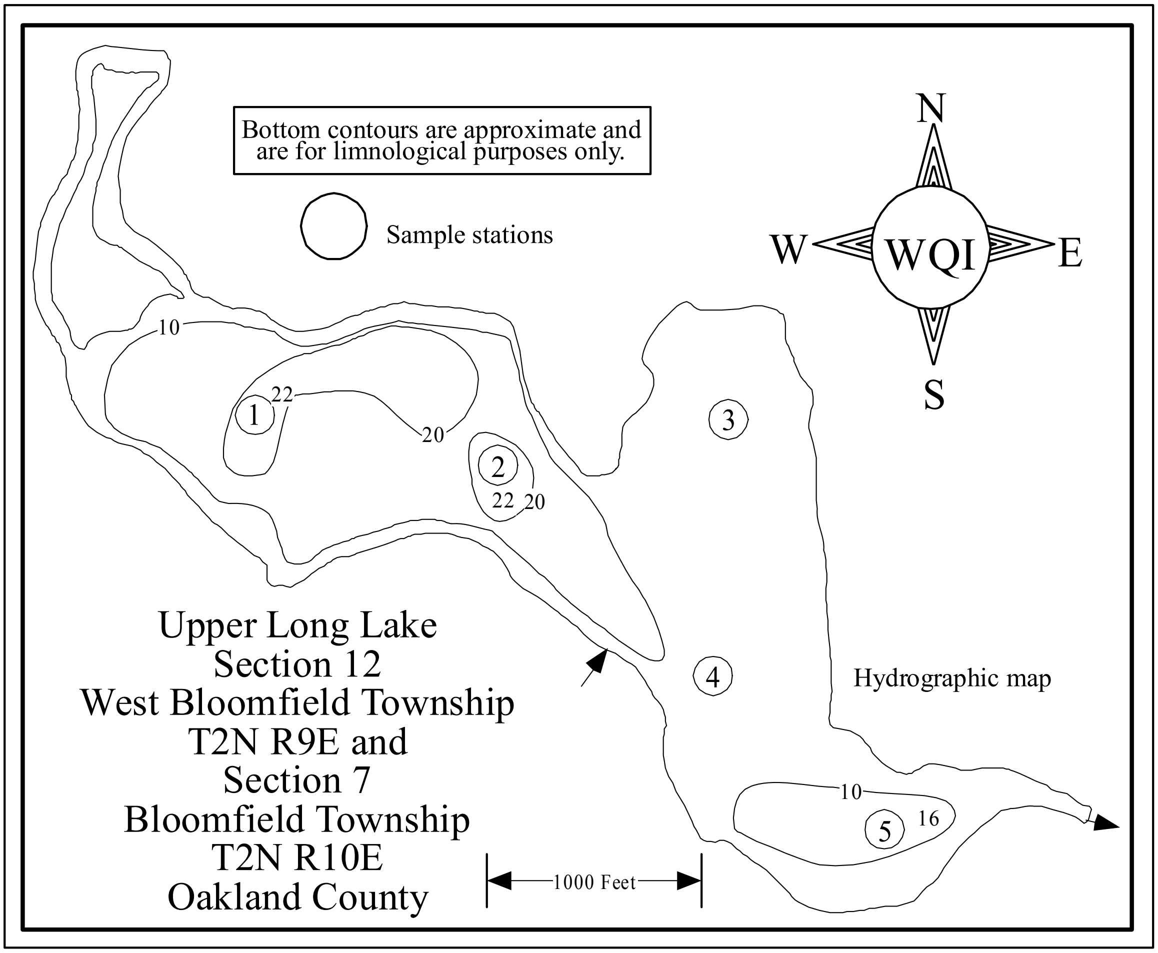
The outlet is on the east end. Water from Upper Long Lake drains into Lower Long Lake, then into Forest Lake. The outlet from Forest Lake is located near the intersection of Club Drive and Lockridge. It consists of a 44-foot-long, 48-inch diameter concrete pipe that passes under Club Drive and discharges into Lake in the Woods. Water from the Forest Lake outlet joins the Rouge River at Birmingham. The Rouge River discharges into the Detroit River at River Rouge.

The longitude and latitude of the 22-foot deep hole is 83° 19.375W and 42° 35.778N.



THE SAMPLE STATIONS

The locations of the in-lake sample stations are shown as circles on the hydrographic map of the lake.



THE SAMPLE DATES

Ron Cousineau and/or Eric Gleisner took spring surface samples for water quality testing at Stations 1, 3 and 5 shown on the map April 25, 1999 and April 20, 2007. Cousineau collected five samples at the stations shown on the map April 13, 2008 and three samples on March 17, 2009 and April 15, 2010.

WQI limnologists collected three surface samples for water quality testing plus top to bottom dissolved oxygen and temperature profiles September 2, 1999, August 11, 2009 and August 10, 2010. They collected five surface samples, plus top to bottom samples for water quality testing and top to bottom temperature and dissolved oxygen profiles May 26 and September 8, 2000, and May 28 and August 20, 2003. They took five surface samples for water quality testing August 23, 2007 and August 13, 2008. Top to bottom temperature and dissolved oxygen were measured in the deep hole each time the lake was sampled in late summer.

Three bottom sediment samples were collected in 1999 and five were collected in 2003. Gleisner and/or Cousineau collected Secchi disk data in summer 1999 and 2003. Cousineau and Steve George collected Secchi disk data through the warm months in 2007. Cousineau collected Secchi disk data through the warm months in 2008 and 2009. Stephen George collected Secchi disk data in 2010. Cousineau collected 10 additional samples of the inlets September 22, 2003. Since the locations of the sample sites are unknown, they are listed by name.

The lake was mapped for limnological purposes in late summer 1999. Cousineau also collected samples of Eurasian water milfoil and Chara for phosphorus analyses in summer 2008.

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 WATER QUALITY STUDY

During certain times of the year, Michigan inland lakes have poorer water quality than other times. This study samples the lake during those two times. The first is in early spring after the ice melts and the lake mixes. The purpose of this sample period is to detect phosphorus released from the bottom sediments during the anoxia (no dissolved oxygen) which may occur under ice cover.

The second is in late summer when the lake is warmest and is maximally stratified. The purpose of this sample period is to see if the lake forms a thermocline, and if it does, does the lake run out of dissolved oxygen in the bottom water. If a lake has good water quality during these two sample periods, it probably has good water quality the rest of the time.

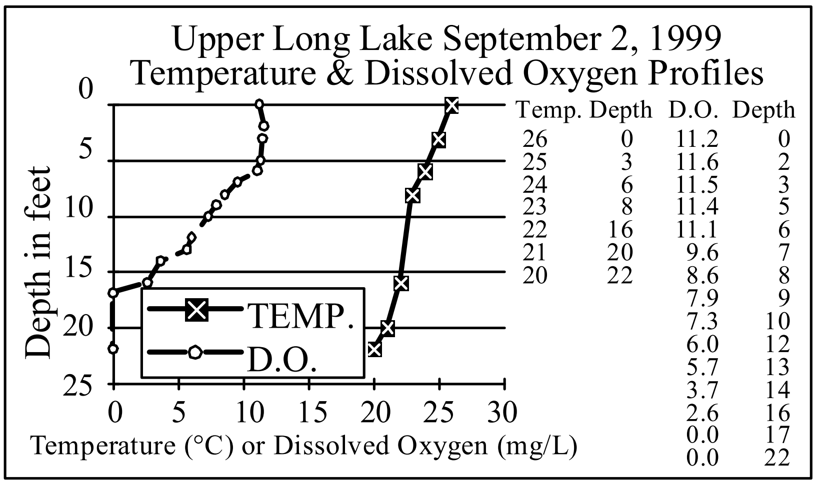
THE TEST RESULTS

The results of the tests are shown in the text below, in the table 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 gases, and biological activity.

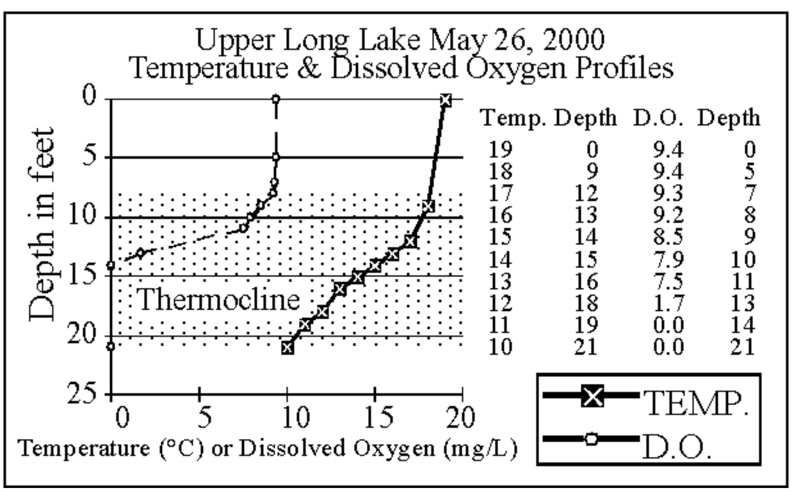
Dissolved oxygen is the parameter most often selected by lake water quality scientists as being important. Besides providing oxygen for aquatic organisms, in natural lakes, oxygen is involved in phenomena such as phosphorus precipitation and release from the lake bottom sediments and decomposition of organic material in the lake.



Temp.	Depth	D.O.	Depth
26	0	11.2	0
25	3	11.6	2
24	6	11.5	3
23	8	11.4	5
22	16	11.1	6
21	20	9.6	7
20	22	8.6	8
		7.9	9
		7.3	10
		6.0	12
		5.7	13
		3.7	14
		2.6	16
		0.0	17
		0.0	22

1999

In late summer 1999, Upper Long Lake did not form a thermocline (where the temperature changes more than one degree C per meter of depth and shown shaded on the graphs) at any depth. Dissolved oxygen was plentiful above six feet. It started to drop below 6 feet, and was zero at 17 feet.



Temp.	Depth	D.O.	Depth
19	0	9.4	0
18	9	9.4	5
17	12	9.3	7
16	13	9.2	8
15	14	8.5	9
14	15	7.9	10
13	16	7.5	11
12	18	1.7	13
11	19	0.0	14
10	21	0.0	21

The hypsographic (depth-area) graph shows about 20 percent of the lake is deeper than 17 feet.

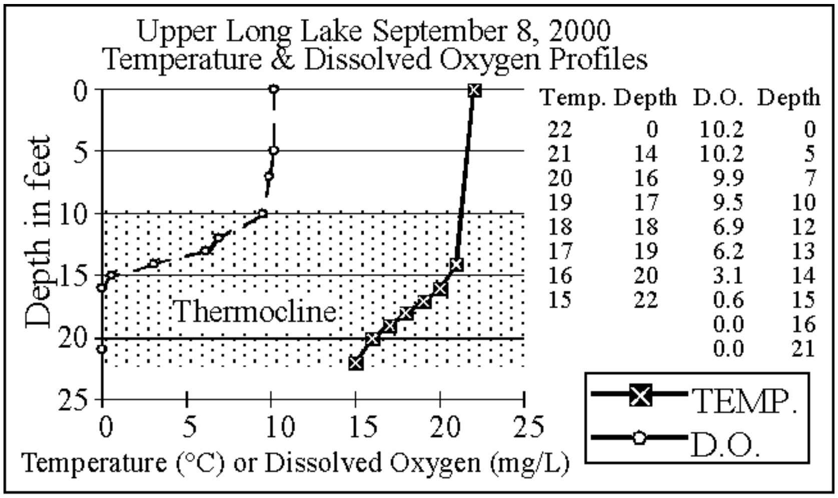
2000

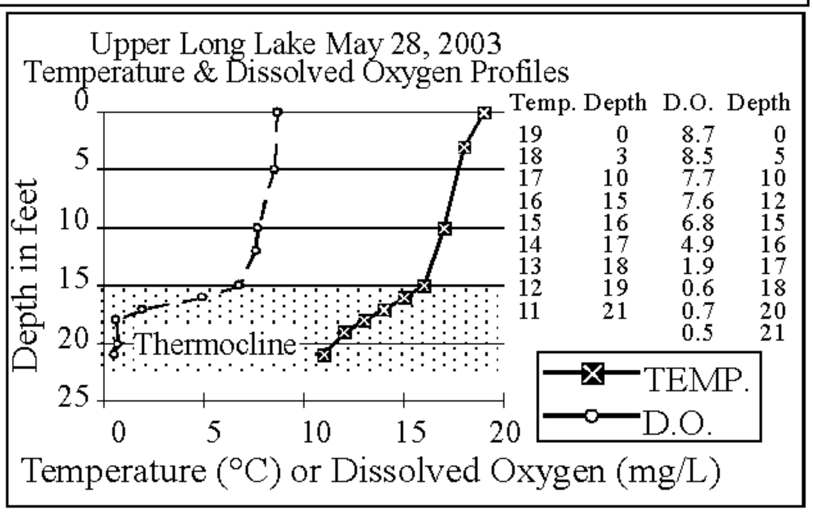
By May 26, 2000, the lake had already formed a 14-foot thick thermocline from 8 to 22 feet. Dissolved oxygen was plentiful above the thermocline and started to decrease at the top of the thermocline. It ran out of dissolved oxygen at 14 feet, and that condition remained to the bottom.

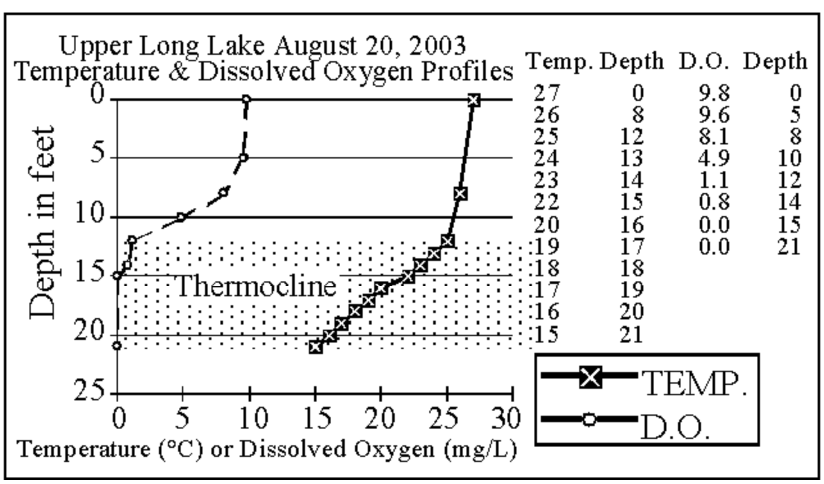
About 30 percent of the lake is deeper than 14 feet.

In late summer 2000, Upper Long Lake formed a 12-foot-thick thermocline from 10 to 22 feet. Dissolved oxygen was plentiful above the thermocline.

The lake started to run out of dissolved oxygen at the top of the thermocline. It was zero at 16 feet. About 20 percent of the lake is deeper than 16 feet.





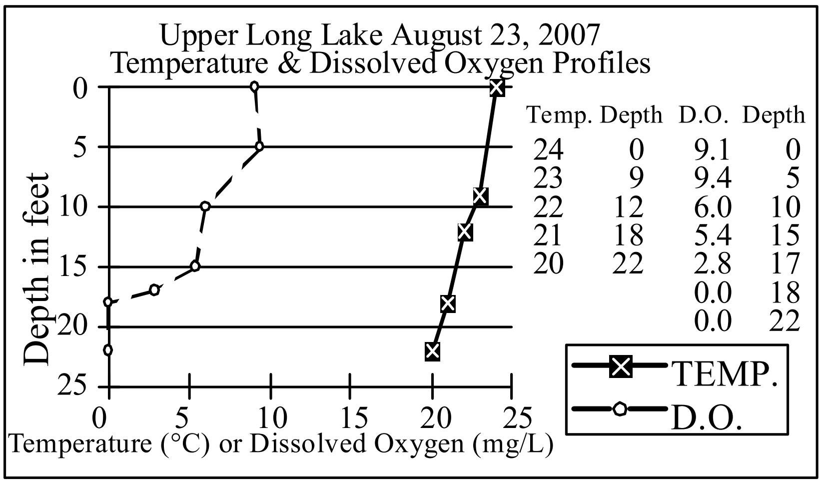


2003

In spring 2003, Upper Long Lake formed a 7-foot-thick thermocline from 15 to 22 feet. Dissolved oxygen was plentiful above the thermocline. It again started to drop at the top of the thermocline and reached less than 1 mg/L at the bottom. However the lake did not run out of dissolved oxygen at any depth in spring.

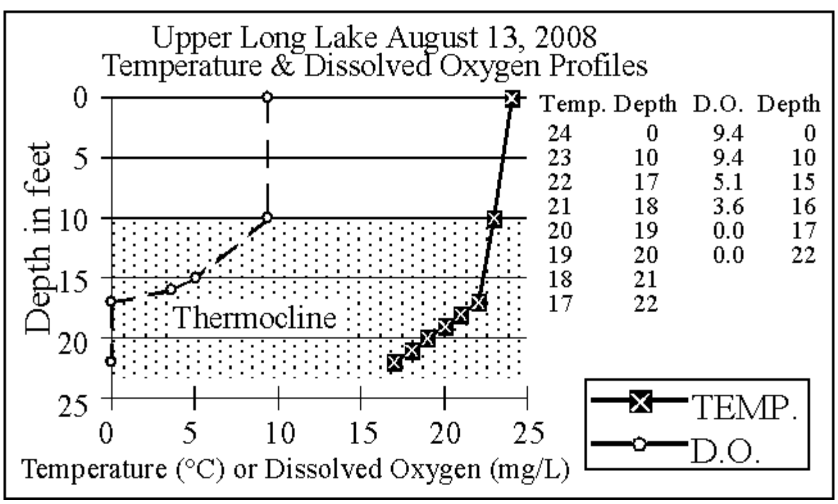
In late summer 2003, Upper Long Lake formed a 9-foot-thick thermocline from 12 to 21 feet. Dissolved oxygen was plentiful above five feet. Below that depth, dissolved oxygen started to decrease, and reached zero at 15 feet. That condition remained to the bottom.

2007



In late summer 2007 the lake did not form a thermocline. Temperature was 24 degrees C at the surface and 20 degrees C at the bottom.

Dissolved oxygen was above 4 mg/L above 17 feet. It was zero at 18 feet and that condition remained to the bottom.

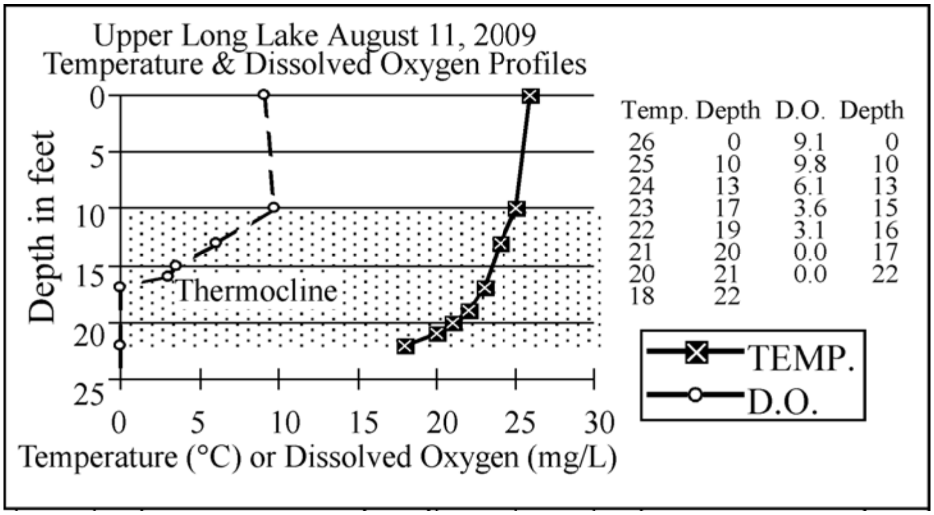


2008

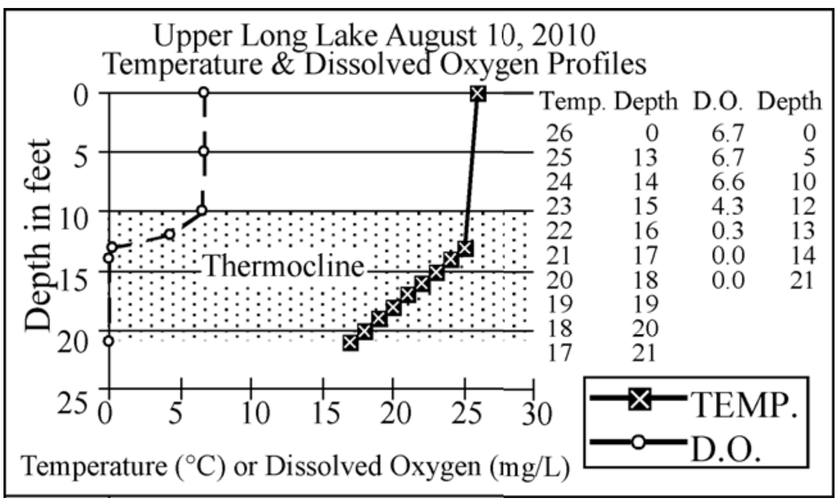
In late summer 2008 the lake formed a 12-foot thick thermocline from 10 to 22 feet.

Dissolved oxygen concentrations were adequate above the thermocline and started to decrease below 10 feet, the top of the thermocline. It was zero at 17 feet and that condition remained to the bottom.

2009



In late summer 2009 the lake formed a 12-foot-thick thermocline from 10 feet to the bottom. Dissolved oxygen was uniform and plentiful above 10 feet and started to decrease below that depth. It was zero a 17 feet and that condition remained to the bottom.



2010

In late summer 2010 the lake formed an 11-foot thick thermocline from 10 to 21 feet. The dissolved oxygen concentration was low but adequate above 10 feet and started to decrease below that depth. It was zero at 14 feet and that condition remained to the bottom.

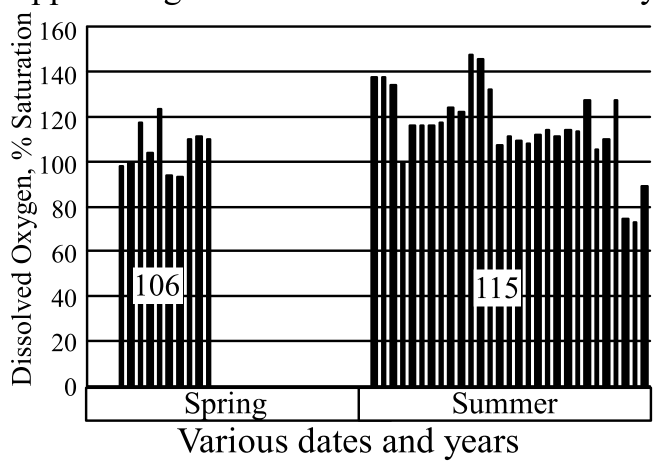
A NOTE ABOUT THE GRAPHS WHICH FOLLOW

The data on the graphs below were first sorted by spring and summer, then by date and sample station. The purpose for this was to see if differences and/or trends occurred in the spring and summer data. The average for each data set are also shown on the graphs.

DISSOLVED OXYGEN SATURATION

Since dissolved oxygen concentrations in water vary as the temperature changes, with cold water holding more dissolved oxygen than warm water, dissolved oxygen saturation is often a better way to determine if dissolved oxygen supplies are adequate in the surface water.

Upper Long Lake 1999-2010 Dissolved Oxygen Saturation



Spring		4/13/08	---	8/20/03	145
4/25/99	---	4/13/08	---	8/20/03	132
4/25/99	---	3/17/09	---	8/23/07	107
4/25/99	---	3/17/09	---	8/23/07	111
5/26/00	98	3/17/09	---	8/23/07	109
5/26/00	100	4/15/10	---	8/23/07	108
5/26/00	117	4/15/10	---	8/23/07	112
5/26/00	104	4/15/10	---	8/13/08	114
5/26/00	123	Summer		8/13/08	111
5/28/03	94	9/2/99	137	8/13/08	114
5/28/03	93	9/2/99	137	8/13/08	113
5/28/03	110	9/2/99	134	8/13/08	127
5/28/03	111	9/8/00	100	8/11/09	105
5/28/03	110	9/8/00	116	8/11/09	110
4/20/07	---	9/8/00	116	8/11/09	127
4/20/07	---	9/8/00	116	8/10/10	74
4/20/07	---	9/8/00	117	8/10/10	73
4/13/08	---	8/20/03	124	8/10/10	89
4/13/08	---	8/20/03	122		
4/13/08	---	8/20/03	147		

The graph shows when the lake was sampled in spring 2000 and 2003, dissolved oxygen saturation ranged from 93 to 123 percent. When the lake was sampled in late summer 1999, 2000 and 2003, dissolved oxygen saturation ranged from 100 to 147 percent. Late summer 2007 saturations were among the best, ranging from 107 to 112 percent. Late summer 2008 and 2009 dissolved oxygen saturation values ranged from 105 to 127 percent. 2010 saturations were low, 73 to 89 percent.

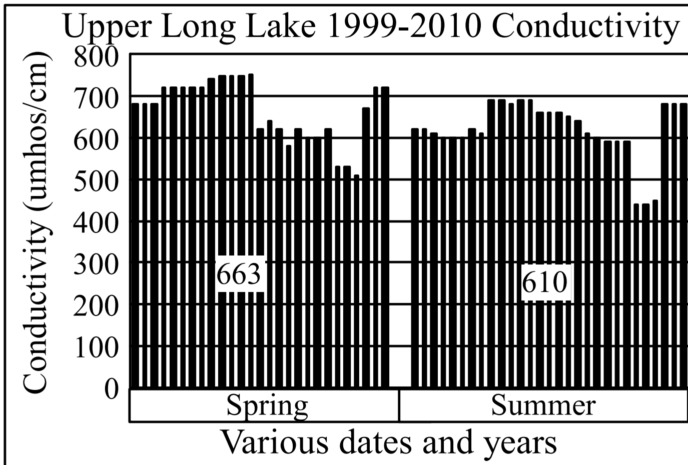
Supersaturated surface dissolved oxygen conditions (above 110 percent) generally indicate plants and/or algae in the water are plentiful.

Best is between 90 and 110 percent.

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 (salts), 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.



Spring		4/13/08	600	8/20/03	690
4/25/99	680	4/13/08	620	8/20/03	690
4/25/99	680	3/17/09	530	8/23/07	660
4/25/99	680	3/17/09	530	8/23/07	660
5/26/00	720	3/17/09	510	8/23/07	660
5/26/00	720	4/15/10	670	8/23/07	650
5/26/00	720	4/15/10	720	8/23/07	640
5/26/00	720	4/15/10	720	8/13/08	610
5/26/00	720	Summer		8/13/08	600
5/28/03	740	9/2/99	620	8/13/08	590
5/28/03	745	9/2/99	620	8/13/08	590
5/28/03	745	9/2/99	610	8/13/08	590
5/28/03	745	9/8/00	600	8/11/09	440
5/28/03	750	9/8/00	600	8/11/09	440
4/20/07	620	9/8/00	600	8/11/09	450
4/20/07	640	9/8/00	620	8/10/10	680
4/20/07	620	9/8/00	610	8/10/10	680
4/13/08	580	8/20/03	690	8/10/10	680
4/13/08	620	8/20/03	690		
4/13/08	600	8/20/03	680		

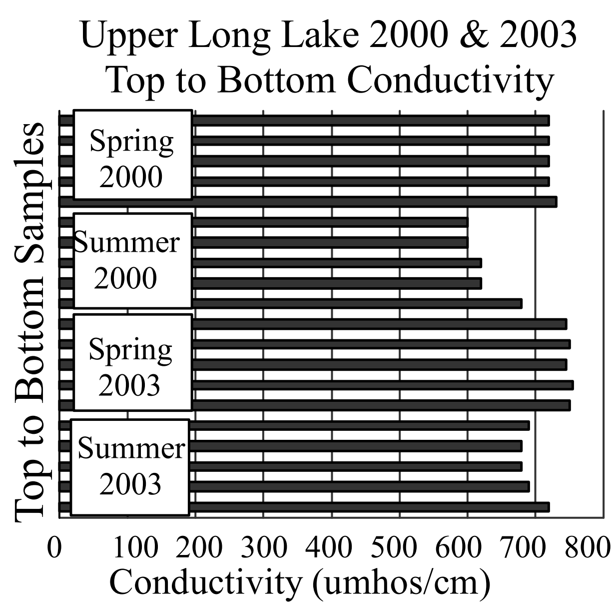
The graph shows the conductivity of Upper Long Lake in spring ranges from a low of 510 micromhos per centimeter to a high of 750 micromhos per centimeter and averages 663 umhos/cm. The graph shows summer conductivities range from 440 to 690 umhos/cm and average 610 umhos/cm. These are high conductivities for a Michigan moderately hard water inland lake. Normal conductivities for Michigan inland lakes are generally below 450 umhos/cm. The data shows salts appear to be entering the lake from road salting activities or water softeners, or both.

The graph shows until 2010, conductivities were decreasing in both spring and summer. However in 2010 both spring and summer conductivities increased significantly. These data indicate salts from some source are entering the lake.

TOP TO BOTTOM CONDUCTIVITIES

The graph of 2000 and 2003 top to bottom conductivity shows conductivities were generally higher and uniform top to bottom in spring, indicating the lake mixed at that time.

Summer conductivities were lower, but increased near the bottom, indicating the lake was stratified in summer.

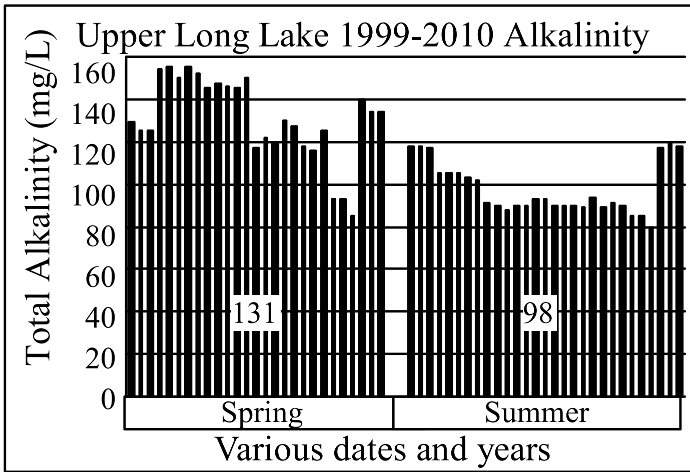


5/26/00	720
5/26/00	720
5/26/00	720
5/26/00	720
5/26/00	730
5/26/00	600
9/8/00	600
9/8/00	620
9/8/00	620
9/8/00	680
5/26/00	745
5/28/03	750
5/28/03	745
5/28/03	755
5/28/03	750
9/8/00	690
8/20/03	680
8/20/03	680
8/20/03	690
8/20/03	720

TOTAL ALKALINITY

Alkalinity is a measure of the ability of the water to absorb acids (or bases) without changing the hydrogen ion concentration (pH). It is, in effect, a chemical sponge. In most Michigan lakes, alkalinity is due to the presence of carbonates and bicarbonates which were introduced into the lake from ground water or streams which flow into the lake. In lower Michigan, acidification of most lakes should not be a problem because of the high alkalinity concentrations.

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.



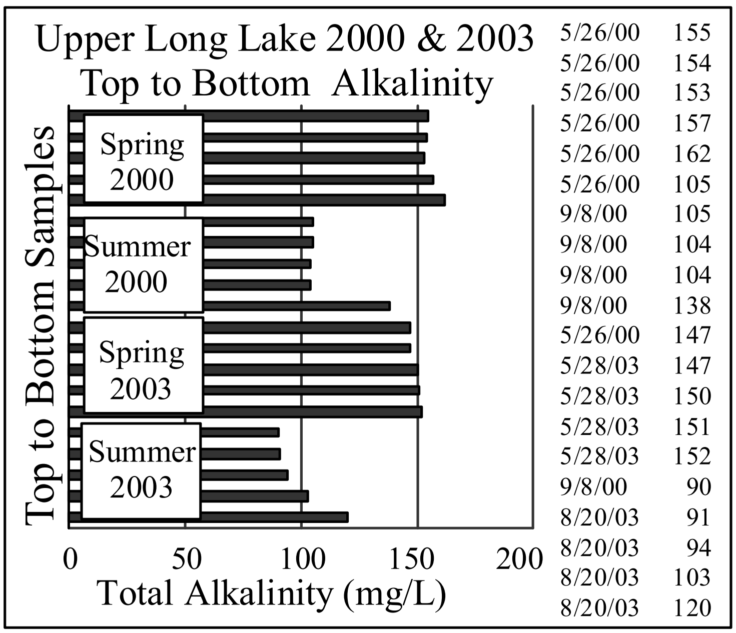
Spring		4/13/08	116	8/20/03	90
4/25/99	129	4/13/08	125	8/20/03	90
4/25/99	125	3/17/09	93	8/23/07	93
4/25/99	125	3/17/09	93	8/23/07	93
5/26/00	154	3/17/09	85	8/23/07	90
5/26/00	155	4/15/10	140	8/23/07	90
5/26/00	150	4/15/10	134	8/23/07	90
5/26/00	155	4/15/10	134	8/13/08	89
5/26/00	152	Summer		8/13/08	94
5/28/03	145	9/2/99	118	8/13/08	89
5/28/03	147	9/2/99	118	8/13/08	91
5/28/03	146	9/2/99	117	8/13/08	90
5/28/03	145	9/8/00	105	8/11/09	85
5/28/03	150	9/8/00	105	8/11/09	85
4/20/07	117	9/8/00	105	8/11/09	80
4/20/07	122	9/8/00	103	8/10/10	117
4/20/07	120	9/8/00	102	8/10/10	120
4/13/08	130	8/20/03	91	8/10/10	118
4/13/08	127	8/20/03	90		
4/13/08	118	8/20/03	88		

The graph shows the alkalinity of Upper Long Lake in spring ranged from 85 to 155 milligrams per liter and averaged 131 mg/L. In summer it ranged from 80 to 120 mg/L and averaged 98 mg/L. This indicates Upper Long

Lake 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.

The graph shows spring alkalinites are higher than summer alkalinities, which is what we expect. It also shows until 2010 the alkalinity of the lake was decreasing in both spring and summer. However in 2010 both spring and summer alkalinities increased significantly, just like conductivities. The cause of this is unknown.

TOP TO BOTTOM ALKALINITIES



The graph of spring and summer 2000 and 2003 top to bottom alkalinites shows spring alkalinities are fairly uniform top to bottom, again showing the lake mixed in spring.

In summer 2000 and 2003 they were lower than the spring alkalinities, and increased near the bottom. This is normal and expected.

Because Upper Long Lake has a maximum depth of 22 feet, in some years the lake mixes all summer long (as shown by the 2000 late summer top to 15 foot alkalinites) while in other years, it stratifies (as shown by the 2003 late summer top to bottom alkalinities).

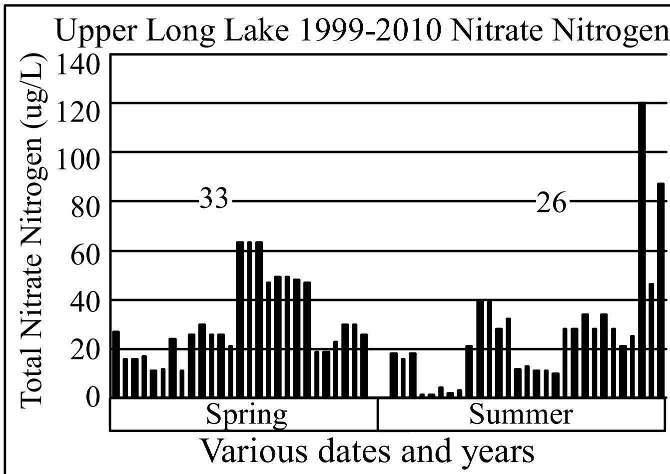
NITRATE NITROGEN

Nitrate, measured in the parts per billion range, has traditionally been considered by lake scientists to be a limiting nutrient. The experts felt any concentration below 200 parts per billion was excellent in terms of lake water quality. The highest value found by this author was 48,000 parts per billion in a river which flowed into an Ottawa County lake.

On the other hand, we've studied hundreds of Michigan inland lakes, and many times we find them nitrate limited (very low nitrate nitrogen concentrations), especially in summer.

We're finding many lakes have lower nitrate nitrogen concentrations in summer than in spring. This is probably due to two factors. First, plants and algae growing in lakes as water warms can remove nitrates from the water column. And second, bacterial denitrification (where nitrates are converted to nitrogen gas by bacteria) also occurs at a much faster rate in summer when the water is warmer.

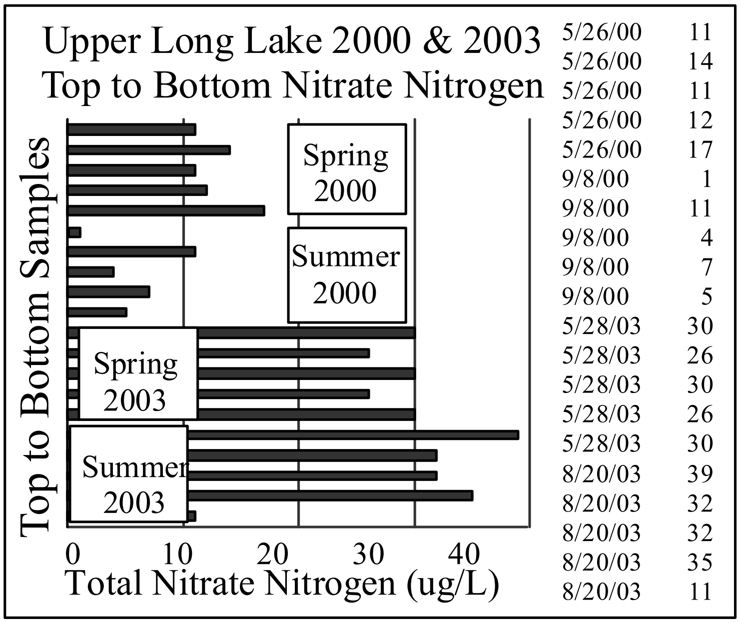
Generally limnologists feel optimal nitrate nitrogen concentrations (which encourage maximum plant and algal growth) are about 10-20 times higher than phosphorus concentrations. The reason more nitrogen than phosphorus is needed is because nitrogen is one of the chemicals used in the production of plant proteins, while phosphorus is used in the transfer of energy, but is not used to create plant material. If the nitrate concentration is less than 10-20 times the phosphorus concentration, the lake is considered nitrogen limited. If the nitrate concentration is higher than 10-20 times the phosphorus concentration, the lake is considered phosphorus limited.



Spring		4/13/08	48	8/20/03	28
4/25/99	27	4/13/08	47	8/20/03	32
4/25/99	16	3/17/09	19	8/23/07	12
4/25/99	16	3/17/09	19	8/23/07	13
5/26/00	17	3/17/09	23	8/23/07	11
5/26/00	11	4/15/10	30	8/23/07	11
5/26/00	12	4/15/10	30	8/23/07	10
5/26/00	24	4/15/10	26	8/13/08	28
5/26/00	11	Summer		8/13/08	28
5/28/03	26	9/2/99	18	8/13/08	34
5/28/03	30	9/2/99	16	8/13/08	28
5/28/03	26	9/2/99	18	8/13/08	34
5/28/03	26	9/8/00	1	8/11/09	28
5/28/03	21	9/8/00	1	8/11/09	21
4/20/07	63	9/8/00	4	8/11/09	25
4/20/07	63	9/8/00	2	8/10/10	120
4/20/07	63	9/8/00	3	8/10/10	46
4/13/08	47	8/20/03	21	8/10/10	87
4/13/08	49	8/20/03	39		
4/13/08	49	8/20/03	39		

The graph shows 1999 through 2010 Upper Long Lake nitrate nitrogen concentrations in spring ranged from 11 to 63 ug/L and averaged 33 ug/L. Summer values over the same period ranged from 1 to 120 ug/L and averaged 26 ug/L. These nitrate nitrogen concentrations are low for spring and normal for summer.

These data indicate Upper Long Lake is probably nitrate rather than phosphorus limited most of the time. It also means no fertilizers should be used on near-lake areas.



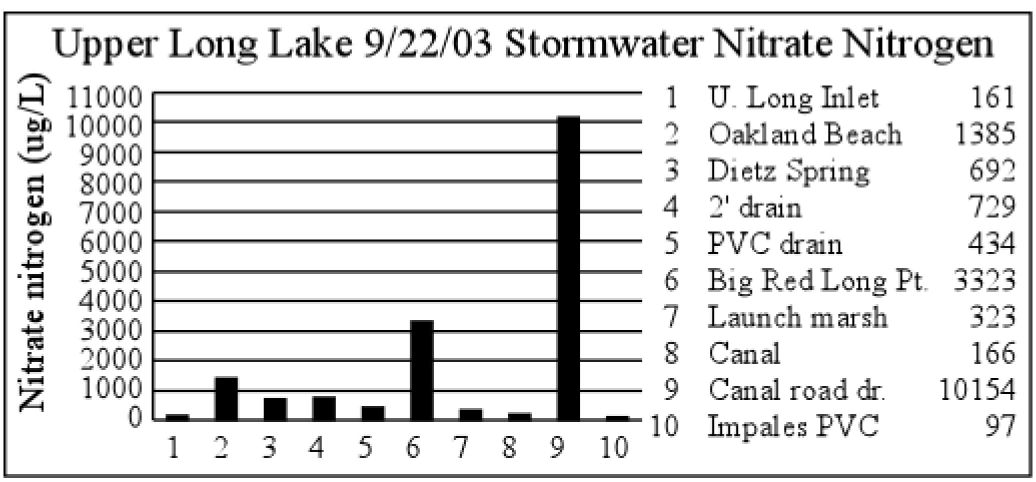
TOP TO BOTTOM NITRATE NITROGEN

The graph of top to bottom 2000 and 2003 nitrate nitrogen concentrations shows 2000 spring and summer values were lower than spring and summer 2003 values, but in any case these are all low nitrate nitrogen concentrations.

STORMWATER NITRATES

Ron Cousineau collected ten inlet samples on September 22, 2003. The graph shows his data.

It would be better if we knew the approximate locations of these sites so we could locate them on a map.



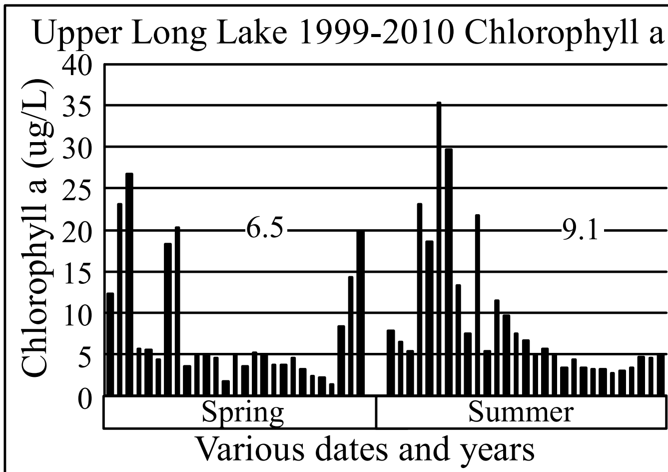
The graph shows the nitrate nitrogen concentrations of inlet samples ranged from 97 to 10154 ug/L. The graph seems to show the biggest problem is from sample site 9, but these are stormwater grab samples so the results may not be representative of normal conditions.

Representative stormwater samples are very difficult to obtain because of something called the first flush phenomenon. This is where the water from the early part of a rain storm may have very high concentrations of various nutrients. Later water from the same storm may have few nutrients because they were washed off the land by the earlier stormwater.

CHLOROPHYLL A

Chlorophyll a is used by lake scientists as a measure of the biological productivity of the water. Generally, the lower the chlorophyll a, the better. High concentrations of chlorophyll a are indicative of an algal bloom in the lake, an indication of poor lake water quality.

The highest surface chlorophyll a concentration found by this writer in a Michigan lake was 216 micrograms per liter. Best is below one microgram per liter.



Spring		4/13/08	4.5	8/20/03	11.4
4/25/99	12.3	4/13/08	3.2	8/20/03	9.7
4/25/99	23.0	3/17/09	2.4	8/23/07	7.4
4/25/99	26.8	3/17/09	2.1	8/23/07	6.6
5/26/00	5.7	3/17/09	1.4	8/23/07	5.0
5/26/00	5.4	4/15/10	8.3	8/23/07	5.6
5/26/00	4.3	4/15/10	14.2	8/23/07	5.0
5/26/00	18.3	4/15/10	20.0	8/13/08	3.4
5/26/00	20.2	Summer		8/13/08	4.3
5/28/03	3.5	9/2/99	7.8	8/13/08	3.4
5/28/03	4.8	9/2/99	6.5	8/13/08	3.1
5/28/03	4.9	9/2/99	5.3	8/13/08	3.1
5/28/03	4.5	9/8/00	23.0	8/11/09	2.7
5/28/03	1.6	9/8/00	18.6	8/11/09	3.0
4/20/07	4.9	9/8/00	35.3	8/11/09	3.4
4/20/07	3.5	9/8/00	29.7	8/10/10	4.6
4/20/07	5.2	9/8/00	13.3	8/10/10	4.4
4/13/08	4.9	8/20/03	7.4	8/10/10	4.9
4/13/08	3.7	8/20/03	21.7		
4/13/08	3.7	8/20/03	5.3		

The graph shows chlorophyll concentrations in spring ranged from 1.4 to 26.8 ug/L, and averaged 6.5 ug/L. Summer chlorophylls ranged from 2.7 to 35.3 ug/L and averaged 9.1 ug/L.

The graph shows in 2010 spring chlorophylls ranged from 8.3 to 20.0 ug/L, while summer 2010 chlorophylls ranged from 4.4 to 4.9 ug/L.

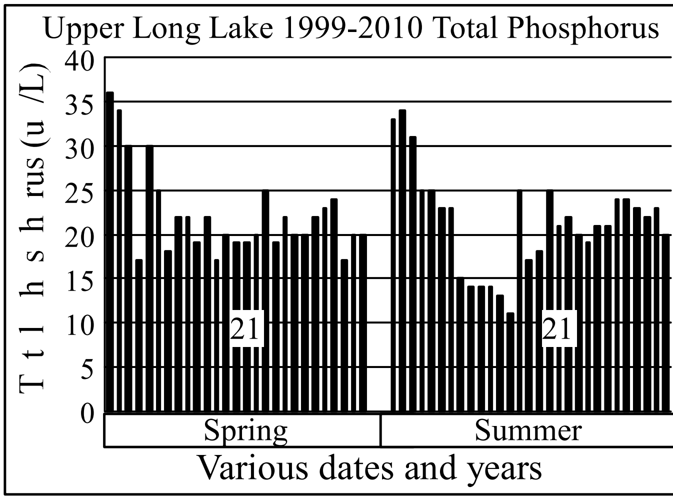
These data indicate Upper Long Lake has algal blooms in both spring and summer.

TOTAL PHOSPHORUS

Although there are several forms of phosphorus found in lakes, the experts selected total phosphorus as being most important. This is probably because all forms of phosphorus can be converted to the other forms. Currently, most lake scientists feel phosphorus, which is measured in parts per billion (1 part per billion is one second in 31 years) or micrograms per liter (ug/L), is the one nutrient which might be controlled. If its addition to lake water could be limited, the lake might not become covered with the algal communities so often found in eutrophic lakes.

However, based on our studies of many Michigan inland lakes, we’ve found many lakes were phosphorus limited in spring (so don’t add phosphorus) and nitrate limited in summer (so don’t add nitrogen).

10 parts per billion is considered a low concentration of phosphorus in a lake and 50 parts per billion is considered high by many limnologists.



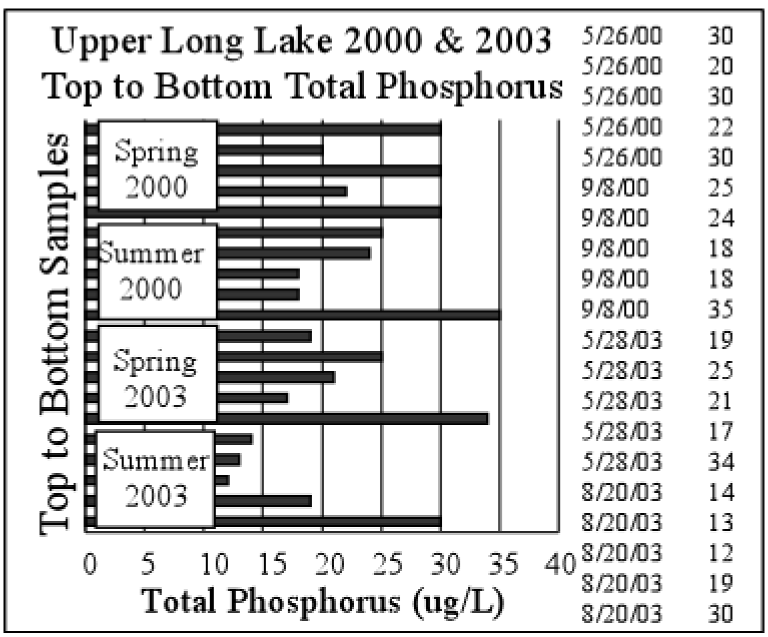
Spring		4/13/08	20	8/20/03	13
4/25/99	36	4/13/08	20	8/20/03	11
4/25/99	34	3/17/09	22	8/23/07	25
4/25/99	30	3/17/09	23	8/23/07	17
5/26/00	17	3/17/09	24	8/23/07	18
5/26/00	30	4/15/10	17	8/23/07	25
5/26/00	25	4/15/10	20	8/23/07	21
5/26/00	18	4/15/10	20	8/13/08	22
5/26/00	22	Summer		8/13/08	20
5/28/03	22	9/2/99	33	8/13/08	19
5/28/03	19	9/2/99	34	8/13/08	21
5/28/03	22	9/2/99	31	8/13/08	21
5/28/03	17	9/8/00	25	8/11/09	24
5/28/03	20	9/8/00	25	8/11/09	24
4/20/07	19	9/8/00	23	8/11/09	23
4/20/07	19	9/8/00	23	8/10/10	22
4/20/07	20	9/8/00	15	8/10/10	23
4/13/08	25	8/20/03	14	8/10/10	20
4/13/08	19	8/20/03	14		
4/13/08	22	8/20/03	14		

The graph shows in spring phosphorus concentrations ranged from 17 to 36 ug/L but are usually in the 18 to 25 ug/L range. In summer, phosphorus concentrations range from 11 to 34 ug/l. From 1999 through 2003, the summer phosphorus was decreasing. Since that time it has stabilized between 17 and 25 ug/L. Spring and summer phosphorus concentrations averaged 21 ug/L.

2007 and 2008 spring phosphorus concentrations ranged from 19 to 25 ug/L and averaged 21 ug/L. 2007 and 2008 summer phosphorus concentrations ranged from 17 to 25 ug/L and averaged 21 ug/L. In spring and summer 2009, phosphorus concentrations ranged from 22 to 24 ug/L. In spring 2010 phosphorus concentrations were 17 or 20 ug/L. In summer they were 20 or 23 ug/L.

As phosphorus concentrations approach 20 ug/L, and of other nutrients are present in adequate amounts, aquatic plants and algae can grow to nuisance proportions.

TOP TO BOTTOM PHOSPHORUS

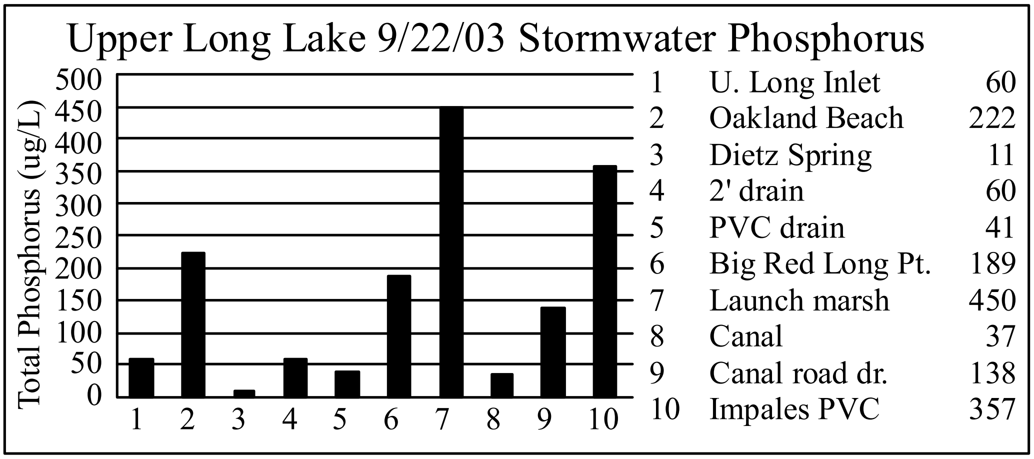


The graph of top to bottom spring and summer 2000 and 2003 phosphorus concentrations shows in spring 2000 the phosphorus concentration ranged from 20 to 30 ug/L in the water column. The other three sets of samples shows phosphorus highest near the bottom. This indicates phosphorus is accumulating near the bottom of the lake.

There are two possible sources. One is that the phosphorus is settling to the bottom as plants and algae die and settle to the bottom. The other is that phosphorus is being released from the bottom sediments during periods of anoxia. Probably a little of both is occurring.

STORMWATER PHOSPHORUS

The graph shows the phosphorus concentration of the stormwater samples collected September 22, 2003 by Ron Cousineau. It shows seven of the ten samples had phosphorus concentrations higher than 50 ug/L. They averaged 157 ug/L



Those are high stormwater phosphorus concentrations for a lake. However the same warning as with the stormwater nitrates. Stormwater samples may or may not be representative of actual conditions.

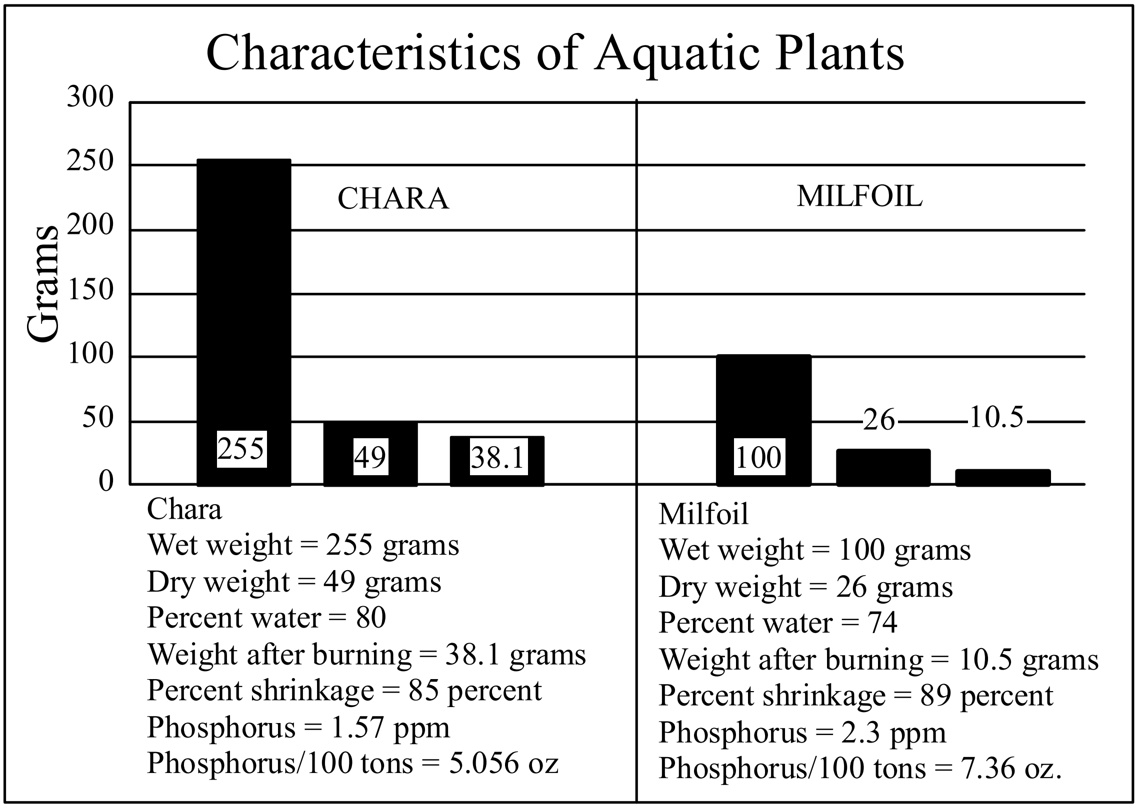
PHOSPHORUS IN AQUATIC PLANTS

Cousineau wanted to know how much phosphorus was removed when aquatic plants were harvested from the lake. He sent two zip-lock bags, one with 255 grams wet weight of Chara and the second with 100 grams wet weight of Eurasian water milfoil.

After drying at 100 degrees C for several days, the 255 grams of Chara shrunk to 49 grams and the 100 grams of Eurasian water milfoil shrunk to 26 grams. This meant the Chara was 81 percent water (241/255X100) and the milfoil was 74 percent water.

The dry plant material was burned at 550 degrees C to eliminate organic material. The 49 grams of Chara decreased to 38.1 grams of minerals and the 26 grams of milfoil decreased to 10.5 grams of minerals. So the mineral content of Chara was 14.9 percent of the wet weight and the mineral content of milfoil was 10.5 percent of the wet weight. The graph shows the data.

1.0 gram of each of the remaining minerals was added to 100 milliliters of distilled water, then analyzed for phosphorus. The phosphorus concentration in the 1.0 gram of Chara minerals in 100 ml of water was 106 parts per billion, and the phosphorus concentration of the 1.0 gram of milfoil minerals in 100 milliliters of water was 219 parts per billion.



Since this was a 1 to 100 dilution, the actual concentration of phosphorus in the two mineral samples was 10,600 parts per billion (or 10.6 parts per million) and 21,900 parts per billion (or 21.9 parts per million) respectively.

Since the minerals were only a part of the total sample (since the evaporation of water and burning off of organic material concentrated the phosphorus, because the amount of phosphorus didn't change, although the weight of the sample did), the amount of phosphorus in total sample needed to be determined using divisors. The divisor was 255 g./38.1 g. = 6.69 for Chara and 100 g./10.5 g. = 9.52 for milfoil.

So 21.9 ppm divided by 9.52 = 2.3 parts per million in milfoil and 10.5 ppm divided by 6.69 = 1.57 parts per million in Chara.

After converting the pounds of phosphorus to ounces and doing the math, harvesting Chara removes about .051 ounces of phosphorus per ton wet weight and harvesting milfoil removes .074 ounces of phosphorus per ton wet weight.

These data indicate if you remove 100 tons wet weight of Chara from your lake, you'll remove 5.1 ounces of phosphorus, and if you remove 100 tons wet weight of milfoil from your lake, you'll remove 7.4 ounces of phosphorus from your lake.

This points out two things. First, it shows how little phosphorus it takes to promote aquatic plant growth in a lake, and second, it shows if you really want to control the amount of phosphorus in your lake, not fertilizing your lawns is a much more effective means to do this than harvesting aquatic plants.

SECCHI DISK TRANSPARENCY (originally Secchi's disk)

In 1865, Angelo Secchi, the Pope's astronomer in Rome 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. 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 grand-children 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.

UPPER LONG LAKE SECCHI DISK DATA

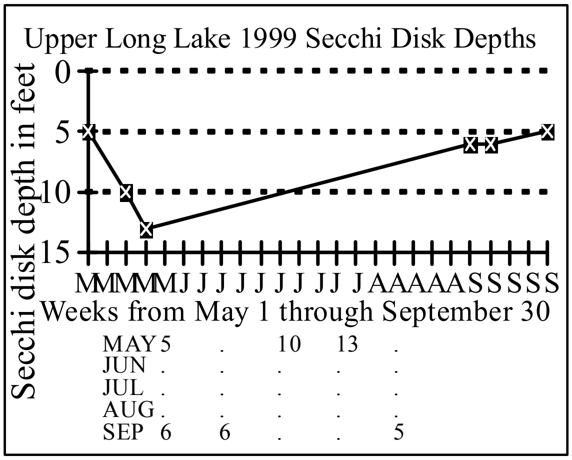
1999

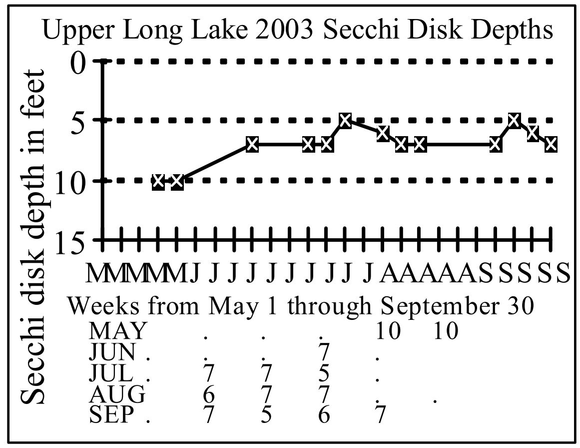
1999 Secchi disk data are a bit sparse, with three readings in May and another three in September. These data show is the clarity was 5 feet in early spring then increased to 13 feet in mid-May before decreasing to 5 and 6 feet in September.

2003

Ron Cousineau did a good job taking Secchi disk readings through the warm months in 2003. The graph shows the data he collected.

Ron's 2003 Secchi disk data shows deeper readings (10 feet) in spring, then shallower readings (5 to 7 feet) as the water warmed in summer, probably the result of algae growing in the lake. (Many algae like warm water.)

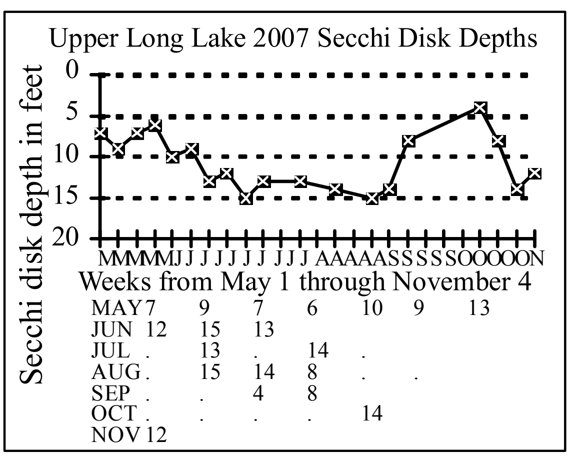


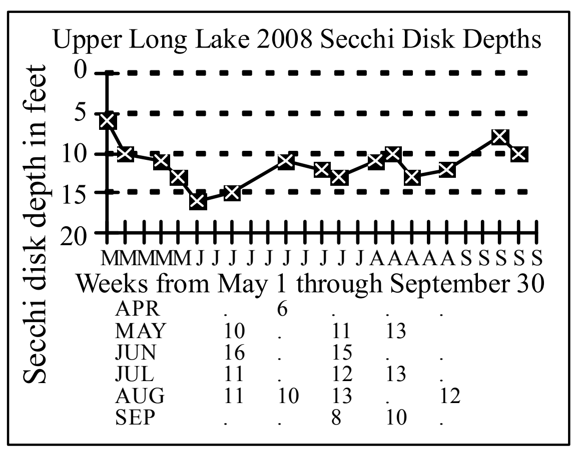


2007

Cousineau and Steve George took Secchi disk readings through the warm months in 2007.

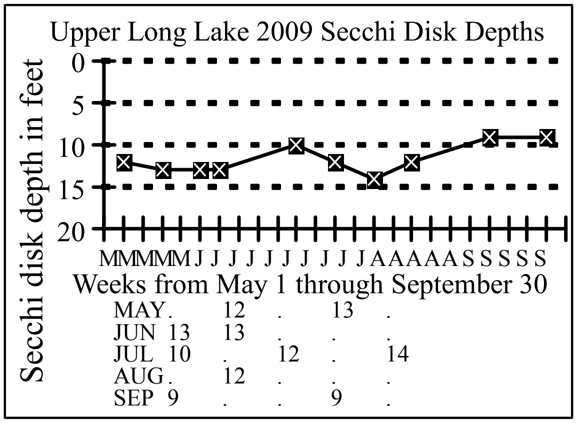
Their data show shallow readings (6 to 10 feet) in May, increasing to 13 to 15 feet by mid June and remaining in that range until early September when the readings decreased to a minimum of 4 feet in September. They then increased to 12 to 14 feet at the end of the year.

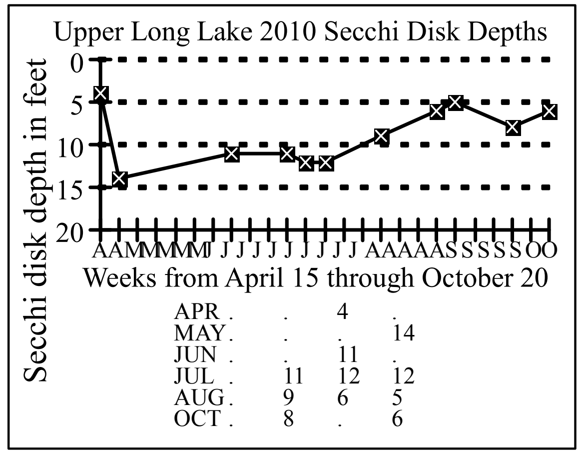




2008

Cousineau's 2008 data shows shallow readings in early spring, probably the result of a diatom bloom, because diatoms like cold water. The clarity increased to a maximum of 16 feet in early June, then gradually decreased to between 8 and 13 feet the rest of the summer.





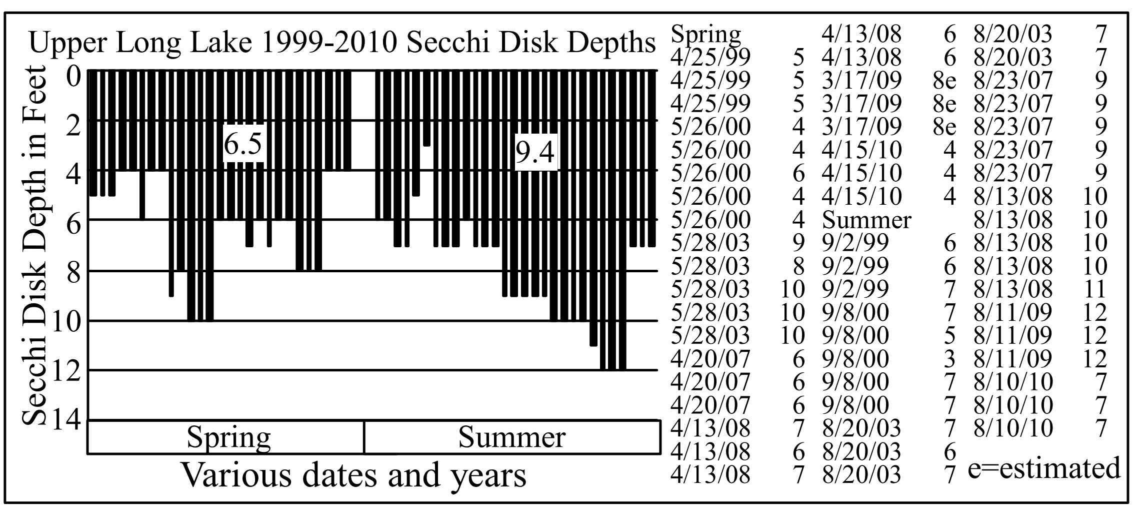
2009

Cousineau's 2009 data show deep readings in spring 12 and 13 feet. In July they drop to 10 feet, then increase to 14 feet the first part of August before decreasing to 9 feet in September.

2010

Stephen George collected Secchi disk data on Upper Long Lake in 2010. His data show shallow (4 feet) readings in April, increasing to 14 feet in May, then decreasing to 11 and 12 feet in June and July, and then decreasing even more to 5 feet in late August. October readings were 8 and 6 feet.

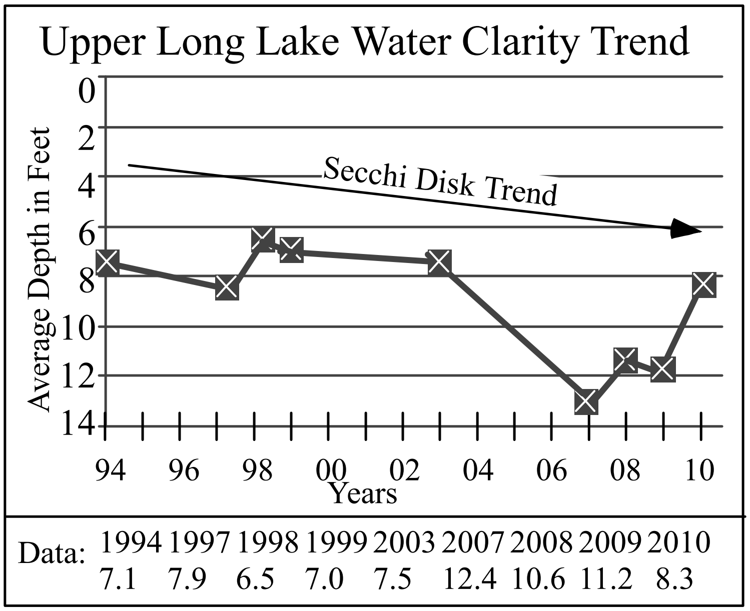
SECCHI DISK READINGS TAKEN WITH THE SAMPLES



The graph shows the Secchi disk readings taken with the samples. It shows spring Secchi disk readings ranged from 4 to 10 feet (spring 2009 data were estimated). Summer Secchi disk readings ranged from 3 to 12 feet.

The graph shows spring readings vary a bit but there is no specific trend. On the other hand, the summer readings are almost a straight line to deeper readings until 2010. This year, spring readings were shallow, 4 feet, and summer readings were about half the 2009 readings, 7 feet. These data mimic the conductivity and alkalinity data. The cause is unknown.

THE SECCHI DISK TREND GRAPH



Using some data collected in past years, we were able to construct a Secchi disk trend graph. The graph shows, based on some data from the 1990s that the clarity of Upper Long Lake improved considerably in 2007, 2008 and 2009. In 2010 they decreased to 8.3 feet.

THE LAKE WATER QUALITY INDEX

The Lake Water Quality Index used in this study to define the water quality of Upper Long Lake 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.

Development of the index invoked 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.

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:

Dissolved oxygen (percent saturation)	
Total phosphorus	Total alkalinity
Chlorophyll a	Temperature
Secchi disk depth	Conductivity
Total nitrate nitrogen	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 LWQI seen by this author was 16 in an Ottawa County lake.

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).

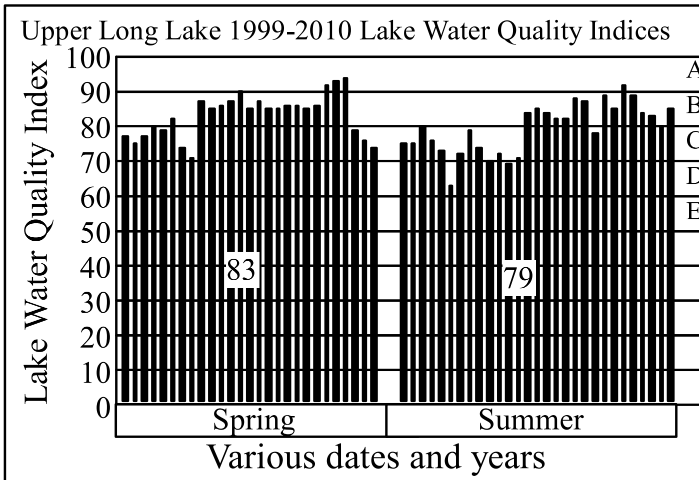
The calculation sheet permits calculation of the Lake Water Quality Index, using the results of all nine lake water quality tests.

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 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 SPRING AND SUMMER LAKE WATER QUALITY INDICES



Spring		4/13/08	84	8/20/03	68
4/25/99	76	4/13/08	85	8/20/03	70
4/25/99	74	3/17/09	91	8/23/07	83
4/25/99	76	3/17/09	92	8/23/07	84
5/26/00	79	3/17/09	93	8/23/07	83
5/26/00	78	4/15/10	78	8/23/07	81
5/26/00	81	4/15/10	75	8/23/07	81
5/26/00	73	4/15/10	73	8/13/08	87
5/26/00	70	Summer		8/13/08	86
5/28/03	86	9/2/99	74	8/13/08	77
5/28/03	84	9/2/99	74	8/13/08	88
5/28/03	85	9/2/99	79	8/13/08	84
5/28/03	86	9/8/00	75	8/11/09	91
5/28/03	89	9/8/00	72	8/11/09	88
4/20/07	84	9/8/00	62	8/11/09	83
4/20/07	86	9/8/00	71	8/10/10	82
4/20/07	84	9/8/00	78	8/10/10	79
4/13/08	84	8/20/03	73	8/10/10	84
4/13/08	85	8/20/03	69		
4/13/08	85	8/20/03	71		

The really obvious thing the graph shows is the water quality was increasing in both spring and summer. In spring 2010 the LWQIs were lower. In summer 2010 they didn't change much from the average.

The graph shows in 1999, the Upper Long Lake LWQIs ranged from 74 to 79, or in the C range.

In 2000, the spring Upper Long Lake LWQIs ranged from 70 to 81, or in the C to B range while the summer LWQIs ranged from 62 to 78, or in the C to D range

In 2003 the spring Upper Long Lake LWQIs ranged from 84 to 89, or in the B range while the summer LWQIs ranged from 68 to 73, or in the C to D range.

In 2007 the spring Upper Long Lake LWQIs ranged from 84 to 86, or in the B range while the summer LWQIs ranged from 81 to 84, again in the B range.

In 2008 the LWQIs for Upper Long Lake ranged from 77 to 88, or in the B to C range.

In 2009 the spring LWQIs for Upper Long Lake ranged from 91 to 93, or in the A range. In summer they ranged from 84 to 91 or in the B to A range.

In spring 2010 the LWQIs ranged from 73 to 78 or in the C range. In summer 2010 they ranged from 79 to 84 or in the B to C range.

THE LAKE WATER QUALITY INDEX CALCULATION SHEETS

Because the 2010 LWQIs for the three springs surface samples were similar (78 75 73) and the LWQIs for three late summer surface samples were also similar (82 79 84), two LWQI calculation sheets are included in this report, one for the three spring 2010 surface samples, using averaged data, and a second for the three late summer 2010 surface samples, again using averaged data.

In the report marked MASTER, all 6 of the LWQI calculation sheets are included. That is the only difference between the MASTER and the rest of the reports.

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, iron sulfides, which are black, are produced. 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.

We determine how much bottom sediments shrink when they air dry because this information is useful when considering dredging a lake. Normal shrinkage after air-drying is in the range of 50 to 80 percent. However sands and gravels don't shrink at all. Excessive shrinkage is more than 95 percent. In other words, there is only five percent or less of the material remaining after air-drying.

If 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 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 hard water lakes to be above 85 percent mineral. And I consider bottom sediments less than 50 percent mineral to be muck.

On the other hand, softwater lakes which have few carbonates and bicarbonates, often have highly organic bottom sediments. It would be better if they did not have lots of organic material in the bottom sediments. A source of these organics are algal blooms which occur in the lake.

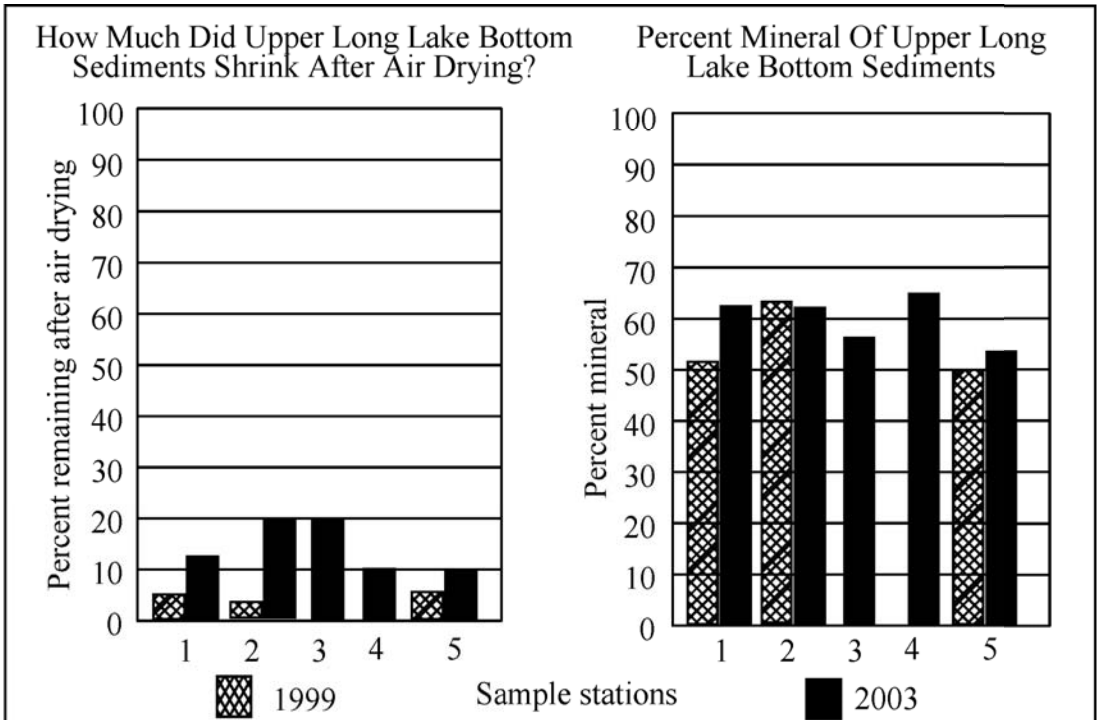
UPPER LONG LAKE BOTTOM SEDIMENTS

Three bottom sediment samples were collected at Stations 1, 3 and 5 in 1999 and at all five stations in 2003. The 1999 data are shown on the graph by the hatched bars and the 2003 data are shown by the solid bars. All sediments were black when retrieved.

STATION 1

The 1999 sample from Station 1 collected in 22 feet of water shrunk 95 percent, remained black after air drying and turned tan gray after burning at 550 degrees C. It was 51 percent mineral.

The 2003 sample from Station 1 collected in 14 feet of water shrunk 88 percent, remained black after air drying and turned red after burning at 550 degrees C. It was 63 percent mineral. The red color was the result of clay in the sediments. Clay is not a normal lake sediment. It is carried into the lake by home or road building activities.



Characteristics of Upper Long Lake Bottom Sediments (1999 & 2003)

Sample I.D.	Year	Percent Shrinkage	Percent Mineral	Dried at 100°C Color & Description	Color after burning at 550°C	Depth of water (feet)
1	1999	95	51	Black	Tan gray	22
	2003	88	63	Black	Red	14
2	1999	97	63	Black	Tan gray	22
	2003	80	62	Black	Gray	22
3	2003	80	57	Black	Gray	7
4	2003	90	65	Black	Tan gray	7
5	1999	95	50	Black	Tan gray	14
	2003	90	53	Black	Red	14

55 percent = average mineral content of bottom sediments (1999)
60 percent = average mineral content of bottom sediments (2003)

STATION 2

The 1999 sample from Station 2 collected in 22 feet of water shrunk 97 percent, remained black after air drying and turned tan gray after burning at 550 degrees C. It was 63 percent mineral.

The 2003 sample from Station 2 collected in 22 feet of water shrunk 80 percent, remained black after air drying and turned gray after burning at 550 degrees C. It was 62 percent mineral.

STATION 3

The 2003 sample from Station 32 collected in 7 feet of water shrunk 80 percent, remained black after air drying and turned gray after burning at 550 degrees C. It was 57 percent mineral.

STATION 4

The 2003 sample from Station 4 collected in 7 feet of water shrunk 90 percent, remained black after air drying and turned tan-gray after burning at 550 degrees C. It was 65 percent mineral.

STATION 5

The 1999 sample from Station 5 collected in 14 feet of water shrunk 95 percent, remained black after air drying and turned tan gray after burning at 550 degrees C. It was 50 percent mineral.

The 2003 sample from Station 5 collected in 14 feet of water shrunk 90 percent, remained black after air drying and turned red after burning at 550 degrees C. It was 53 percent mineral.

BOTTOM SEDIMENT COMMENTS

The bottom sediment samples shrunk more than a normal amount, 80 to 97 percent, which meant they were light and fluffy and easily mixed into the water column by wind, wave and/or boat action. All remained black after air-drying.

After burning at 550 degrees C, 6 of the 8 sediment samples turned gray or tan gray indicating the lake is filling with carbonates and bicarbonates. Two turned red, indicating the presence of clay in the bottom sediments.

The average mineral content of the 1999 samples was 55 percent, while the average mineral content of the 2003 samples was 60 percent. These data are essentially similar.

The bottom sediment data indicates Upper Long Lake is accumulating organic material at a rapid rate. Residents should make every effort to prevent this from happening, because it is by this process that lakes die.

NUTRIENT BUDGETS

Calculating a theoretical nutrient budget can help lake residents understand the sources, sinks and pathways and amounts of nutrients that can cause unwanted plant or algal conditions in their lake. Nitrogen and phosphorus are both nutrients. Currently, most people involved in lake management feel if the amount of nutrients in a lake could be reduced, water quality problems will be reduced in the lake. The following discussion addresses the sources and sinks of phosphorus, one of the nutrients that cause excess plants and algae to grow.

A PHOSPHORUS NUTRIENT BUDGET FOR UPPER LONG LAKE

The following is a theoretical phosphorus nutrient budget for Upper Long Lake in 2007. The following data (and sources) were used in the nutrient budget calculations. The lake volume is in billions of pounds because in the nutrient budget, phosphorus is measured in pounds of phosphorus per one billion pounds of water (or parts per billion).

This makes it easy to determine the amount of phosphorus in Upper Long Lake, if that needs to be done in the future. Just multiply the average phosphorus concentration in the lake (in parts per billion) times 3.19 billion pounds, the number of billions of pounds of water in Upper Long Lake.

- Upper Long Lake water volume = 3,191,101,056 pounds
- Upper Long Lake Drainage area = 907 acres
- Upper Long Lake watershed area = 779 acres
- Upper Long Lake riparian lot area = 169 acres
- Upper Long Lake non-riparian watershed lot area = 610 acres
- Upper Long Lake surface area = 121 acres
- Average phosphorus concentration of stormwater runoff = 800 ug/L (Gannon, 1975)
- Water weighs 62.4 pounds per cubic foot, or 8.34 pounds per gallon
- Upper Long Lake flushes once every 1.65 years, or 602 days
- Mean spring lawn fertilizer phosphorus concentration = 4% Sloan, 1984
- Mean fall lawn fertilizer phosphorus concentration = 20% Sloan, 1984

- Upper Long Lake average discharge = 0.98 cfs or 711 acre feet per year or 1.93 billion pounds of water per year
- All lake lots are one acre lots, and 50% of each lot is lawn
- The average Upper Long Lake 2007 spring phosphorus concentration was 19 micrograms per liter
- The average Upper Long Lake late summer phosphorus concentration was 21 micrograms per liter
- 142 riparian homes on Upper Long Lake are served by public sewers.
- 27 riparian homes on Upper Long Lake are on septic tanks and tile fields.
- 169 homes are riparian to Upper Long Lake or the canals.
- Riparians have 2.5 people per household.
- 50 percent of the riparian homes (85) fertilize their lawns in both spring and fall.
- Mean phosphorus concentration in domestic waste water = 23 milligrams per liter (USEPA, 1980)
- Mean phosphorus concentration of septage = 233 milligrams per liter (USEPA, 1980)
- Average daily per capita water use = 45.6 gallons. (USEPA, 1980).
- Each riparian household with an on-site system has a 1000-gallon septic tank.
- The laboratory test results were representative of the concentration of nutrients in Upper Long Lake for a six month period.
- The phosphorus concentration in the outlet water is the same as in the lake water. This is true because just a few minutes before, it was lake water.

UPPER LONG LAKE PHOSPHORUS RETENTION

In 2007 the total amount of phosphorus in the water of Upper Long Lake in spring, based on surface concentrations, is 61 pounds. In summer it's 67 pounds.

PHOSPHORUS LOST THROUGH FLUSHING

Upper Long Lake loses about 0.98 cubic feet per second of water through the outlet. This amounts to 1.93 billion pounds per year. If the 2007 phosphorus concentration of the water flowing out of Upper Long Lake is the same as the lake (since it was lake water just a few minutes earlier), and we average spring (19 parts per billion) and late summer (21 ppb) phosphorus concentrations and multiply that by the amount of water that leaves the lake in a year, we can determine how much phosphorus is lost through flushing each year. Here is the calculation:

(19 ppb + 21 ppb) / 2 X 1.93 billion pounds = 39 pounds

PHOSPHORUS ADDITIONS FROM LAWN FERTILIZER

As stated above, we assume 85 riparian residences (50% of 169 homes) on Upper Long Lake use lawn fertilizer at a commonly applied rate, 40 pounds of phosphorus per acre per year, that half the lot is lawn, and that a spring and fall fertilizer application is made each year (a local nurseryman reports he sells almost as much lawn fertilizer in the fall that he does in spring, but the fall fertilizer has a much higher phosphorus concentration).

The average spring phosphorus concentration in lawn fertilizer is 4%, while the average late summer phosphorus concentration is 20%. Most lawn fertilizers are sold in 40-pound bags that cover 10,000 square feet (or a quarter of an acre).

Thus, each person who fertilizes his/her lawn buys 80 pounds of fertilizer in spring containing 4% phosphorus and 80 pounds in late summer containing 20% phosphorus. Each person who fertilizes his/her lawn uses about 20 pounds of phosphorus each year. Here is the calculation:

80 pounds X 4% plus 80 pounds X 20% = 19.2 pounds

This amounts to 1632 pounds for the 85 homes that fertilize their lawns. Assuming half the phosphorus is taken up by the lawns, 816 pounds of phosphorus from lawn fertilizers could be washed into Upper Long Lake each year.

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PHOSPHORUS ADDITIONS FROM NON-RIPARIAN STORM WATER

The watershed of Upper Long Lake is 779 acres, and of that riparians occupy about 169 acres. That means 610 acres are occupied by non-riparians living in the Upper Long Lake watershed. The average yearly flow from those 610 acres is 1.298 billion pounds. Gannon reported the average phosphorus concentration of stormwater is about 800 ug/L. Thus the non-riparian portion of the watershed adds about 1038 pounds of phosphorus per year. Here is the calculation.

1.298 billion pounds X 800 ppb = 1038 pounds

PHOSPHORUS FROM SEPTIC TANKS OF LAKE FRONT HOMES

Full time residents make up 100 percent of the 169 homes on Upper Long Lake. Of those, 27 have on-site sewage disposal systems (septic tanks and tile fields).

Each full-time riparian household (consisting of 2.5 persons) with an on-site system, releases 8.0 pounds of phosphorus per year into Upper Long Lake watershed. Here is the calculation:

(45.6 gallons per person X 2.5 persons per household X 8.34 pounds (the weight of a gallon of water) X 365 days X 23/1000000 = 8.0 pounds.)

Therefore the 27 full-time families living on Upper Long Lake release 216 pounds of phosphorus per year (27 X 8.0 pounds = 216 pounds) into the soils around Upper Long Lake each year.

PHOSPHORUS LOST FROM PUMPING SEPTIC TANKS

Assuming each riparian septic tank contains 1000 gallons (or 8,340 pounds) of septage, and using the EPA-defined concentration of 232 pounds of phosphorus for every one million pounds of water, the amount of phosphorus in a 1000 gallon septic tank is 1.93 pounds. Here is the calculation.

(1000 gallons X 8.34 pounds X 232/1,000,000 = 1.93 pounds)

Every time a septic tank is pumped, 1.93 pounds of phosphorus is removed from the Upper Long Lake watershed.

SEPTIC TANK PUMPING EVERY YEAR

If all 27 septic tanks from homes on Upper Long Lake were pumped dry every year, 52 pounds of phosphorus will be removed from the Upper Long Lake watershed each year.

SEPTIC TANK PUMPING EVERY 3 YEARS

If all 27 septic tanks from homes on Upper Long Lake were pumped dry every 3 years, 52 pounds of phosphorus will be removed from the Upper Long Lake watershed. This amounts to removing 17 pounds of phosphorus from the Upper Long Lake watershed each year.

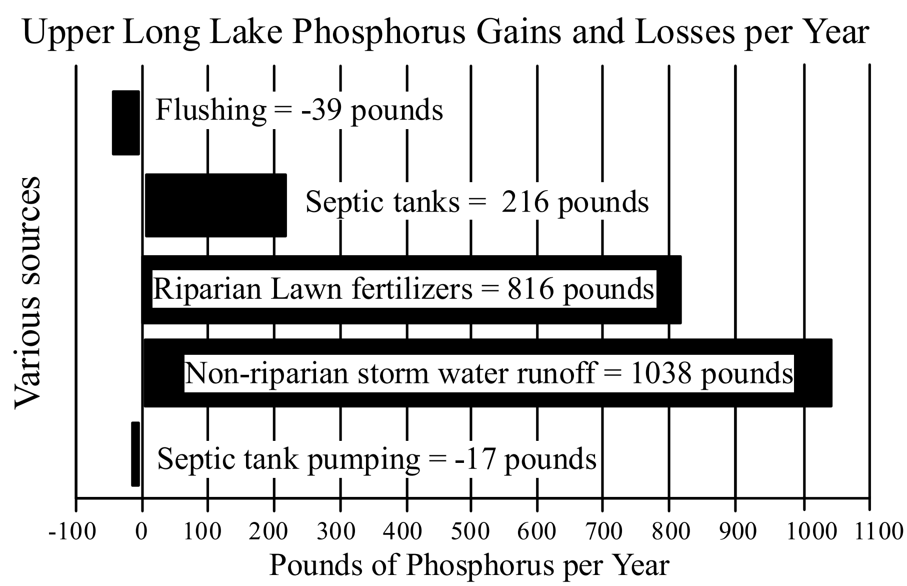
SEPTIC TANK PUMPING EVERY 10 YEARS

If all 27 septic tanks from homes on Upper Long Lake were pumped dry every 10 years, 52 pounds of phosphorus will be removed from the Upper Long Lake watershed. This amounts to removing 5 pounds of phosphorus from the Upper Long Lake watershed each year.

SUMMARY OF PHOSPHORUS ADDITIONS AND LOSSES

Flushing losses	-39 pounds per year
Riparian lawn fertilizer additions	816 pounds per year
Non-riparian stormwater fertilizer additions	1038 pounds per year
Full time riparian onsite additions	216 pounds per year
Septic tank pumping every 3 years	-17 pounds per year

TOTAL POUNDS OF PHOSPHORUS 2014 pounds per year



Upper Long Lake gains about 2014 pounds of phosphorus per year from various sources.

The graph shows the data. It shows the largest potential source of phosphorus to Upper Long Lake is stormwater runoff from non-riparian property which adds about 1038 pounds of phosphorus per year.

Stormwater runoff from riparian lawn fertilization adds about 816 pounds of phosphorus per year.

The 27 riparian septic tanks are third, adding 216 pounds of phosphorus per year.

The lake watershed loses about 39 pounds of phosphorus per year through flushing, and an additional 17 pounds per year if all 27 residential septic tanks are pumped once every three years, the generally recommended procedure.

WHERE DOES ALL THE PHOSPHORUS GO?

The above analysis shows Upper Long Lake has 61 pounds of phosphorus in spring 2007, and 67 pounds in summer 2007. About 2070 pounds of phosphorus are generated by the various sources in the watershed. And the watershed loses about 56 pounds through flushing and septic tank pumping (assuming septic tanks are pumped once every three years). Where does all this phosphorus go?

As long as there is oxygen dissolved in the lake water, phosphorus will precipitate to the bottom sediments. And that's where most of it is probably going. That's the reason the aquatic plants are increasing and growing well in the lake.

If this rate of phosphorus addition were constant, over the last 20 years the lake would have accumulated over 20 tons of phosphorus in the bottom sediments. This breaks down to more than 330 pounds per acre, which is more than eight times the recommended rate for lawns (at 40 pounds of phosphorus per acre per year).

However, the phosphorus in the bottom sediments doesn't disappear. It remains, fueling plant and algal growth. And that appears to be happening in Upper Long Lake.

Wallace E. Fusilier, Ph.D.
Consulting Limnologist
Water Quality Investigators
Dexter, Michigan
March 2010

Upper Long Lake Water Quality Data`

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
4/25/99	2	---	---	---	23.0	5	16	125	8.1	680	34	74	C
4/25/99	3	---	---	---	26.8	5	16	125	8.1	680	30	76	C
9/2/99	1	25	11.5	137	7.8	6	18	118	8.8	620	33	74	C
9/2/99	2	26	11.2	137	6.5	6	16	118	8.8	620	34	74	C
9/2/99	3	26	11.0	134	5.3	7	18	117	8.7	610	31	79	C
9/2/99	B	---	---	---	---	---	79	110	8.5	660	50	---	---
5/26/00	1	18	9.3	98	5.7	4	17	154	8.5	720	17	79	C
5/26/00	2	19	9.4	100	5.4	4	11	155	8.5	720	30	78	C
5/26/00	2-5	19	9.4	100	---	---	14	154	8.4	720	20	---	---
5/26/00	2-10	18	7.9	83	---	---	11	153	8.4	720	30	---	---
5/26/00	2-15	14	0.0	0	---	---	12	157	7.8	720	22	---	---
5/26/00	2-20	14	0.0	0	---	---	17	162	7.7	730	30	---	---
5/26/00	3	20	10.8	117	4.3	6	12	150	8.6	720	25	81	B
5/26/00	4	19	9.8	104	18.3	4	24	155	8.6	720	18	73	C
5/26/00	5	20	11.3	123	20.2	4	11	152	8.7	720	22	70	C
9/8/00	1	22	8.8	100	23.0	7	1	105	8.7	600	25	75	C
9/8/00	2	22	10.2	116	18.6	5	1	105	8.8	600	25	72	C
9/8/00	2-5	22	10.2	116	---	---	11	105	8.8	600	24	---	---
9/8/00	2-10	22	9.5	108	---	---	4	104	8.8	620	18	---	---
9/8/00	2-15	21	0	0	---	---	7	104	8.3	620	18	---	---
9/8/00	2-20	16	0	0	---	---	5	138	7.4	680	35	---	---
9/8/00	3	22	10.2	116	35.3	3	4	105	8.8	600	23	62	D
9/8/00	4	22	10.2	116	29.7	7	2	103	8.8	620	23	71	C
9/8/00	5	22	10.3	117	13.3	7	3	102	8.7	610	15	78	C
5/28/03	1	19	8.8	94	3.5	9	26	145	8.4	740	22	86	B
5/28/03	2	19	8.7	93	4.8	8	30	147	8.3	745	19	84	B
5/28/03	2-5	18	8.5	89	---	---	26	147	8.3	750	25	---	---
5/28/03	2-10	17	7.7	79	---	---	30	150	8.3	745	21	---	---
5/28/03	2-15	16	6.8	68	---	---	26	151	8.2	755	17	---	---
5/28/03	2-20	12	0.7	6	---	---	30	152	7.7	750	34	---	---
5/28/03	3	19	10.4	110	4.9	10	26	146	8.3	745	22	85	B
5/28/03	4	19	10.5	111	4.5	10	26	145	8.3	745	17	86	B
5/28/03	5	19	10.4	110	1.6	10	21	150	8.3	750	20	89	B
8/20/03	1	28	9.8	124	7.4	7	21	91	9.1	690	14	73	C
8/20/03	2	27	9.8	122	21.7	6	39	90	9.0	690	14	69	D
8/20/03	2-5	27	9.6	120	---	---	32	91	9.1	680	13	---	---
8/20/03	2-10	26	4.9	53	---	---	32	94	8.8	680	12	---	---
8/20/03	2-15	22	0.0	0	---	---	35	103	8.0	690	19	---	---
8/20/03	2-20	16	0.0	0	---	---	11	120	7.7	720	30	---	---
8/20/03	3	28	11.6	147	5.3	7	39	88	9.2	680	14	71	C
8/20/03	4	27	11.6	145	11.4	7	28	90	9.2	690	13	68	D
8/20/03	5	28	10.4	132	9.7	7	32	90	9.1	690	11	70	C
9/22/03	Inlet	---	---	---	---	---	161	---	---	1100	60	---	---
9/22/03	Oakland Beach	---	---	---	---	---	1385	---	---	1060	222	---	---
9/22/03	Dietz Spring	---	---	---	---	---	692	---	---	1060	11	---	---
9/22/03	2' drain	---	---	---	---	---	729	---	---	1040	60	---	---
9/22/03	PVC drain	---	---	---	---	---	434	---	---	1080	41	---	---
9/22/03	Long Pt.	---	---	---	---	---	3323	---	---	1080	189	---	---
9/22/03	Launch marsh	---	---	---	---	---	323	---	---	1060	450	---	---
9/22/03	Canal	---	---	---	---	---	166	---	---	1070	37	---	---
9/22/03	Canal road dr.	---	---	---	---	---	154	---	---	1050	138	---	---
9/22/03	Impales PVC	---	---	---	---	---	97	---	---	1020	357	---	---
4/20/07	1	---	---	---	4.9	6	63	117	7.6	620	19	84	B
4/20/07	2	---	---	---	3.5	6	63	122	7.6	640	19	86	B
4/20/07	3	---	---	---	5.2	6	63	120	7.9	620	20	84	B
8/23/07	1	24	9.1	107	7.4	9	12	93	8.6	660	25	83	B
8/23/07	2	23	9.1	111	6.6	9	13	93	8.6	660	17	84	B
8/23/07	3	24	10.3	109	5.0	9	11	90	8.8	660	18	83	B
8/23/07	4	24	9.2	108	5.6	9	11	90	8.8	650	25	81	B
8/23/07	5	24	9.6	112	5.0	9	10	90	8.9	640	21	81	B
4/13/08	1	---	---	---	4.9	7	47	130	7.6	580	25	84	B
4/13/08	2	---	---	---	3.7	6	49	127	7.6	620	19	85	B
4/13/08	3	---	---	---	3.7	7	49	118	7.4	600	22	85	B
4/13/08	4	---	---	---	4.5	6	48	116	7.4	600	20	84	B
4/13/08	5	---	---	---	3.2	6	47	125	7.5	620	20	85	B

Upper Long Lake Water Quality Data

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
4/13/08	1	---	---	---	4.9	7	47	130	7.6	580	25	84	B
4/13/08	2	---	---	---	3.7	6	49	127	7.6	620	19	85	B
4/13/08	3	---	---	---	3.7	7	49	118	74	600	22	85	B
4/13/08	4	---	---	---	4.5	6	48	116	7.4	600	20	84	B
4/13/08	5	---	---	---	3.2	6	47	125	7.5	620	20	85	B
8/13/08	1	24	9.7	114	3.4	10	28	89	8.6	610	22	87	B
8/13/08	2	24	9.4	111	4.3	10	28	94	8.6	600	20	86	B
8/13/08	3	24	9.6	114	3.4	10	34	89	8.9	590	19	77	C
8/13/08	4	24	9.6	113	3.1	10	28	91	8.6	590	21	88	B
8/13/08	5	24	10.8	127	3.1	11	34	90	8.7	590	21	84	B
3/17/09	1	---	---	---	2.4	8E	19	93	8.0	530	22	91	A
3/17/09	2	---	---	---	2.1	8E	19	93	8.0	530	23	92	A
3/17/09	3	---	---	---	1.4	8E	23	85	8.5	510	24	93	A
8/11/09	1	25	8.8	105	2.7	12	28	85	8.6	440	24	91	A
8/11/09	2	26	9.1	110	3.0	12	21	85	8.8	440	24	88	B
8/11/09	3	27	10.5	127	3.4	12	25	80	8.8	450	23	84	B
4/15/10	1	---	---	---	8.3	4	30	140	7.7	670	17	78	C
4/15/10	2	---	---	---	14.2	4	30	134	7.7	720	20	75	C
4/15/10	3	---	---	---	20.0	4	26	134	7.7	720	20	73	C
8/10/10	1	26	6.8	74	4.6	7	120	117	8.2	680	22	82	B
8/10/10	2	26	6.7	73	4.4	7	46	120	8.1	680	23	79	C
8/10/10	3	26	7.3	89	4.9	7	87	118	8.2	680	20	84	B