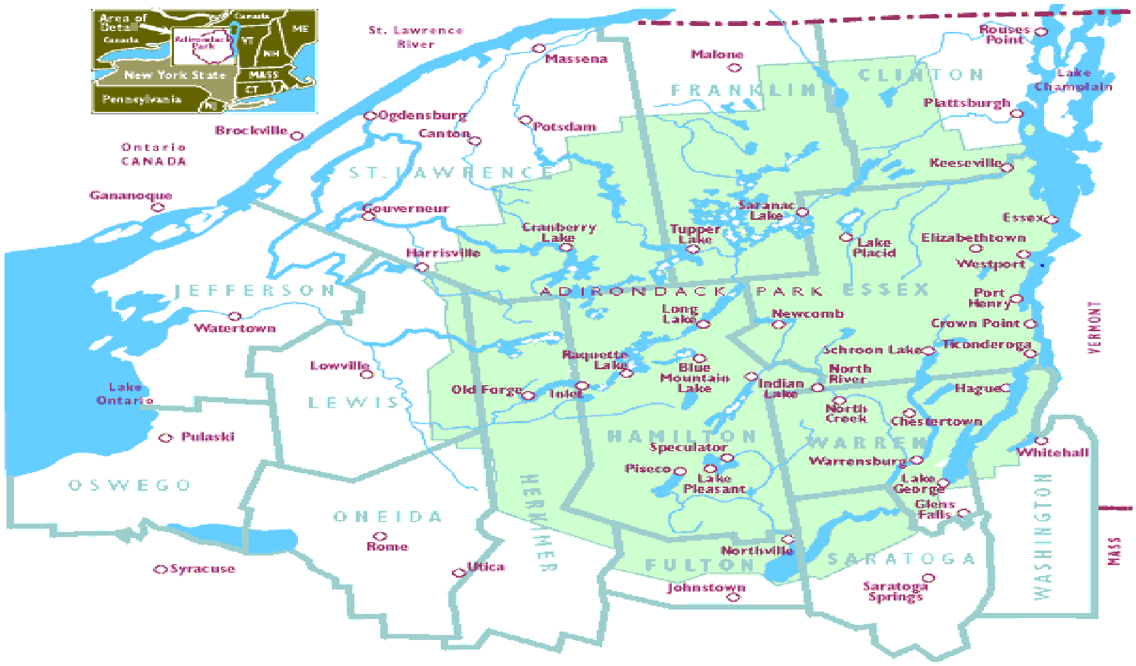
Adirondack Lake Assessment Program
2010



<u>**Thirteen Years in the program**</u>
Cranberry Lake, Loon Lake, Oven Mountain Pond, Blue Mountain Lake, Silver Lake, Eagle Lake
<u>**Twelve Years in the program**</u>
Little Long Lake, Gull Pond, Stony Creek Ponds, Thirteenth Lake, Eli Pond
<u>**Eleven Years in the program**</u>
Austin Pond, Osgood Pond, Middle Saranac Lake, White Lake, Brandreth Lake, Trout Lake
<u>**Ten Years in the program**</u>
Hoel Pond, Great Sacandaga Lake, Tripp Lake, Sherman Lake, Wolf Lake, Twitchell Lake, Deer Lake, Arbutus Pond, Rich Lake, Catlin Lake, Pine Lake, Lake of the Pines, Pleasant Lake
<u>**Nine Years in the program**</u>
Spitfire Lake, Upper St. Regis, Lower St. Regis, Garnet Lake, Lens Lake, Snowshoe Pond, Lake Ozonia, Long Pond, Lower Saranac Lake
<u>**Eight Years in the program**</u>
Raquette Lake, Lake Colby, Kiwassa Lake, Canada Lake
<u>**Seven Years in the program**</u>
Indian Lake, Schroon Lake, Lake Eaton, Chazy Lake, Big Moose Lake
<u>**Six Years in the program**</u>
Dug Mountain Pond, Seventh Lake, Abanakee Lake, Moss Lake, Mountain View Lake, Indian Lake, Tupper Lake
<u>**Five Years in the program**</u>
Sylvia Lake, Fern Lake
<u>**Four Years in the program**</u>
Adirondack Lake, Lower Chateaugay Lake, Upper Chateaugay Lake, Lake Easka, Lake Tekeni
<u>**Three Years in the program**</u>
Simon Pond
<u>**Two Years in the program**</u>
Amber Lake, Jordan Lake, Otter Pond, Rondaxe Lake
<u>**One Year in the program**</u>
Auger Lake, Lake Titus, Star Lake

Adirondack Lake

Assessment Program

Twitchell Lake

Summer 2010

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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' thirteenth year. The program was established to help develop a current database of water quality in Adirondack lakes and ponds. There were 70 participating lakes in the program in 2010.

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, 21st edition* (Greenberg, *et al*, 2005). 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

Twitchell Lake was sampled three times by a volunteer in 2010. Samples were collected on the following dates: 6/27/10, 7/25/10 and 8/28/10. Results for 2010 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 waterbody'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 2010 Adirondack Lake Assessment program, Twitchell Lake seems to be highly threatened by acidic inputs. The pH level indicates that the lake is highly threatened and the alkalinity levels show a moderate sensitivity to acidification. The calcium concentrations also show a lake that is sensitive to further acidic inputs.

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 2010 Adirondack Lake Assessment Program, Twitchell Lake is considered to mesotrophic in nature.

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 water of Twitchell Lake ranged from 5.81 to 5.90. The average pH was 5.84. Based solely on pH, Twitchell Lake should be considered endangered or threatened by further acidic inputs.

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 water of Twitchell Lake ranged from 2.0 ppm to 3.2 ppm and averaged 2.53 ppm. These values indicate a moderate sensitivity to further 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 levels in the upper waters of Twitchell Lake were measured and found to range from 1.17 to 1.18 ppm. The average calcium concentration in the upper waters was found to be 1.173 ppm. These values show a lake that is sensitive to further acidification.

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

The CSI value for Twitchell Lake for the upper waters was calculated and found to be 4.55. This shows us a lake that is very vulnerable to further acidic inputs.

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 water of Twitchell Lake ranged from 15 ppb to 21 ppb. The average concentration was 17.7 ppb. These levels are 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 water of Twitchell Lake ranged from 5.37 ppb to 6.01 ppb. The average concentration was 5.62 ppb. These levels are 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 is 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 Twitchell Lake ranged from 3.0 meters to 3.5 meters. The average transparency was 3.33 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 concentration in the upper water of Twitchell Lake ranged from 0.200 to 0.240 and the average was 0.220 ppm.

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. Chlorides levels 10 ppm and higher are 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 chloride levels for the upper waters of Twitchell ranged from 0.25 to 0.75 ppm. The average chloride concentration was a very low 0.58 ppm.

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 water of Twitchell Lake ranged from 8.25 μohms/cm to 9.22 μohms/cm. The average conductivity was 8.83 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 water of Twitchell Lake ranged from 27 Pt-Co to 39 Pt-Co and averaged 35.0 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 aluminum concentrations in Twitchell Lake were measured and found to be 0.130 ppm for all three samples collected.

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 Twitchell Lake for 2002 -2004 and 2008 are attached in Appendix A. During 2002, the temperature profile seems to be correct; the dissolved oxygen probe was malfunctioning during the site visit by AWI staff, so it is incorrect. The 2003, 2004 and 2008 dissolved oxygen profiles show that the dissolved oxygen decreases as we go below 6 meters in Twitchell Lake. The level becomes very low near the bottom and there does not appear to be enough dissolved oxygen present to support a cold water fish population.

Summary

Twitchell Lake was a moderately productive mesotrophic lake during 2010. Based on the results of the 2010 Adirondack Lake Assessment program, Twitchell Lake seems to be highly threatened by acidic inputs. The pH level indicates that the lake is highly threatened and the alkalinity levels show a moderate sensitivity to acidification. The calcium concentrations also show a lake that is sensitive to further acidic inputs.

With ten years of testing there is sufficient data to detect water quality trends, and it is possible to compare the current data with the data collected in 2001- 2009. The pH levels for the last ten years have been very low but there has been improvement in recent years. The alkalinity levels have increased slightly, most likely due to the improvement in acid levels in Adirondack rain water over the last decade. All other parameters have seen year to year fluctuations but with no significant trends.

Literature Cited

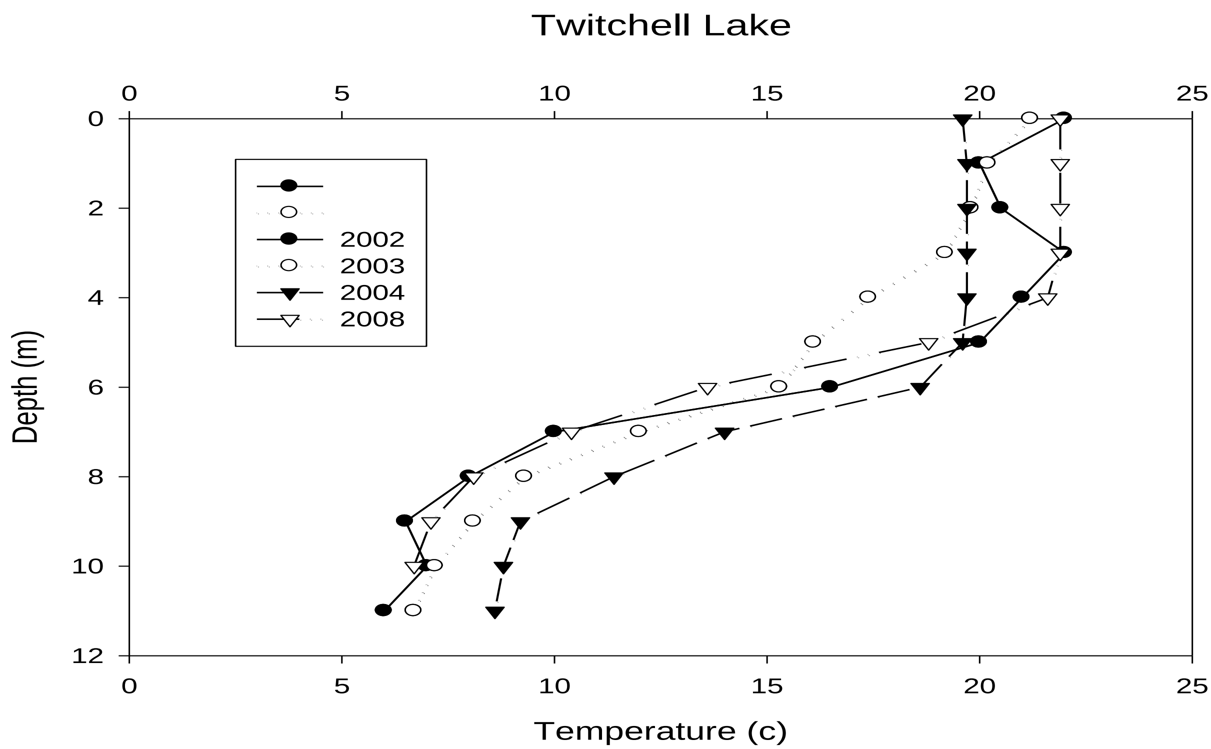
DEC & FOLA. (1990). Diet for a Small Lake: A New Yorker's Guide to Lake Management. New York State Department of Environmental Conservation & The Federation of Lake Associations, Inc.: Albany, New York.

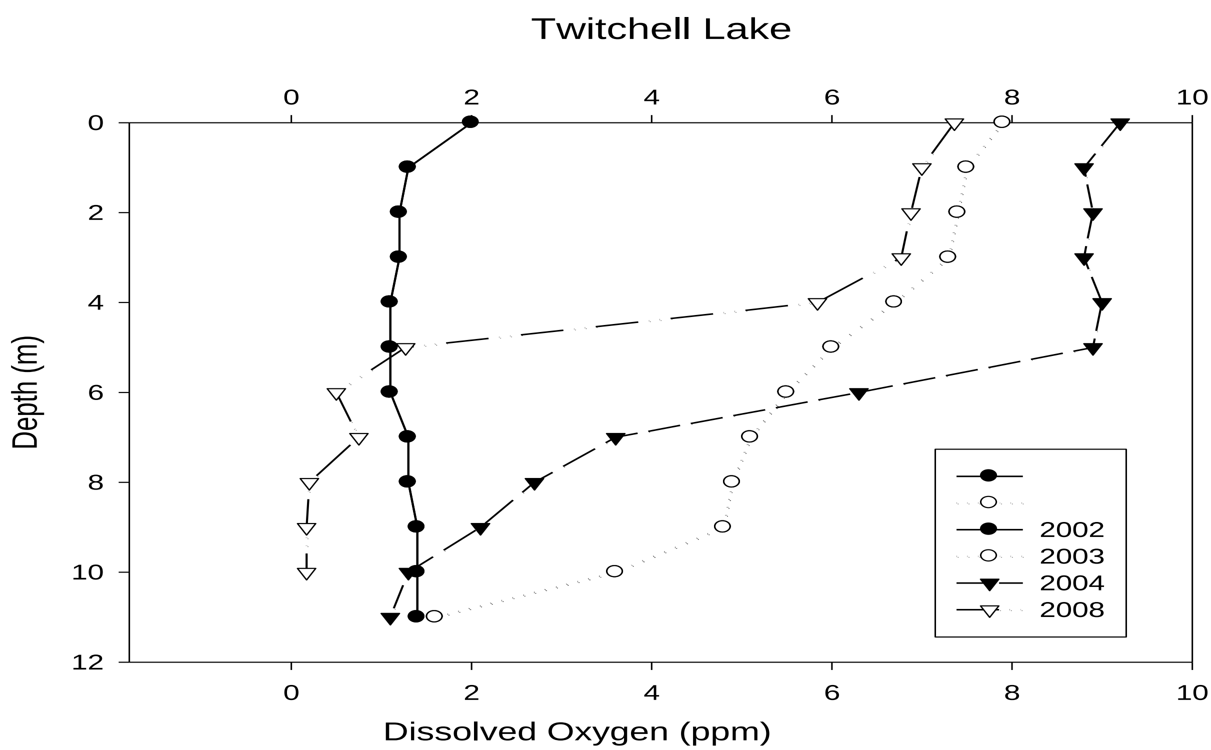
Greenberg, A.E., Eaton, A.D., and Leseri, L.A. (editors). (2005). Standard Methods for the Examination of Water and Wastewater, 21st Edition. American Public Health Association: Washington, D.C.

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


Twitchell Lake
2002
2003
2004
2008
Depth (m)
Temperature (c)


Twitchell Lake
2002
2003
2004
2008
Depth (m)
Dissolved Oxygen (ppm)

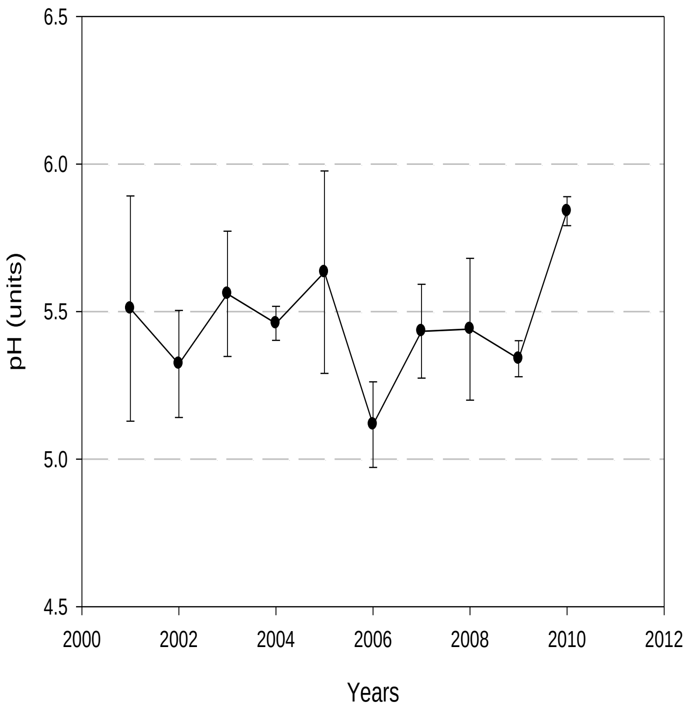
Source	Lake/Pond Name	Sampling Location	Sampling Date	pH (units)	Alkalinity (ppm)	Conductivity (μohms/cm)	Color (Pt-Co)	Total P (ppm)	Chl a (μg/l)
Vol	Twitchell Lake	Deephole	8/26/2001	5.2400	0.6000	14.6000	10.0000	0.0210	9.0700
Vol	Twitchell Lake	Deephole	10/6/2001	5.7800	1.2000	11.1000	12.0000	0.0600	1.5100
			MEAN	5.5100	0.9000	12.8500	11.0000	0.0405	5.2900
			Std Dev	0.3818	0.4243	2.4749	1.4142	0.0276	5.3457
AWI	Twitchell Lake	Epilimnion	8/23/2002	5.4100	1.2000	15.2000	25.0000	0.0400	3.8500
Vol	Twitchell Lake	Deephole	6/26/2002	5.0800	0.2000	17.3000	25.0000	0.0300	4.1400
Vol	Twitchell Lake	Deephole	7/27/2002	5.3000	0.6000	15.7000	26.0000	0.0300	2.7800
Vol	Twitchell Lake	Deephole	8/23/2002	5.5000	1.2000	14.3000	23.0000	0.0400	3.9600
			MEAN	5.3225	0.8000	15.6250	24.7500	0.0350	3.6825
			Std Dev	0.1812	0.4899	1.2580	1.2583	0.0058	0.6134
AWI	Twitchell Lake	Hypolimnion	8/23/2002	5.4000	2.6000	17.5000	121.0000	0.0600	
AWI	Twitchell Lake	Epilimnion	6/23/2003	5.5600	2.0000	16.0000	21.0000	0.0130	2.8400
Vol	Twitchell Lake	Deephole	6/23/2003	5.3100	2.0000	17.0000	38.0000	0.0130	1.9400
Vol	Twitchell Lake	Deephole	7/26/2003	5.5500	2.0000	19.0000	24.0000	0.0120	2.4500
Vol	Twitchell Lake	Deephole	8/23/2003	5.8300	2.0000	11.0000	0.0000	0.0110	1.7300
			Mean	5.5625	2.0000	15.7500	20.7500	0.0123	2.2400
			Std Dev	0.2125	0.0000	3.4034	15.6924	0.0010	0.5014
AWI	Twitchell Lake	Hypolimnion	6/23/2003	5.1500	2.0000	17.0000	46.0000	0.0160	
AWI	Twitchell Lake	Epilimnion	8/20/2004	5.4100	2.0000	22.8000	10.0000	0.0180	5.6700
Vol	Twitchell Lake	Deephole	6/13/2004	5.5100	2.0000	20.5000	10.0000	0.0150	2.2700
Vol	Twitchell Lake	Deephole	7/24/2004	5.5100	2.0000	20.1000	10.0000	0.0170	3.1200
Vol	Twitchell Lake	Deephole	8/20/2004	5.4100	1.2000	23.7000	10.0000	0.0190	5.7100
			Mean	5.4600	1.8000	21.7750	10.0000	0.0173	4.1925
			Std Dev	0.0577	0.4000	1.7500	0.0000	0.0017	1.7637
AWI	Twitchell Lake	Hypolimnion	8/20/2004	5.3500	2.0000	22.6000	37.0000	0.0340	
Vol	Twitchell Lake	Deephole	6/18/2005	5.3200	1.2000	16.9000	15.0000	0.0130	3.0500
Vol	Twitchell Lake	Deephole	7/23/2005	5.5800	1.2000	14.0000	17.0000	0.0140	2.7100
Vol	Twitchell Lake	Deephole	8/27/2005	6.0000	2.0000	14.4000	40.0000	0.0170	4.2700
			Mean	5.6333	1.4667	15.1000	24.0000	0.0147	3.3433
			Std Dev	0.3431	0.4619	1.5716	13.8924	0.0021	0.8203
Vol	Twitchell Lake	Deephole	6/18/2006	5.2100	1.4000	14.0000	6.0000	0.0150	5.7100
Vol	Twitchell Lake	Deephole	7/23/2006	4.9500	0.4000	13.1000	11.0000	0.0190	6.7500
Vol	Twitchell Lake	Deephole	8/13/2006	5.1900	1.2000	12.8000	20.0000	0.0190	7.0800
			Mean	5.1167	1.0000	13.3000	12.3333	0.0177	6.5133
			Std Dev	0.1447	0.5292	0.6245	7.0946	0.0023	0.7150
Vol	Twitchell Lake	Deephole	6/17/2007	5.2500	1.8000	12.2000	10.0000	0.0170	5.7100
Vol	Twitchell Lake	Deephole	7/17/2007	5.5200	3.4000	12.8000	31.0000	0.0160	5.8900
Vol	Twitchell Lake	Deephole	8/19/2007	5.5300	3.6000	11.8000	46.0000	0.0150	4.5600
			Mean	5.4333	2.9333	12.2667	29.0000	0.0160	5.3867
			Std Dev	0.1589	0.9866	0.5033	18.0831	0.0010	0.7215

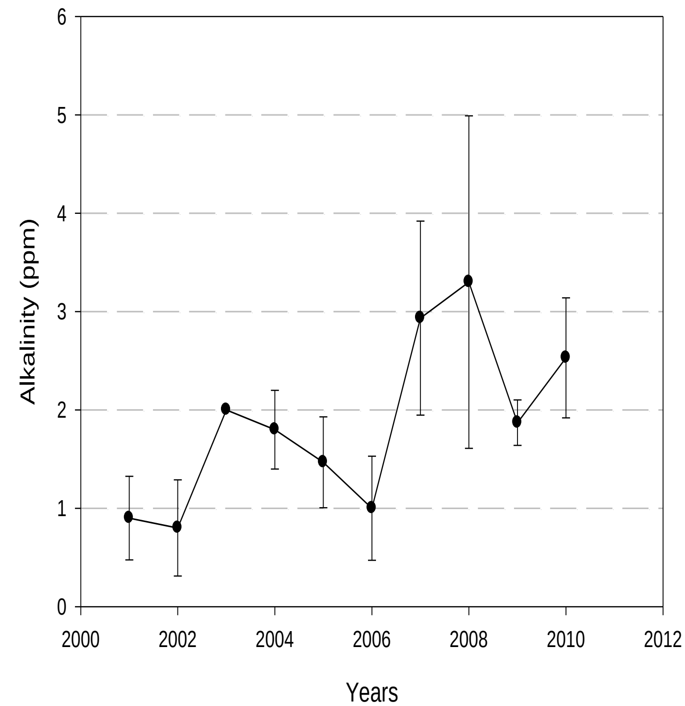
AWI	Twitchell Lake	Epilimnion	8/4/2008	5.6500	4.4000	12.5000	39.0000	0.0150	4.6000
Vol	Twitchell Lake	Deephole	6/22/2008	5.5800	3.8000	12.0000	28.0000	0.0210	6.6700
Vol	Twitchell Lake	Deephole	7/26/2008	5.4200	4.2000	12.8000	27.0000	0.0180	5.1000
Vol	Twitchell Lake	Deephole	8/24/2008	5.1100	0.8000	10.8000	22.0000	0.0180	5.8800
			Mean	5.4400	3.3000	12.0250	29.0000	0.0180	5.5625
			Std Dev	0.2401	1.6852	0.8808	7.1647	0.0024	0.9070
AWI	Twitchell Lake	Hypolimnion	8/4/2008	6.1600	9.2000	23.0000	33.0000	0.0240	X

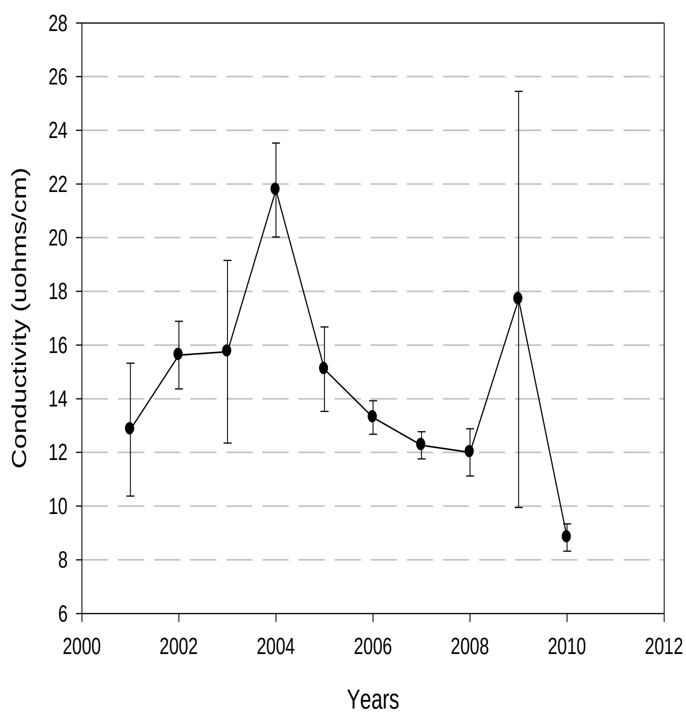
Source	Lake/Pond Name	Sampling Location	Sampling Date	pH (units)	Alkalinity (ppm)	Conductivity (μohms/cm)	Color (Pt-Co)	Total P (ppm)	Chl a (μg/l)
Vol	Twitchell Lake	Deephole	6/28/2009	5.2700	1.6000	26.6000	17.0000	0.0210	6.2500
Vol	Twitchell Lake	Deephole	7/25/2009	5.3700	2.0000	13.6000	21.0000	0.0170	5.4500
Vol	Twitchell Lake	Deephole	8/22/2009	5.3800	2.0000	12.8000	68.0000	0.0150	4.7600
			Mean	5.3400	1.8667	17.6667	35.3333	0.0177	5.4867
			Std Dev	0.0608	0.2309	7.7468	28.3608	0.0031	0.7457
Vol	Twitchell Lake	Deephole	6/27/2010	5.8100	2.4000	9.0200	27.0000	0.0170	6.0100
Vol	Twitchell Lake	Deephole	7/25/2010	5.9000	3.2000	9.2200	39.0000	0.0140	5.3700
Vol	Twitchell Lake	Deephole	8/28/2010	5.8200	2.0000	8.2500	39.0000	0.0140	5.4700
			Mean	5.8433	2.5333	8.8300	35.0000	0.0150	5.6167
			Std Dev	0.0493	0.6110	0.5122	6.9282	0.0017	0.3443

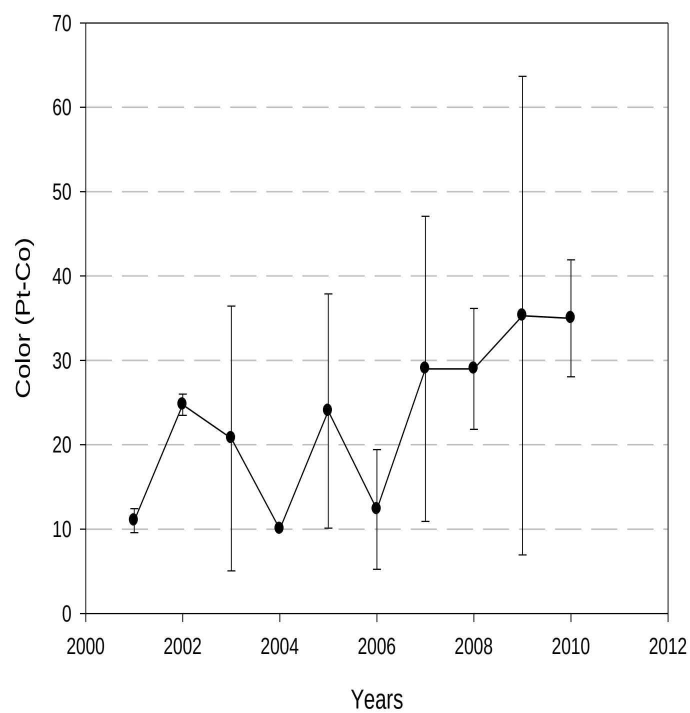
Source	Lake/Pond Name	Sampling Location	Sampling Date	Secchi (meters)	Nitrate (ppm)	Calcium (ppm)	Chloride (ppm)	Aluminum (ppm)	CSI
Vol	Twitchell Lake	Deephole	8/26/2001	2.5000	0.1000				
Vol	Twitchell Lake	Deephole	10/6/2001	3.0000	0.1000				
			MEAN	2.7500	0.1000				
			Std Dev	0.3536	0.0000				
AWI	Twitchell Lake	Epilimnion	8/23/2002	3.5000	0.2000	1.6200	0.0000	0.0100	5.6000
Vol	Twitchell Lake	Deephole	6/26/2002	3.0000	0.3000				
Vol	Twitchell Lake	Deephole	7/27/2002	4.0000	0.3000				
Vol	Twitchell Lake	Deephole	8/23/2002	3.3000	0.2000				
			MEAN	3.4500	0.2500				
			Std Dev	0.4203	0.0577				
AWI	Twitchell Lake	Hypolimnion	8/23/2002		0.5000	1.9400	0.0000	0.0500	5.2000
AWI	Twitchell Lake	Epilimnion	6/23/2003	3.8000	0.0600	1.7300	5.0000	0.0960	5.2000
Vol	Twitchell Lake	Deephole	6/23/2003	4.6000	0.0700				
Vol	Twitchell Lake	Deephole	7/26/2003	4.6000	0.6000				
Vol	Twitchell Lake	Deephole	8/23/2003	4.5000	0.5000				
			Mean	4.3750	0.3075				
			Std Dev	0.3862	0.2830				
AWI	Twitchell Lake	Hypolimnion	6/23/2003		0.0900	1.3300	5.0000	0.1480	5.7500
AWI	Twitchell Lake	Epilimnion	8/20/2004		0.1000	1.5900	0.0000	0.0870	#REF!
Vol	Twitchell Lake	Deephole	6/13/2004	4.3000	0.2000				
Vol	Twitchell Lake	Deephole	7/24/2004	3.8000	0.2000				
Vol	Twitchell Lake	Deephole	8/20/2004	3.0000	0.3000				
			Mean	3.7000	0.2000				
			Std Dev	0.6557	0.0816				
AWI	Twitchell Lake	Hypolimnion	8/20/2004		0.2000	1.5200	0.0000	0.1320	#REF!

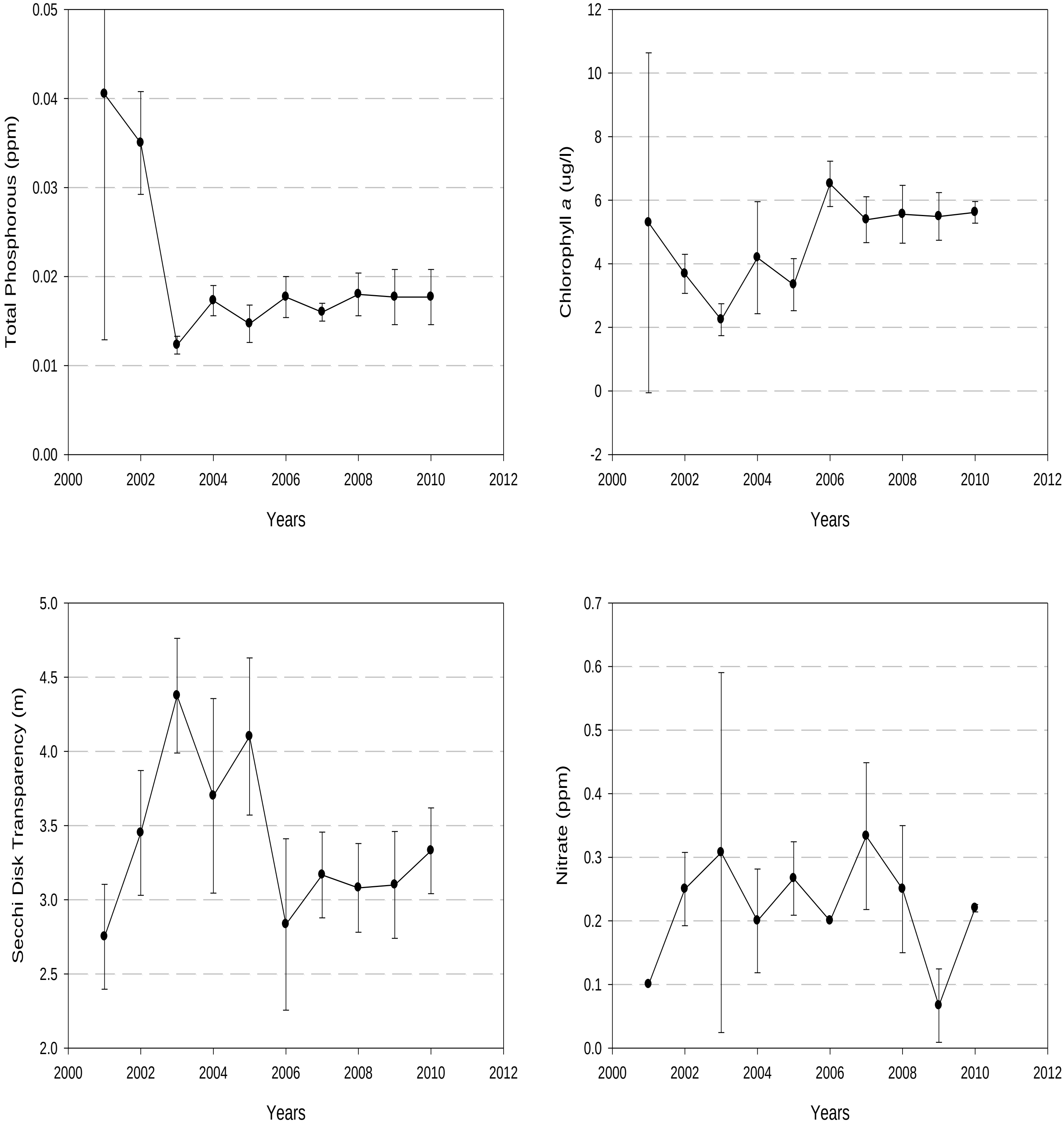
Vol	Twitchell Lake	Deephole	6/18/2005	4.3000	0.3000				
Vol	Twitchell Lake	Deephole	7/23/2005	4.5000	0.2000				
Vol	Twitchell Lake	Deephole	8/27/2005	3.5000	0.3000				
			Mean	4.1000	0.2667				
			Std Dev	0.5292	0.0577				
Vol	Twitchell Lake	Deephole	6/18/2006	3.5000	0.2000				
Vol	Twitchell Lake	Deephole	7/23/2006	2.5000	0.2000				
Vol	Twitchell Lake	Deephole	8/13/2006	2.5000	0.2000				
			Mean	2.8333	0.2000				
			Std Dev	0.5774	0.0000				
Vol	Twitchell Lake	Deephole	6/17/2007	3.0000	0.4000				
Vol	Twitchell Lake	Deephole	7/17/2007	3.0000	0.4000				
Vol	Twitchell Lake	Deephole	8/19/2007	3.5000	0.2000				
			Mean	3.1667	0.3333				
			Std Dev	0.2887	0.1155				
AWI	Twitchell Lake	Epilimnion	8/4/2008	3.5000	0.3000	1.9800	1.0000	0.0230	4.7000
Vol	Twitchell Lake	Deephole	6/22/2008	2.8000	0.1000				
Vol	Twitchell Lake	Deephole	7/26/2008	3.0000	0.3000				
Vol	Twitchell Lake	Deephole	8/24/2008	3.0000	0.3000				
			Mean	3.0750	0.2500				
			Std Dev	0.2986	0.1000				
AWI	Twitchell Lake	Hypolimnion	8/4/2008	X	0.2000	2.1800	1.0000	0.0210	
Source	Lake/Pond Name	Sampling Location	Sampling Date	Secchi (meters)	Nitrate (ppm)	Calcium (ppm)	Chloride (ppm)	Aluminum (ppm)	CSI
Vol	Twitchell Lake	Deephole	6/28/2009	2.7000	0.1000	1.3400	2.0000	0.1050	5.7000
Vol	Twitchell Lake	Deephole	7/25/2009	3.2000	0.1000				
Vol	Twitchell Lake	Deephole	8/22/2009	3.4000	0.0000				
			Mean	3.1000	0.0667				
			Std Dev	0.3606	0.0577				
Vol	Twitchell Lake	Deephole	6/27/2010	3.0000	0.2400	1.1700	0.7500	0.1300	
Vol	Twitchell Lake	Deephole	7/25/2010	3.5000	0.2200	1.1800	0.7500	0.1300	
Vol	Twitchell Lake	Deephole	8/28/2010	3.5000	0.2000	1.1700	0.2500	0.1300	
			Mean	3.3333	0.2200	1.1733	0.5833	0.1300	
			Std Dev	0.2887	0.0200	0.0058	0.2887	0.0000	

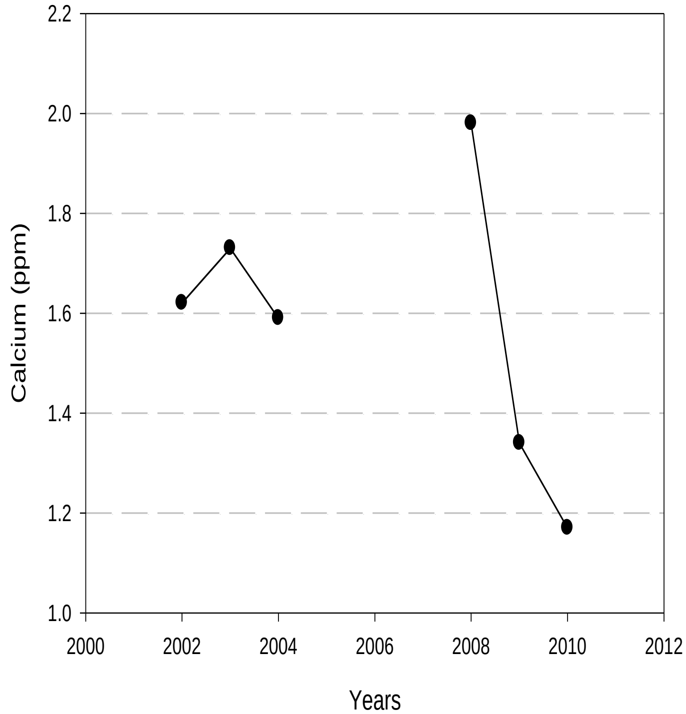

pH (units)
Years

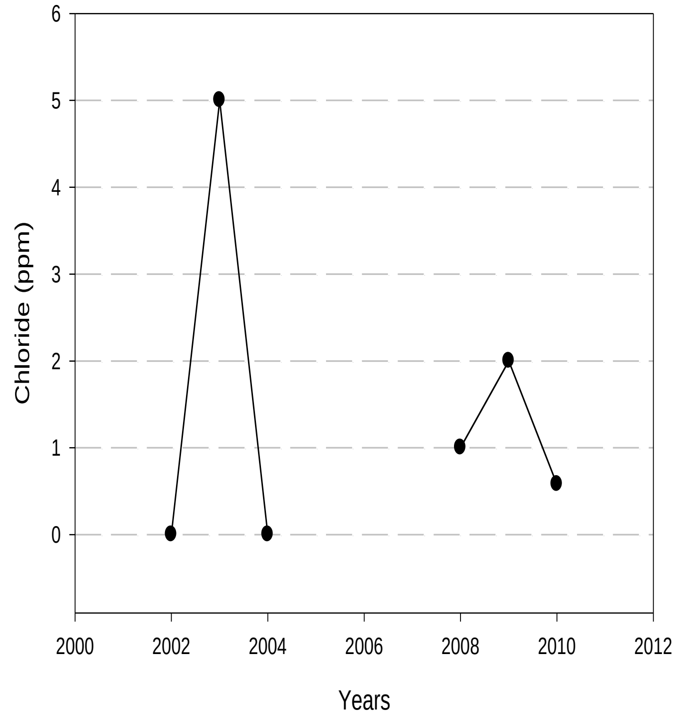

Alkalinity (ppm)
Years

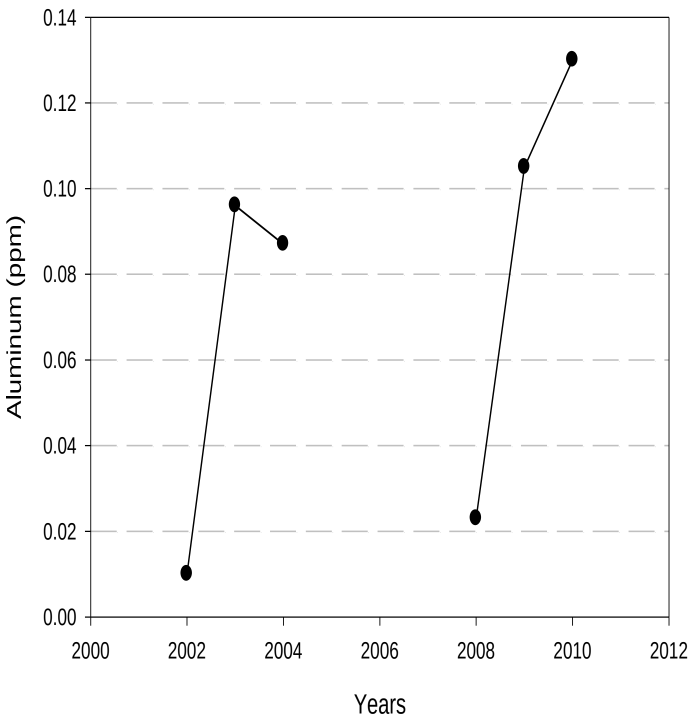

Conductivity (uohms/cm)
Years


Color (Pt-Co)
Years


Total Phosphorous (ppm)
Years
Chlorophyll a (ug/l)
Years
Secchi Disk Transparency (m)
Years
Nitrate (ppm)
Years


Calcium (ppm)
2.2
2.0
1.8
1.6
1.4
1.2
1.0
2000
2002
2004
2006
2008
2010
2012
Years


Chloride (ppm)
6
5
4
3
2
1
0
2000
2002
2004
2006
2008
2010
2012
Years


Aluminum (ppm)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
2000
2002
2004
2006
2008
2010
2012
Years