Introduction

The Adirondack Lake Assessment Program is a volunteer monitoring program established by the Residents' Committee to Protect the Adirondacks (RCPA) and the Adirondack Watershed Institute (AWI). The program is now in its' tenth year and continues to grow. The program was established to help develop a current database of water quality in Adirondack lakes and ponds. There were 74 participating lakes in the program in year 2007.

Methodology

Each month participants (trained by AWI staff) measured transparency with a secchi disk and collected a 2-meter composite of lake water for chlorophyll-a analysis and a separate 2-meter composite for total phosphorus and other chemical analyses. The participants filtered the chlorophyll-a sample prior to storage. Both the chlorophyll-a filter and water chemistry samples were frozen for transport to the laboratory at Paul Smith's College.

In addition to the volunteer samples, AWI staff sampled water quality parameters in most of the participating lakes as time and weather allowed. In most instances, a 2-meter composite of lake water was collected for chlorophyll-a analysis. Samples were also collected at depths of 1.5 meters from the surface (epilimnion) and within 1.5 meters of the bottom (hypolimnion) for chemical analysis. Once collected, samples were stored in a cooler and transported to the laboratory at Paul Smith's College.

All samples were analyzed by AWI staff in the Paul Smith's College laboratory using the methods detailed in *Standard Methods for the Examination of Water and Wastewater, 20th edition* (Greenberg, *et al*, 1999). Volunteer samples were analyzed for pH, alkalinity, conductivity, color, nitrate, chlorophyll a and total phosphorus concentrations. Samples taken by AWI staff were analyzed for the same parameters, as well as for calcium, chloride, and aluminum concentrations.

Results Summary

Lake Flower was sampled two times by a volunteer in 2007. Samples were collected on the following dates: 7/29/07, and 8/31/07. Results for 2007 are presented in Appendix A and will be discussed in the following sections. Results are presented as concentrations in milligrams per liter (mg/L) or its equivalent of parts per million (ppm) and micrograms per liter (μg/L) or its equivalent of parts per billion (ppb).

1 mg/L = 1 ppm; 1 μg/L = 1 ppb; 1 ppm = 1000 ppb.

Adirondack lakes are subject to the effects of acidic precipitation (i.e. snow, rain). A water body's susceptibility to acid producing ions is assessed by measuring pH, alkalinity, calcium concentrations, and the Calcite Saturation Index (CSI). These parameters define both the acidity of the water and its buffering capacity. Based on the results of the 2007 Adirondack Lakes Assessment program, the acidity status of Lake Flower is slightly impacted. The pH values are in the acceptable range and the alkalinity values show a lake that may be slightly impacted from acid rain.

Limnologists, the scientists who study bodies of fresh water, classify lake health (trophic status) into three main categories: oligotrophic, mesotrophic, and eutrophic. The trophic status of a lake is determined by measuring the level of three basic water quality parameters: total phosphorus, chlorophyll-a, and secchi disk transparency. These parameters will be defined in the sections that follow. Oligotrophic lakes are characterized as having low levels of total phosphorus, and, as a consequence, low levels of chlorophyll-a and high transparencies. Eutrophic lakes have high levels of total phosphorus and chlorophyll-a, and, as a consequence, low transparencies. Mesotrophic lakes have moderate levels of all three of these water quality parameters. Based upon the results of the 2007 Adirondack Lakes Assessment Program, Lake Flower is considered to be a mesotrophic water body.

Five years of data is sufficient to begin to detect water quality trends. In 2007, the color and chlorophyll-a values decreased from 2006. The total phosphorus, Secchi disk transparency, conductivity, pH, alkalinity, and nitrate values increased when compared to 2006. Over the last five years the water quality for Lake Flower has remained virtually unchanged with a few year to year variations. The biggest exceptions would be that the alkalinity has been increasing in recent years. This could be to an overall improvement in acid rain levels in the Adirondacks over the last decade as reported by the Department of Environmental Conservation. Also, conductivity levels seem to be quite high the last few years and this could be due to the use of road salt by NYS Department of Transportation along the road that rims the lake.

pH

The pH level is a measure of acidity (concentration of hydrogen ions in water), reported in standard units on a logarithmic scale that ranges from 1 to 14. On the pH scale, 7 is neutral, lower values are more acidic, and higher numbers are more basic. In general, pH values between 6.0 and 8.0 are considered optimal for the maintenance of a healthy lake ecosystem. Many species of fish and amphibians have difficulty with growth and reproduction when pH levels fall below 5.5 standard units. Lake acidification status can be assessed from pH as follows:

pH less than 5.0	Critical or Impaired
pH between 5.0 and 6.0	Endangered or Threatened
pH greater than 6.0	Satisfactory or Acceptable

The pH in the upper waters of Lake Flower ranged from 6.62 to 6.64. The average pH was 6.63. Based solely on pH, Lake Flower acidity levels should be considered satisfactory.

Alkalinity

Alkalinity (acid neutralizing capacity) is a measure of the buffering capacity of water, and in lake ecosystems refers to the ability of a lake to absorb or withstand acidic inputs. In the northeast, most lakes have low alkalinities, which mean they are sensitive to the effects of acidic precipitation. This is a particular concern during the spring when large amounts of low pH snowmelt runs into lakes with little to no contact with the soil's natural buffering agents. Alkalinity is reported in milligrams per liter (mg/L) or microequivelents per liter (μeq/L). Typical summer concentrations of alkalinity in northeastern lakes are around 10 mg/l (200 μeq/L). Lake acidification status can be assessed from alkalinity as follows:

Alkalinity less than 0 ppm	Acidified
Alkalinity between 0 and 2 ppm	Extremely sensitive
Alkalinity between 2 and 10 ppm	Moderately sensitive
Alkalinity between 10 and 25 ppm	Low sensitivity
Alkalinity greater than 25 ppm	Not sensitive

The alkalinity of the upper waters of Lake Flower was 19.8 ppm on both days of sampling in 2007. These values indicate a low sensitivity to acidification.

Calcium

Calcium is one of the buffering materials that occur naturally in the environment. However, it is often in short supply in Adirondack lakes and ponds, making these bodies of water susceptible to acidification by acid precipitation. Calcium concentrations provide information on the buffering capacity of that lake, and can assist in determining the timing and dosage for acid mitigation (liming) activities. Adirondack lakes containing less than 2.5 ppm of calcium are considered to be sensitive to acidification.

The calcium in the upper waters of Lake Flower was not measured due to the lack of a site visit by AWI staff.

Calcite Saturation Index

The Calcite Saturation Index (CSI) is another method that is used to determine the sensitivity of a lake to acidification. High CSI values are indicative of increasing sensitivity to acidic inputs. CSI is calculated using the following formula:

$$CSI = -\log_{10}\frac{Ca}{40000} - \log_{10}\frac{Alk}{50000} - pH + 2$$

Where *Ca* = Calcium level of water sample in ppm or mg/L
Alk = Alkalinity of the water sample in ppm or mg/L
pH = pH of the water sample in standard units

Lake sensitivity to acidic inputs is assessed from CSI as follows:

CSI greater than 4	Very vulnerable to acidic inputs
CSI between 3 & 4	Moderately vulnerable to acidic inputs
CSI less than 3	Low vulnerability to acidic inputs

CSI values for Lake Flower could not be calculated without calcium concentrations.

Total Phosphorus

Phosphorus is one of the three essential nutrients for life, and in northeastern lakes, it is often the controlling, or limiting, nutrient in lake productivity. Total phosphorus is a measure of all forms of phosphorus, both organic and inorganic. Total phosphorus concentrations are directly related to the trophic status (water quality conditions) of a lake. Excessive amounts of phosphorus can lead to algae blooms and a loss of dissolved oxygen within the lake. Surface water (epilimnion) concentrations of total phosphorus less than 10 ppb are associated with oligotrophic (clean, clear water) conditions. Concentrations greater than 25 ppb are associated with eutrophic (nutrient-rich) conditions.

The total phosphorus in the upper waters of Lake Flower ranged from 15 ppb to 23 ppb. The average concentration was 19 ppb. This is indicative of mesotrophic conditions.

Chlorophyll-a

Chlorophyll-a is the green pigment in plants used for photosynthesis, and measuring it provides information on the amount of algae (microscopic plants) in lakes. Chlorophyll-a concentrations are also used to classify a lakes trophic status. Concentrations less than 2 ppb are associated with oligotrophic conditions and those greater than 8 ppb are associated with eutrophic conditions.

The chlorophyll-a concentrations in the upper waters of Lake Flower ranged from 3.87 ppb to 6.98 ppb. The average concentration was 5.43 ppb. This is indicative of mesotrophic conditions.

Secchi Disk Transparency

Transparency is a measure of water clarity in lakes and ponds. It is determined by lowering a 20 cm black and white disk (Secchi) into a lake to the depth where it is no longer visible from the surface. This depth is then recorded in meters. Since algae are the main determinant of water clarity in non-stained, low turbidity (suspended silt) lakes, transparency are also used as an indicator of the trophic status of a body of water. Secchi disk transparencies greater than 4.6 meters (15.1 feet) are associated with oligotrophic conditions, while values less than 2 meters (6.6 feet) are associated with eutrophic conditions (DEC & FOLA, 1990).

Secchi disk transparency in Lake Flower ranged from 2.0 meters to 3.5 meters. The average transparency was 2.75 meters. These values are indicative of mesotrophic conditions.

Nitrate

Nitrogen is another essential nutrient for life. Nitrate is an inorganic form of nitrogen that is naturally occurring in the environment. It is also a component of atmospheric pollution. Nitrogen concentrations are usually less than 1 ppm in most lakes. Elevated levels of nitrate concentration may be indicative of lake acidification or wastewater pollution.

The nitrate values for Lake Flower were 0.2 ppm on both sampling dates in 2007.

Chloride

Chloride is an anion that occurs naturally in surface waters, though typically in low concentrations. Background concentrations of chloride in Adirondack Lakes are usually less than 1 ppm. Chloride levels 10 ppm and higher is usually indicative of pollution and, if sustained, can alter the distribution and abundance of aquatic plant and animal species. The primary sources of additional chloride in Adirondack lakes are road salt (from winter road de-icing) and wastewater (usually from faulty septic systems). The most salt impacted waters in the Adirondacks usually have chloride concentrations of 100 ppm or less.

The average chloride in the upper waters of Lake Flower was not measured due to lack of a site visit by AWI staff.

Conductivity

Conductivity is a measure of the ability of water to conduct electric current, and will increase as dissolved minerals build up within a body of water. As a result, conductivity is also an indirect measure of the number of ions in solution, mostly as inorganic substances. High conductivity values (greater than 50 μohms/cm) may be indicative of pollution by road salt runoff or faulty septic systems. Conductivities may be naturally high in water that drains from bogs or marshes. Eutrophic lakes often have conductivities near 100 μohms/cm, but may not be characterized by pollution inputs. Clean, clear-water lakes in our region typically have conductivities up to 30 μohms/cm, but values less than 50 μohms/cm are considered normal.

The conductivity in the upper waters of Lake Flower ranged from 55.7 μohms/cm to 68.9 μohms/cm. The average conductivity was 62.3 μohms/cm.

Color

The color of water is affected by both dissolved (e.g., metallic ions, organic acids) and suspended (e.g., silt and plant pigments) materials. Water samples are collected and compared to a set of standardized chloroplatinate solutions in order to assess the degree of coloration. The measurement of color is usually used in lake classification to describe the degree to which the water body is stained due to the accumulation of organic acids. The standard for drinking water color, as set by the United States Environmental Protection Agency (US EPA) using the platinum-cobalt method, is 15 Pt-Co. However, dystrophic lakes (heavily stained, often the color of tea) are common in this part of the country, and are usually found in areas with poorly drained soils and large amounts of coniferous vegetation (i.e., pines, spruce, hemlock). Dystrophic lakes usually have color values upwards of 75 Pt-Co.

Color can often be used as a possible index of organic acid content since higher amounts of total organic carbon (TOC) are usually found in colored waters. TOC is important because it can bond with aluminum in water, locking it up within the aquatic system and resulting in possible toxicity to fish (see Aluminum).

The color in the upper waters of Lake Flower ranged from 27 Pt-Co to 38 Pt-Co. The average color was 32.5 Pt-Co.

Aluminum

Aluminum is one of the most abundant elements found within the earth's crust. Acidic runoff (from rainwater and snowmelt) can leach aluminum out of the soil as it flows into streams and lakes. If a lake is acidic enough, aluminum may also be leached from the sediment at the bottom of it. Low concentrations of aluminum can be toxic to aquatic fauna in acidified water bodies, depending on the type of aluminum available, the amount of dissolved organic carbon available to bond with the aluminum, and the pH of the water. Aluminum can form thick mucus that has been shown to cause gill destruction in aquatic fauna (i.e., fish, insects) and, in cases of prolonged exposure, can cause mortality in native fish populations (Potter, 1982). Aluminum concentrations are reported as mg/L of total dissolved aluminum.

The average aluminum in the upper waters of Lake Flower was not measured due to lack of a site visit by AWI staff.

Dissolved Oxygen

The dissolved oxygen in a lake is an extremely important parameter to measure. If dissolved oxygen decreases as we approach the bottom of a lake we know that there is a great amount of bacterial decay that is going on. This usually means that there is an abundance of nutrients, like phosphorous that have collected on the lake bottom. Oligotrophic lakes tend to have the same amount of dissolved oxygen from the surface waters to the lake bottom, thus showing very little bacterial decay. Eutrophic lakes tend to have so much decay that their bottom waters will have very little dissolved oxygen. Cold-water fish need 6.0 ppm dissolved oxygen to thrive and reproduce. Warm water fish need 4.0 ppm oxygen.

The dissolved oxygen and temperature profiles for Lake Flower for 2007 were not measured due to lack of site visit by AWI staff.

Summary

Lake Flower was a moderately productive mesotrophic lake during 2007. Based on the results of the 2007 Adirondack Lakes Assessment program, the acidity status of Lake Flower is considered to be slightly threatened by further acidic inputs. The pH values are satisfactory; however, the alkalinity values indicate a slight sensitivity to acidification.

Five years of data is sufficient to begin to detect water quality trends. In 2007, the color and chlorophyll-a values decreased from 2006. The total phosphorus, Secchi disk transparency, conductivity, pH, alkalinity, and nitrate values increased when compared to 2006. Over the last five years the water quality for Lake Flower has remained virtually unchanged with a few year to year variations. The biggest exceptions would be that the alkalinity has been increasing in recent years. This could be to an overall improvement in acid rain levels in the Adirondacks over the last decade as reported by the Department of Environmental Conservation. Also, conductivity levels seem to be quite high the last few years and this could be due to the use of road salt by NYS Department of Transportation along the road that rims the lake.

Literature Cited

DEC & FOLA. (1990). Diet for a Small Lake: A New Yorker's Guide to Lake Management. New York State Department of Environmental Conservation & The Federation of Lake Associations, Inc.: Albany, New York.

Greenberg, A.E., Eaton, A.D., and Leseri, L.A. (editors). (1999). Standard Methods for the Examination of Water and Wastewater, 20th Edition. American Public Health Association: Washington, D.C.

Potter, W. (1982). *The Effects of Air Pollution and Acid Rain on Fish, Wildlife and Their Habitats – Lakes*. Technical Report FWS/OBS – 80/50.4. United States Fish and Wildlife Service, Biological Services Program: Washington, D.C.

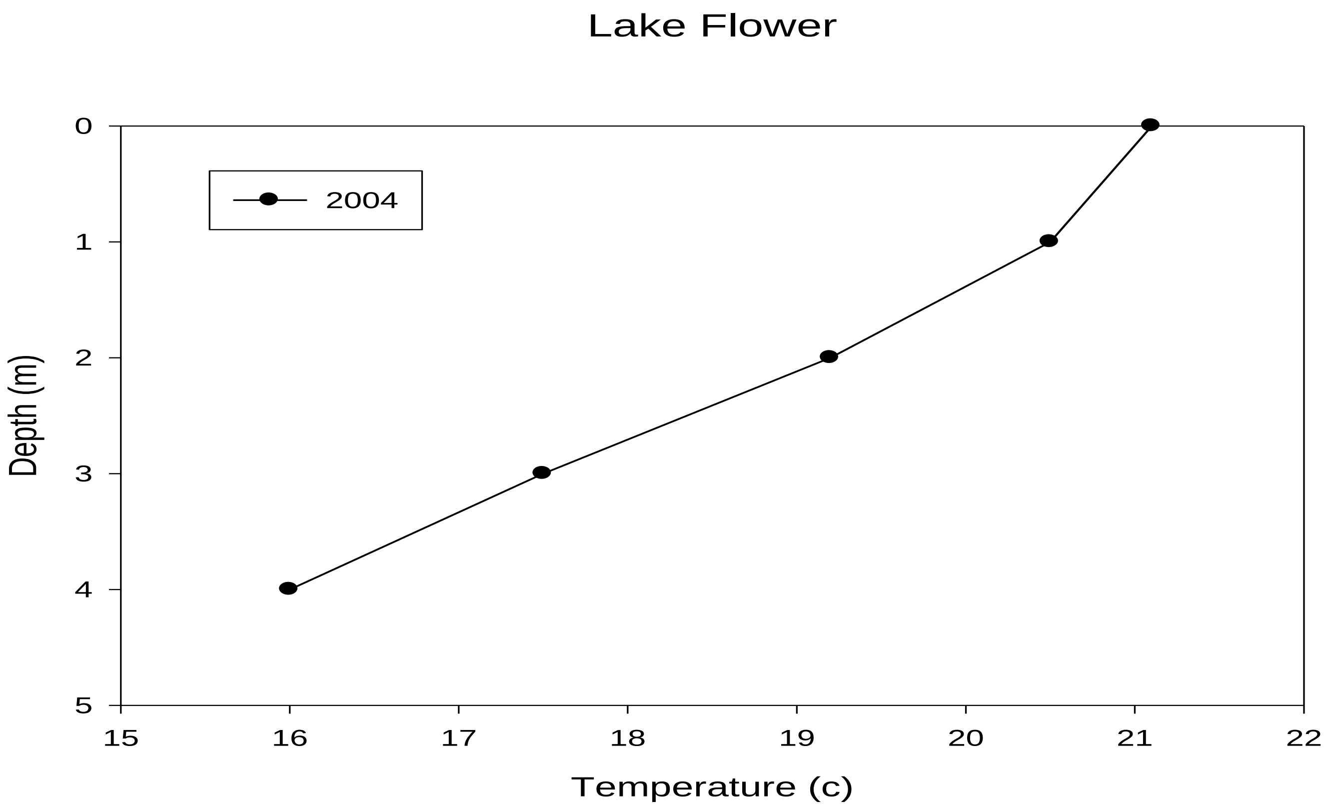
Appendix A

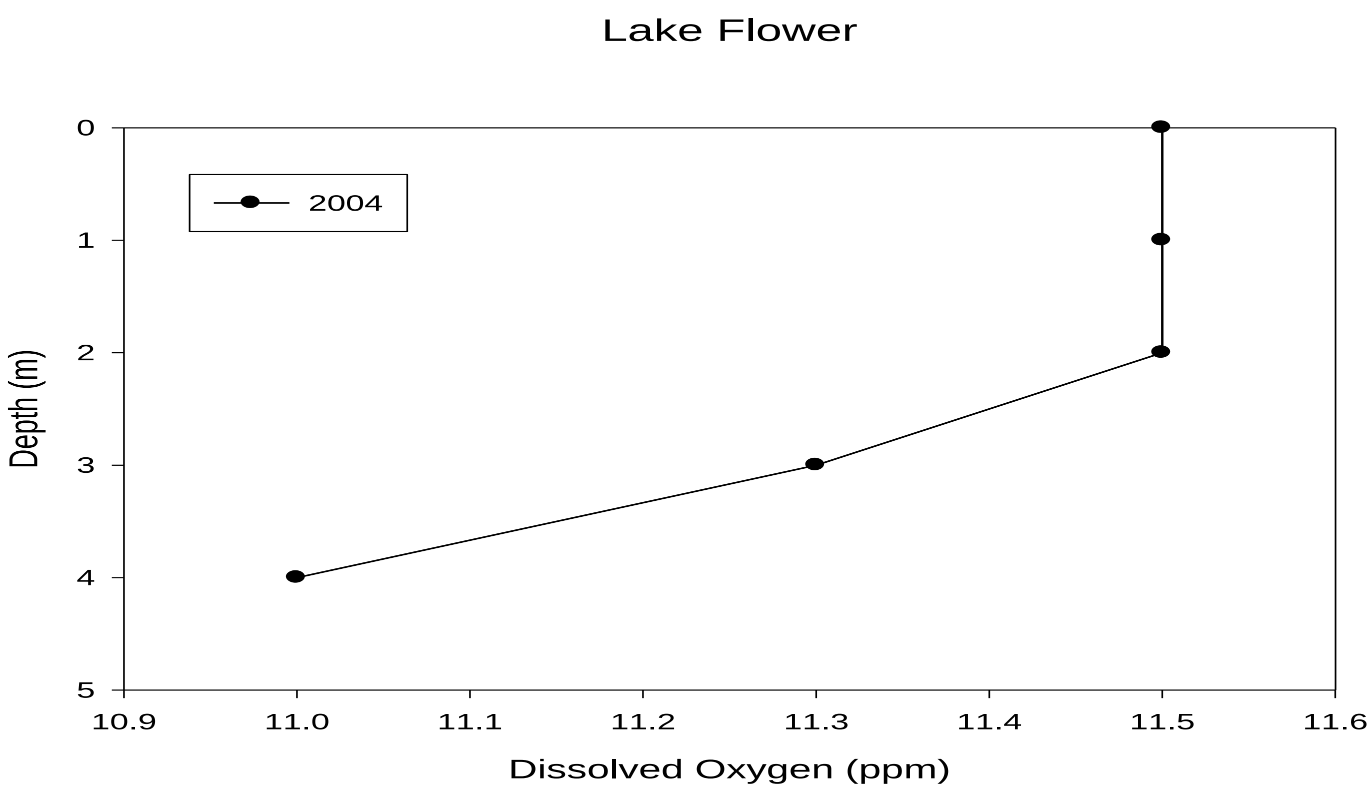
Water Quality Data

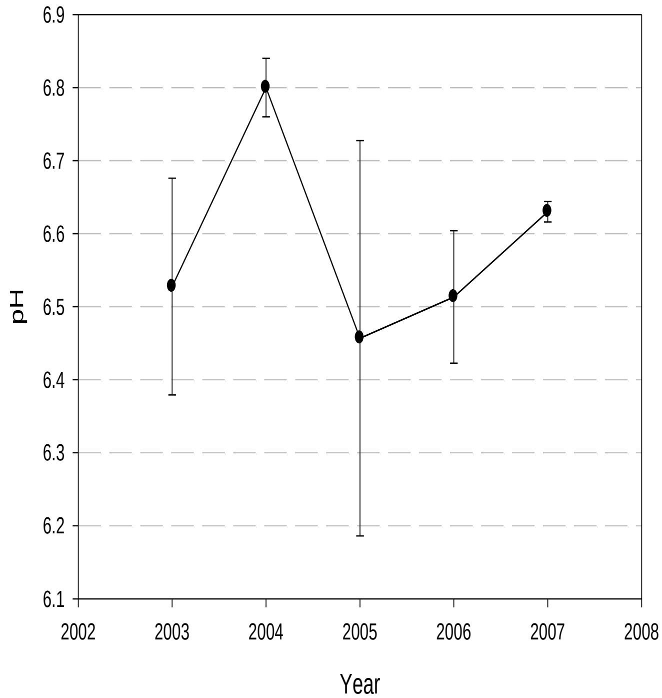
Source	Lake/Pond Name	Sampling Location	Sampling Date	pH (units)	Alkalinity (ppm)	Conductivity (μohms/cm)	Color (Pt-Co)	Total P (ppm)	Chl a (μg/l)
Vol	Lake Flower	Deephole	6/12/2003	6.6500	18.0000	59.0000	60.0000	0.0220	5.8400
Vol	Lake Flower	Deephole	7/26/2003	6.4600	10.0000	37.0000	99.0000	0.0150	4.2300
Vol	Lake Flower	Deephole	8/28/2003	6.6500	16.0000	28.0000	147.0000	0.0130	3.6700
Vol	Lake Flower	Deephole	9/26/2003	6.3500	10.0000	29.0000	20.0000	0.0180	4.9500
			Mean	6.5275	13.5000	38.2500	81.5000	0.0170	4.6725
			Std Dev	0.1484	4.1231	14.4078	54.2863	0.0039	0.9382
AWI	Lake Flower	Epilimnion	5/14/2004	6.8000	16.0000	38.0000	22.0000	0.0180	5.6000
Vol	Lake Flower	Deephole	7/19/2004	6.7600	14.0000	64.3000	41.0000	0.0130	10.2600
Vol	Lake Flower	Deephole	8/25/2004	6.8400	18.0000	63.2000	38.0000	0.0050	2.4300
			Mean	6.8000	16.0000	55.1667	33.6667	0.0120	6.0967
			Std Dev	0.0400	2.0000	14.8769	10.2144	0.0066	3.9386
AWI	Lake Flower	Hypolimnion	5/14/2004	6.7400	16.0000	42.0000	19.0000	0.0250	
Vol	Lake Flower	Deephole	6/26/2005	6.2400	5.6000	37.1000	34.0000	0.0190	6.1400
Vol	Lake Flower	Deephole	8/3/2005	6.3700	8.4000	54.5000	31.0000	0.0170	9.3800
Vol	Lake Flower	Deephole	9/28/2005	6.7600	6.0000	60.0000	24.0000	0.0190	3.7400
			Mean	6.4567	6.6667	50.5333	29.6667	0.0183	6.4200
			Std Dev	0.2706	1.5144	11.9542	5.1316	0.0012	2.8304
Vol	Lake Flower	Deephole	5/28/2006	6.6100	18.4000	54.5000	47.0000	0.0180	5.7100
Vol	Lake Flower	Deephole	7/6/2006	6.4300	10.0000	44.1000	81.0000	0.0210	6.8400
Vol	Lake Flower	Deephole	8/23/2006	6.5000	17.6000	54.4000	59.0000	0.0160	6.7100
			Mean	6.5133	15.3333	51.0000	62.3333	0.0183	6.4200
			Std Dev	0.0907	4.6361	5.9758	17.2434	0.0025	0.6183
Vol	Lake Flower	Deephole	7/29/2007	6.6400	19.8000	55.7000	27.0000	0.0150	3.8700
Vol	Lake Flower	Deephole	8/31/2007	6.6200	19.8000	68.9000	38.0000	0.0230	6.9800
Vol	Lake Flower	Deephole							
			Mean	6.6300	19.8000	62.3000	32.5000	0.0190	5.4250
			Std Dev	0.0141	0.0000	9.3338	7.7782	0.0057	2.1991

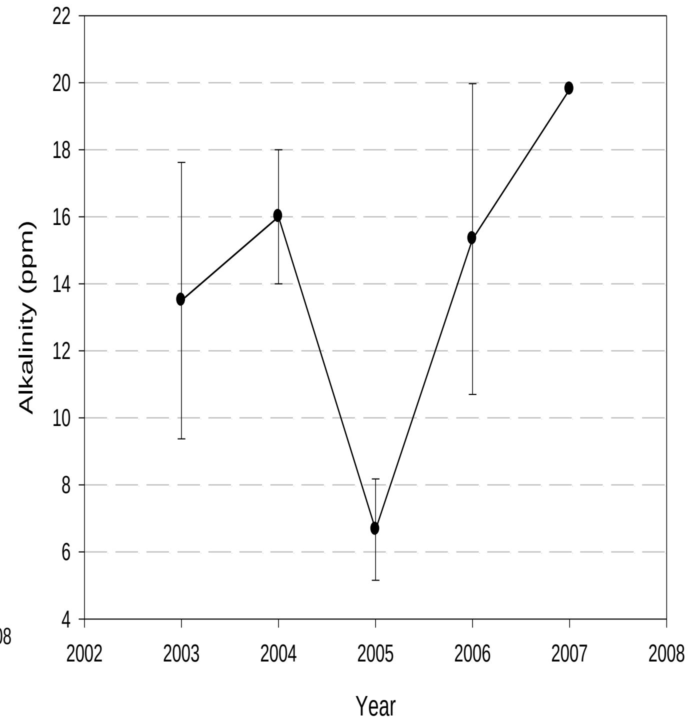
Source	Lake/Pond Name	Sampling Location	Sampling Date	Secchi (meters)	Nitrate (ppm)	Calcium (ppm)	Chloride (ppm)	Aluminum (ppm)	CSI
Vol	Lake Flower	Deephole	6/12/2003	1.4000	0.6000	5.1700	4.4000	0.0030	#REF!
Vol	Lake Flower	Deephole	7/26/2003	3.9000	0.9000	3.5700	2.6000	0.0050	#REF!
Vol	Lake Flower	Deephole	8/28/2003	4.2000	1.0000	4.5600	2.3000	0.0030	#REF!
Vol	Lake Flower	Deephole	9/26/2003	3.5000	0.5000	3.4200	2.3000	0.0070	#REF!
			Mean	3.2500	0.7500	4.1800	2.9000	0.0045	#REF!
			Std Dev	1.2662	0.2380	0.8315	1.0100	0.0019	#REF!
AWI	Lake Flower	Epilimnion	5/14/2004	2.6000	0.5000	5.0500	7.0000	0.0070	#REF!
Vol	Lake Flower	Deephole	7/19/2004	2.2000	0.0000				
Vol	Lake Flower	Deephole	8/25/2004	2.2000	0.1000				
			Mean	2.3333	0.2000				
			Std Dev	0.2309	0.2646				
AWI	Lake Flower	Hypolimnion	5/14/2004		0.6000	4.8900	9.0000	0.0050	#REF!
Vol	Lake Flower	Deephole	6/26/2005	2.2000	0.7000				
Vol	Lake Flower	Deephole	8/3/2005	2.6000	0.7000				

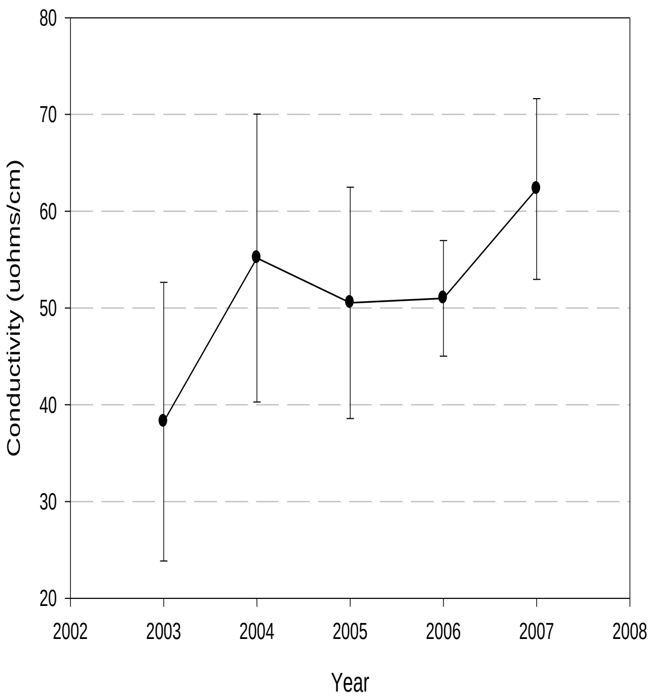
Vol	Lake Flower	Deephole	9/28/2005	2.2000	0.6000
			Mean	2.3333	0.6667
			Std Dev	0.2309	0.0577
Vol	Lake Flower	Deephole	5/28/2006	2.3000	0.2000
Vol	Lake Flower	Deephole	7/6/2006	2.0000	0.2000
Vol	Lake Flower	Deephole	8/23/2006	2.6000	0.0800
			Mean	2.3000	0.1600
			Std Dev	0.3000	0.0693
Vol	Lake Flower	Deephole	7/29/2007	3.5000	0.2000
Vol	Lake Flower	Deephole	8/31/2007	2.0000	0.2000
Vol	Lake Flower	Deephole			
			Mean	2.7500	0.2000
			Std Dev	1.0607	0.0000

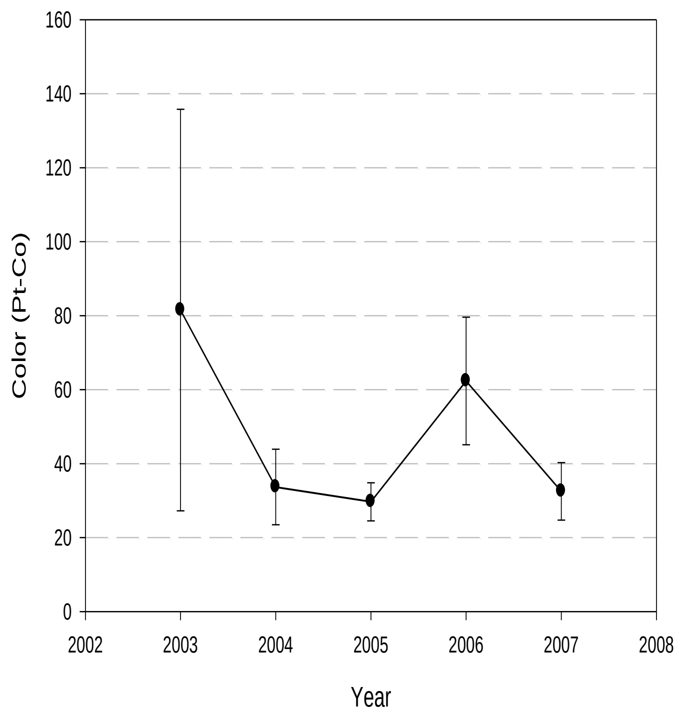

Lake Flower
2004
Depth (m)
0
1
2
3
4
5
15
16
17
18
19
20
21
22
Temperature (c)

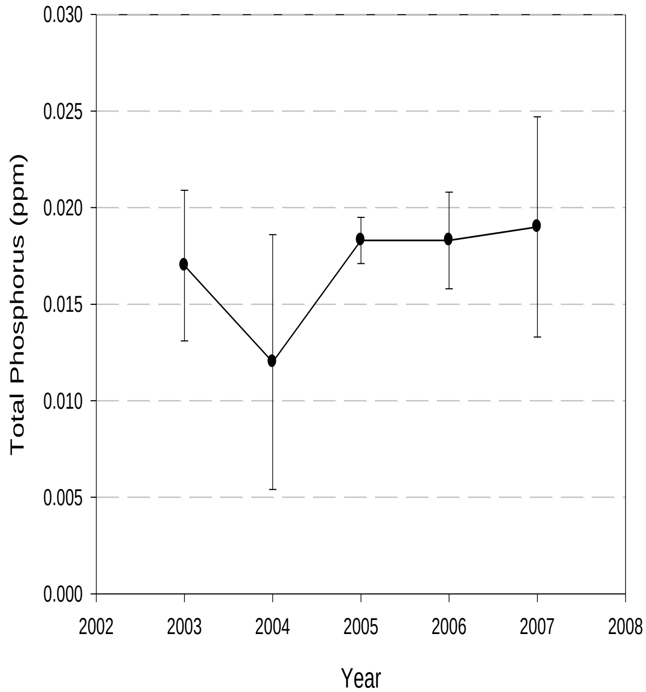

Lake Flower
2004
Depth (m)
0
1
2
3
4
5
10.9
11.0
11.1
11.2
11.3
11.4
11.5
11.6
Dissolved Oxygen (ppm)

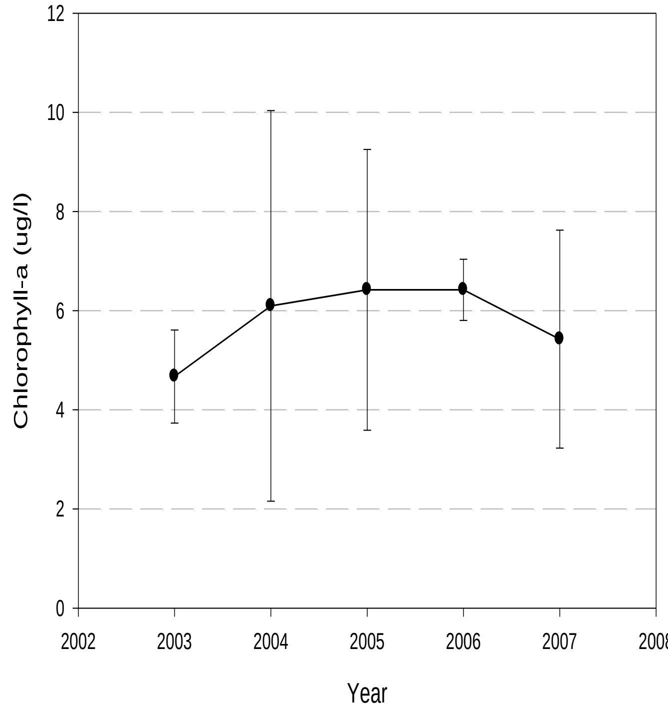

6.9
6.8
6.7
6.6
6.5
6.4
6.3
6.2
6.1
pH
2002
2003
2004
2005
2006
2007
2008
Year

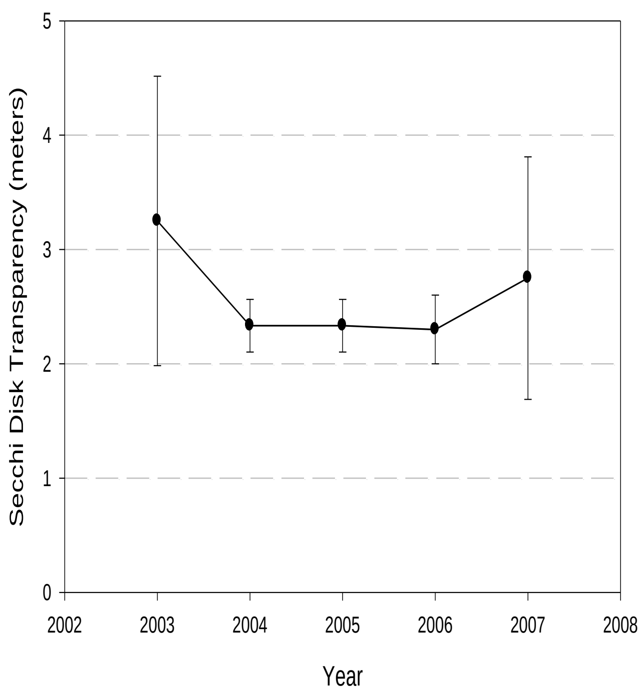

22
20
18
16
14
12
10
8
6
4
Alkalinity (ppm)
2002
2003
2004
2005
2006
2007
2008
Year

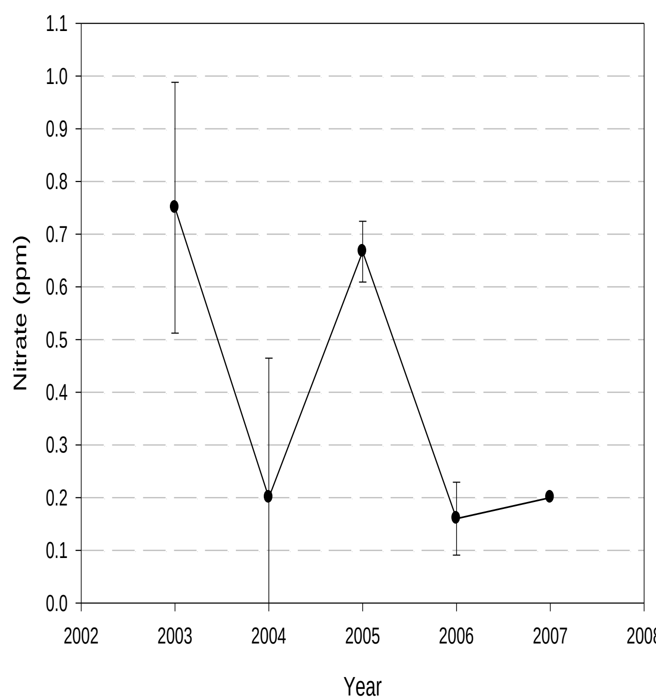

80
70
60
50
40
30
20
Conductivity (uohms/cm)
2002
2003
2004
2005
2006
2007
2008
Year


160
140
120
100
80
60
40
20
0
Color (Pt-Co)
2002
2003
2004
2005
2006
2007
2008
Year


Total Phosphorus (ppm)
0.030
0.025
0.020
0.015
0.010
0.005
0.000
2002
2003
2004
2005
2006
2007
2008
Year


Chlorophyll-a (ug/l)
12
10
8
6
4
2
0
2002
2003
2004
2005
2006
2007
2008
Year


Secchi Disk Transparency (meters)
5
4
3
2
1
0
2002
2003
2004
2005
2006
2007
2008
Year


Nitrate (ppm)
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2002
2003
2004
2005
2006
2007
2008
Year