9353 Hill Road • Swartz Creek, MI 48473
(810) 635-4400 • Fax (810) 635-4404
www.lakeproinc.com

2013 Lower Long Lake Water Quality Review

Introduction:
The goals of this testing protocol were to monitor various water quality parameters of the lake, compare results to historical data, and identify any potential risks to the health of Lower Long Lake. Water samples were taken at four different locations and tested for 14 parameters. Tests were conducted on a monthly basis from April through August. Tests were conducted with a Hanna Multiparameter Water Quality Meter or LaMotte SMART2 Colorimeter.

Test results were compared to historical data. In this case, the historical data was from the report "2012 Lower Long Lake Water Quality Review" by LakePro, Inc.

General Discussion
Lower Long Lake's water quality remained in very good condition. The lake had some areas of concern, but most parameters improved from the previous summer.

The long term trends for the parameters should compliment each other to tell the story of how the lake is changing. Generally, increasing nutrients leads to more chlorophyll, which decreases transparency. In Lower Long Lake, the opposite has been true. Since testing began in 2011, the nutrient levels (Total Phosphorus, Phosphate, Nitrate) decreased and the Chlorophyll concentrations followed. Less plant production led to clearer water, evidenced by the increase in transparency over the years.

Plant management aided these trends. Mechanical harvesting removed nutrients while they were bound into plant material. This lowered the nutrient loads and reduced the internal recycling of nutrients. The reduction of nutrients was also due to the state ban on phosphorus-laden fertlizers and more responsible land management by residents within the lake's watershed.

The temperature of the lake decreased over the testing history, which drove the oxygen solubility higher. Correspondingly, the dissolved oxygen increased during this period. During all testing events, the oxygen concentrations remained sufficient to support a healthy fishery.

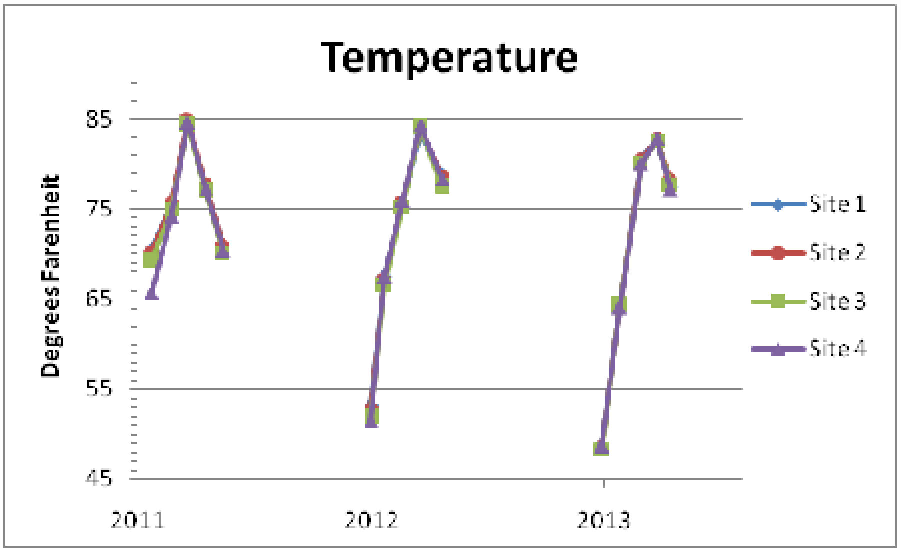
The water chemistry parameters (pH, TDS, Conductivity, Alkalinity) all decreased over the testing history but remained within their target ranges. This showed a general reduction in the load of dissolved molecules in the lake. This year, the alkalinity was near its lower limit, but should replenish as more groundwater enters the lake bringing in beneficial carbonate ions.

Finally, the Sulfate, Fluoride, and Chloride all have decreased since testing began. These were positive trends for the lake that coincided with the decrease of TDS. These parameters are all indicators of pollution, so it is important that they stay within their target ranges.

In summary, the water quality of Lower Long Lake was good and has shown improvement in most areas. The main priority of the lake should be to continue reducing the nutrient loads of the lake in order to prevent worsening of the plant growth.

Peter J. Filpansick, B.S.
Environmental Biologist
LakePro, Inc.

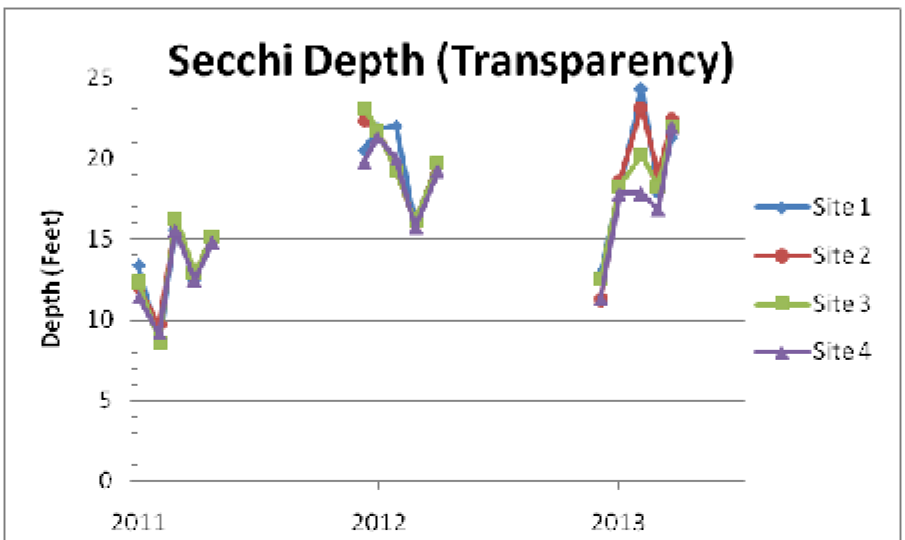
LakePro Inc.
9353 Hill Road • Swartz Creek, MI 48473
(810) 635-4400 • Fax (810) 635-4404
www.lakeproinc.com



(°F)	Site 1	Site 2	Site 3	Site 4
April	48.7	48.5	48.2	48.7
May	64.2	64.3	64.3	64.0
June	80.6	80.5	80.0	80.0
July	82.6	82.7	82.6	82.8
August	77.4	78.1	77.6	77.1

Discussion

Plants and algae usually begin their spring growth when water temperatures rise through 50's and reach 60 ˚F. The water temperatures of the lake were much better than in 2012, especially in April and May. The lake started very cool in April, keeping the plant growth down as long as possible. The cold start also helped ensure summer water temperatures were not extremely high.



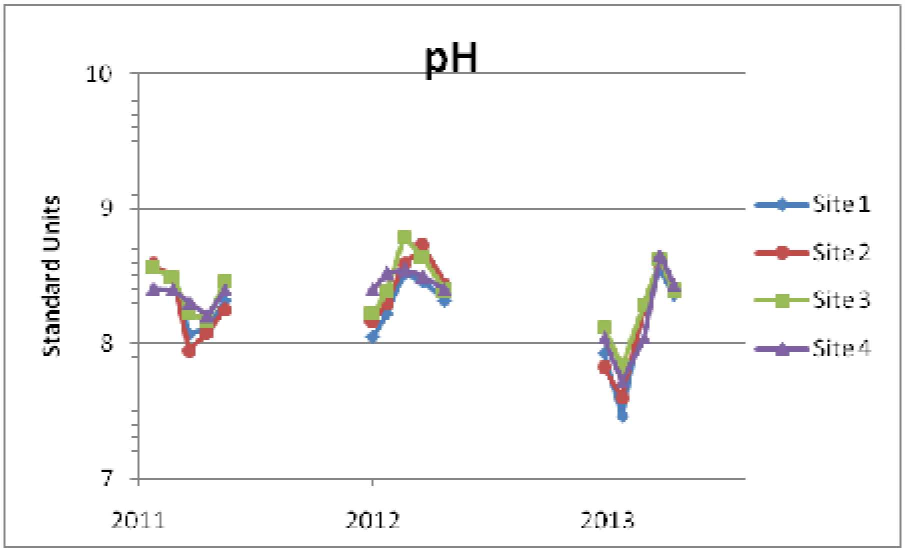
Target Range: >6.5 feet

Trophic State Index: 36
Trophic State: Oligotrophic

(feet)	Site 1	Site 2	Site 3	Site 4
April	12.9	11.2	12.5	11.3
May	18.1	18.6	18.3	17.8
June	24.3	23.1	20.2	17.8
July	17.9	19.0	18.2	16.8
August	21.3	22.4	22.0	21.9

Discussion

In April, the transparency was lower than usual, but increased quickly and stayed very high for the rest of the summer despite abundant rainfall that mixed the lake. The transparency also showed an upward trend from 2011 to 2013. This meant the clarity of the lake is improving which is generally good, but it could also lead to increases of plant growth due to increased sunlight penetration.

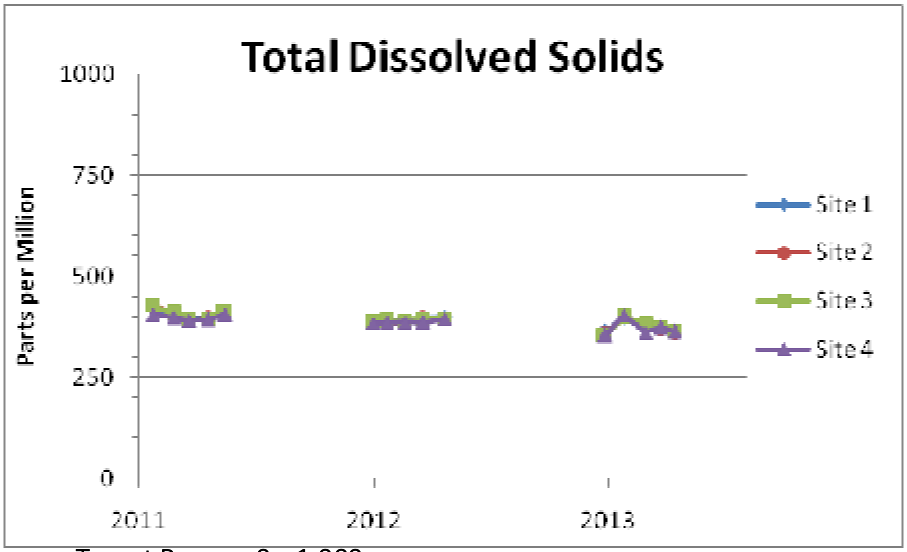


(S.U.)	Site 1	Site 2	Site 3	Site 4
April	7.93	7.82	8.12	8.04
May	7.46	7.60	7.83	7.72
June	8.30	8.26	8.29	8.04
July	8.55	8.61	8.63	8.66
August	8.36	8.41	8.39	8.44

Target Range: 7.0 – 9.0 S.U.

Discussion

The pH varied slightly throughout the summer, but no changes were severe enough to cause any negative impacts on aquatic life. The season average of 8.17 was normal for lower-Michigan lakes and slightly lower than in 2012. The pH showed a slightly downward trend from 2011 to 2013.



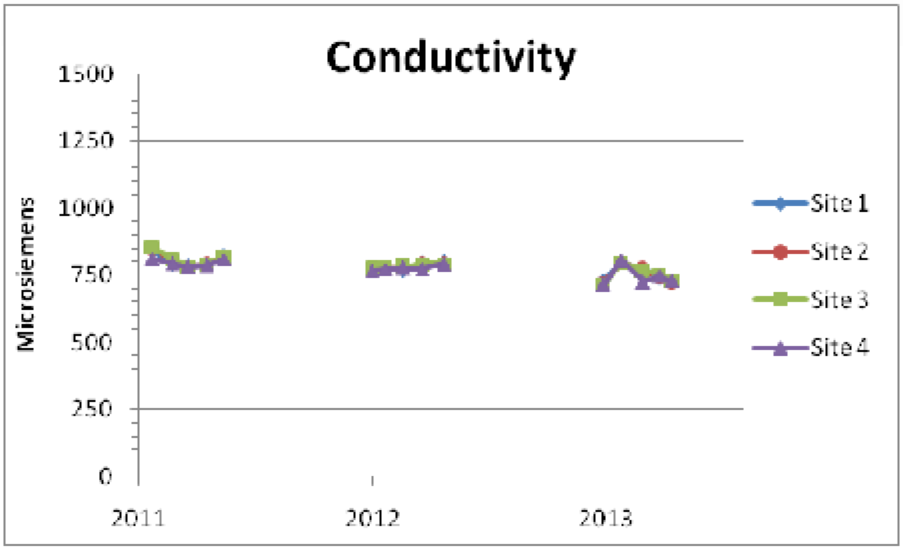
(ppm)	Site 1	Site 2	Site 3	Site 4
April	363	359	355	354
May	399	398	399	404
June	386	385	385	362
July	370	371	374	373
August	362	362	366	364

Target Range: 0 – 1,000 ppm

Discussion

From April to May there was an increase in TDS, likely because snowmelt and spring rains brought foreign substances into the lake. However, continued rain and the draining of the lake helped flush these excess molecules throughout the rest of the year. The season average of 375 indicated a decrease in total dissolved solids from 2012. Because the TDS measurement included nutrients and salt ions, this was a positive trend for the health of the lake.

9353 Hill Road • Swartz Creek, MI 48473
(810) 635-4400 • Fax (810) 635-4404
www.lakeproinc.com

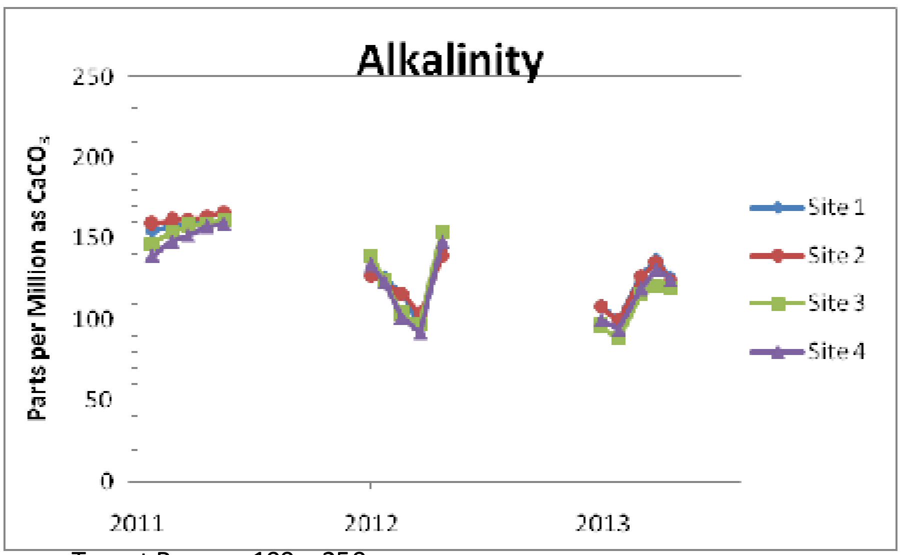


(µS)	Site 1	Site 2	Site 3	Site 4
April	731	722	715	713
May	798	797	797	807
June	772	771	769	726
July	741	743	749	747
August	725	725	731	729

Target Range: 0 – 1,500 µS

Discussion

The season average of 750 µS is a decrease from 2012. This confirmed the TDS readings that showed fewer ionic molecules (salts) in the water than last year and confirmed a positive trend for the lake.



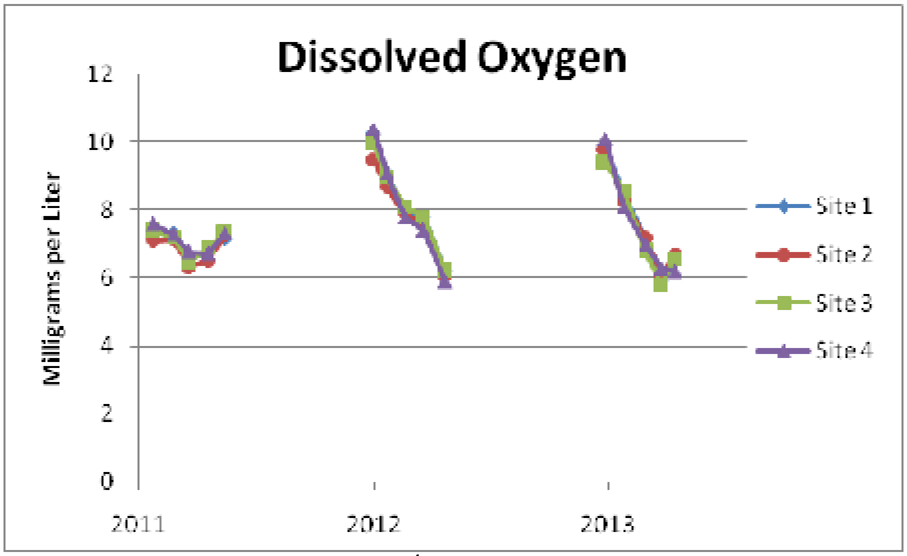
(ppm)	Site 1	Site 2	Site 3	Site 4
April	109	108	96	100
May	99	99	88	94
June	127	126	115	119
July	137	136	121	131
August	126	124	120	125

Target Range: 100 – 250 ppm

Discussion

The Alkalinity is normal for a freshwater lake. Alkalinity refers to the ability of the water to neutralize acids, mainly through the hydrogenation of carbonate ions. This is why the alkalinity is expressed as “ppm as $CaCO_3$”. The alkalinity decreased from last year, consistent with the downward trend of the pH. Both of these parameters were still within their target ranges, but it is important that the lake replenish its carbonate concentration to increase its alkalinity and ability to buffer against drastic changes in pH.

9353 Hill Road • Swartz Creek, MI 48473
(810) 635-4400 • Fax (810) 635-4404
www.lakeproinc.com

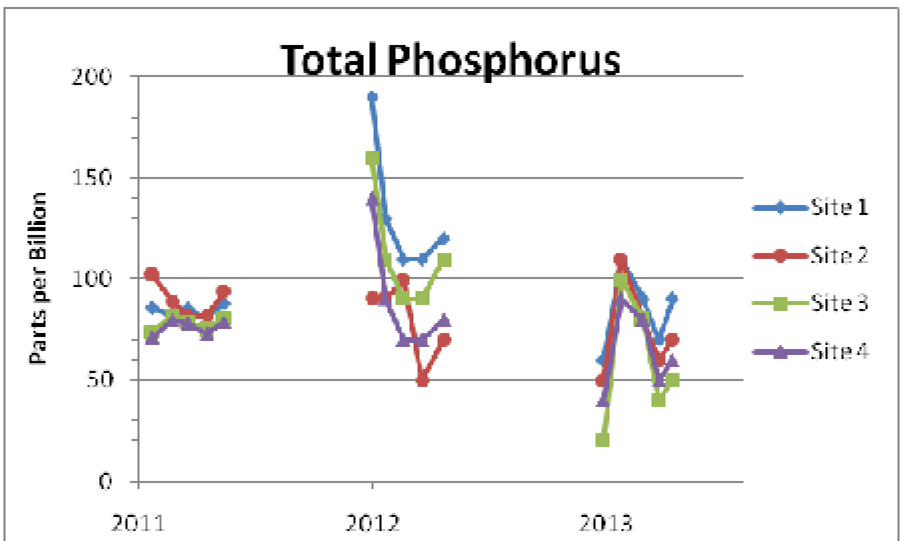


(mg/L)	Site 1	Site 2	Site 3	Site 4
April	9.9	9.8	9.4	10.1
May	8.5	8.3	8.6	8.1
June	7.2	7.2	6.8	7.0
July	5.9	6.1	5.8	6.3
August	6.5	6.7	6.6	6.2

Target Range: 4.0 – 12.0 mg/L

Discussion

The dissolved oxygen remained at a very healthy level most of the year. Oxygen dissolution is dependent upon water temperatures, so the D.O. generally decreases as water temperatures increases. Hence, the hooked-shape trend of Dissolved Oxygen was a mirror image of the temperature trend. Furthermore, the long-term downward trend of temperature resulted in higher dissolved oxygen concentrations over the three years of testing.



Trophic State Index: 64
Trophic State: Eutrophic

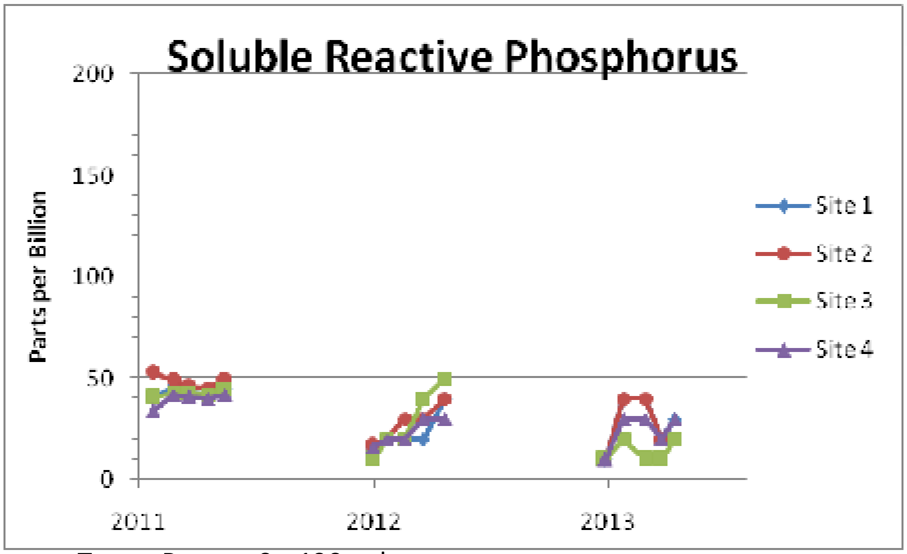
(ppb)	Site 1	Site 2	Site 3	Site 4
April	60	50	20	40
May	110	110	100	90
June	90	80	80	80
July	70	60	40	50
August	90	70	50	60

Target Range: 0 – 100 ppb

Discussion

The Total Phosphorus test includes all forms of organic and inorganic phosphorus. At 70 ppb, the average concentration in Lower Long Lake was in the upper third of the target range, but was still at an acceptable level. Harvesting, which removes organically-bound nutrients, has kept the lake from accumulating nutrients beyond target levels. Furthermore, responsible land use by the residents around the lake will limit the amount of this nutrient that reaches the lake.

9353 Hill Road • Swartz Creek, MI 48473
(810) 635-4400 • Fax (810) 635-4404
www.lakeproinc.com

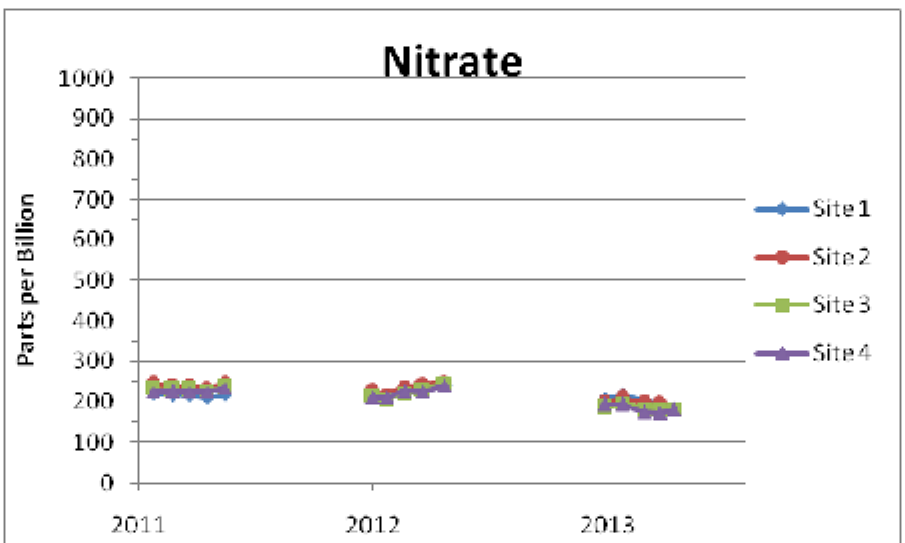


(ppb)	Site 1	Site 2	Site 3	Site 4
April	10	10	10	10
May	40	40	20	30
June	40	40	10	30
July	20	20	10	20
August	30	20	20	30

Target Range: 0 – 100 ppb

Discussion

The amount of Orthophosphate in the lake decreased from 2012, remaining within the target range. The long term trend was downward.



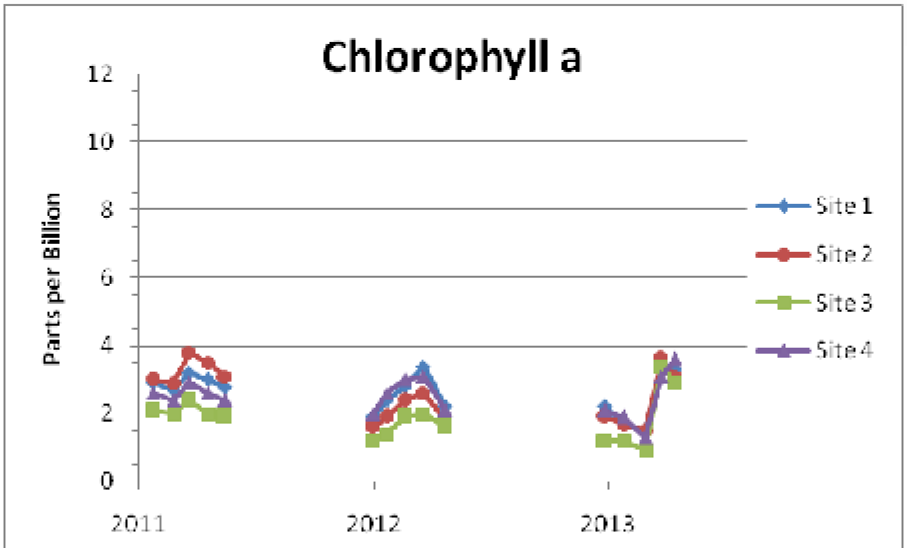
(ppb)	Site 1	Site 2	Site 3	Site 4
April	220	176	88	220
May	308	308	220	264
June	308	264	176	220
July	220	176	88	176
August	264	176	132	220

Target Range: 0 – 1,000 ppb

Discussion

The season average decreased from 2012 to 211 ppb and the long term trend is also downward. Mechanical harvesting and responsible land use (fertilizing) by residents helped reduce the load of this nutrient in the lake. Continuing to reduce the amount of nitrates in the lake will limit nuisance plant growth in the future.

9353 Hill Road • Swartz Creek, MI 48473
(810) 635-4400 • Fax (810) 635-4404
www.lakeproinc.com



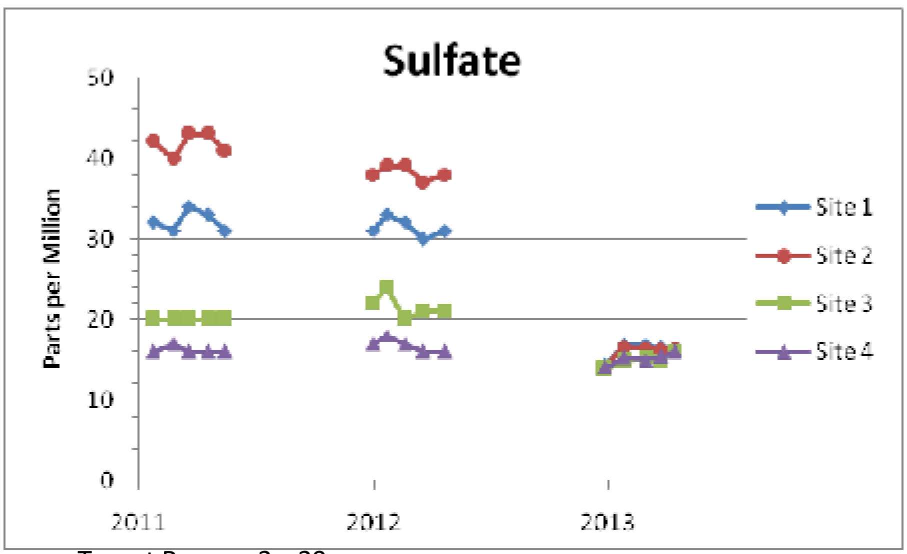
Target Range: 0 – 7.3 ppb

Trophic State Index: 38
Trophic State: Oligotrophic

(ppb)	Site 1	Site 2	Site 3	Site 4
April	2.2	1.9	1.2	2.1
May	1.7	1.7	1.2	1.9
June	1.5	1.5	0.9	1.3
July	3.4	3.6	3.4	3.1
August	3.3	3.1	2.9	3.6

Discussion

The Chlorophyll-a measurement is the most direct indicator of the plant (algae) growth of the lake. The season average of 2.3 ppb was slightly higher than 2012. However, the long-term trend for chlorophyll was downward and confirmed that nutrient reduction and mechanical harvesting reduced the plant production of the lake.

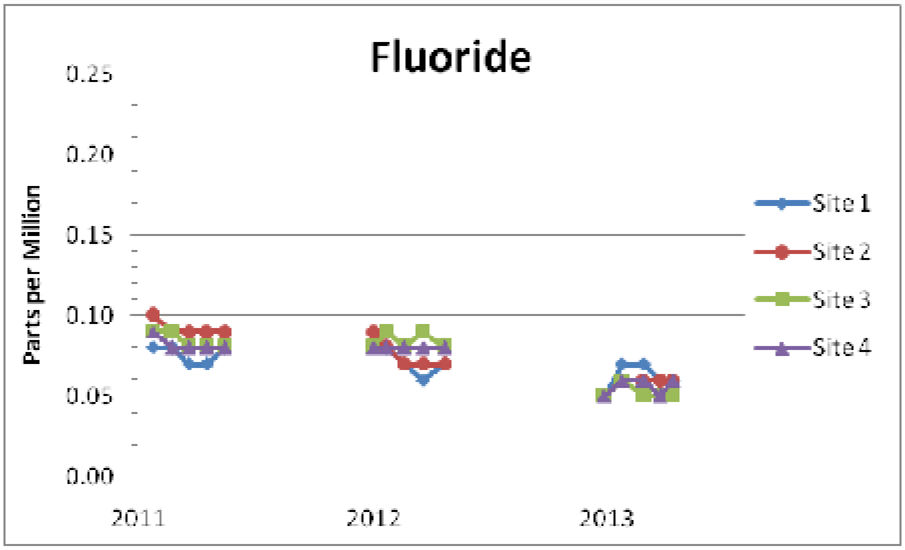


Target Range: 3 – 30 ppm

(ppm)	Site 1	Site 2	Site 3	Site 4
April	14.3	14.2	13.8	14.0
May	16.8	16.6	14.9	15.2
June	16.8	16.4	15.2	15.0
July	16.5	16.3	15.0	15.4
August	16.3	16.2	16.1	16.0

Discussion

The Sulfate concentrations were the lowest they have been since we began testing in 2011. This could be attributed to the limited Copper Sulfate treatments made to Island and Forest Lakes. Also, abundant rainfall throughout the summer helped to flush excess molecules from the lake.

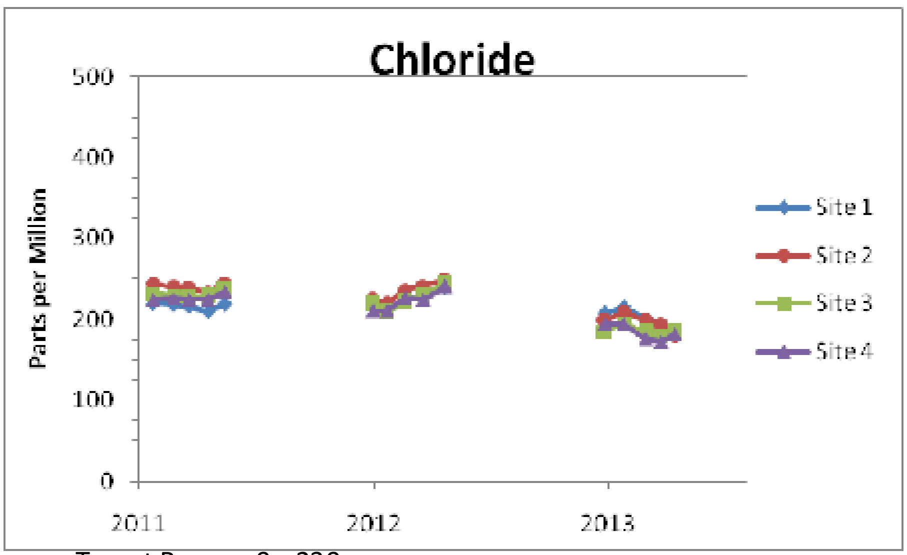


(ppm)	Site 1	Site 2	Site 3	Site 4
April	0.05	0.05	0.05	0.05
May	0.07	0.06	0.06	0.06
June	0.07	0.06	0.05	0.06
July	0.06	0.06	0.05	0.05
August	0.06	0.06	0.05	0.06

Target Range: 0.01 – 0.30 ppm

Discussion

The Fluoride concentrations were at normal levels. The season average of 0.06 ppm was the lowest since we began testing in 2011.



(ppm)	Site 1	Site 2	Site 3	Site 4
April	208	198	185	194
May	216	210	196	194
June	202	198	184	176
July	194	194	180	172
August	183	180	184	182

Target Range: 0 – 230 ppm

Discussion

The concentrations decreased each year since we began testing in 2011. The season average of Chloride was 192 ppm, within the target range.

Analysis Information

Temperature:	The water temperature directly affects the amount of oxygen that is able to dissolve into the water. The temperature of surface waters is not indicative of the entire water column.
Transparency:	The ability of light to penetrate the water column is determined by the amount of dissolved and suspended particles in the water. Although aesthetically desirable, transparent water allows increased light to reach the lake bed and may result in vegetation growth.
pH:	pH is a measure of acidity or alkalinity. pH is a general measure of lake health and can roughly indicate the range of other measurements such as alkalinity and hardness.
TDS:	Total Dissolved Solids is the amount of all organic and inorganic substances in the water in a molecular or ionized state. Higher values generally indicate richer and more productive water. Lower values usually indicate cleaner and less productive water.
Conductivity:	Conductivity is a measure of the ability of water to conduct electricity. Dissolved ions in the water increase conductivity, thus TDS and Conductivity are closely related.
Alkalinity:	Alkalinity refers to the ability of the water to neutralize acids, mainly through the hydrogenation of carbonate ions. This is why the alkalinity is expressed as “ppm as $CaCO_3$”. However, other basic molecules in the water can also contribute to alkalinity.
Dissolved Oxygen:	D.O. is a measure of the amount of oxygen dissolved in the water. This oxygen is available to fish and other animals for respiration. Vegetation generally increases DO, particularly during the day and early evening. Animals and other respiring organisms consume the oxygen, mostly during the day. Oxygen is also added to the lake through wave action, rain, fountains and aerators.
Total Phosphorus:	Phosphorus is an essential nutrient for plant growth. However, concentrations exceeding 100 ppb can impair the water and results in nuisance vegetation growth.
Phosphates:	Phosphate is the form of phosphorous that is most readily available to plants and algae.
Nitrate:	Nitrogen is also essential for plant growth. Nitrate is the predominant form of nitrogen in water. Excessive nitrate concentrations may also result in pollution and increased vegetation.
Chlorophyll-a:	Chlorophyll-a is a direct measurement of the amount of green pigment produced by plants and phytoplankton. This indicates the amount of plant growth and is used to calculate a Trophic State Index.
Sulfate:	Sulfate occurs naturally as minerals, such as calcium sulfate and magnesium sulfate. In fresh water, sulfate is usually the second or third most abundant anion. Other sources of sulfate include water material from pulp mills, steel mills, food processing operations, and municipal wastes. Under low oxygen conditions, sulfate can by reduced to hydrogen sulfide gas, which smells like rotten eggs.
Fluoride:	Fluoride may occur naturally or be added to public drinking water supplies.
Chloride:	Chloride is one of the major anions found in water and sewage. The presence of chlorides may be due to water passing through salt formations in the earth or pollution from industrial processes, domestic wastes, or road salt. The salt content of water affects the

9353 Hill Road • Swartz Creek, MI 48473
(810) 635-4400 • Fax (810) 635-4404
www.lakeproinc.com

distribution of plant and animal life in an aquatic system, based on the amount of slat they can tolerate.

Fecal Coliforms: Non-fecal coliforms are naturally found as soil organisms. Fecal Coliforms, such as *E. coli*, are coliforms found in the intestines of warm-blooded animals and humans. The presence of fecal coliforms indicates contamination from either animals or humans.

Trophic States

Oligotrophic: Water is very clear. Nutrient levels are generally low. Plant and algae productivity is also low. Sufficient dissolved oxygen in the bottom, cooler waters allows cold-water fish to survive, such as salmon and trout.

Mesotrophic: Water is moderately clear. Nutrient levels are slightly elevated. Plant and algae productivity is present, but generally not a nuisance. Oxygen and temperature in the lower portion of the lake allow walleye and perch to survive.

Eutrophic: Water is not clear due to high nutrients levels, increased turbidity, and excessive algal growth. There is no oxygen in the bottom, cooler waters, restricting the lake to warm water species, such as bass and bluegill.

Hypereutrophic: Nutrient levels are extremely high, promoting very high algae productivity. Blue-green algae blooms are likely. High turbidity and algae growth make the water opaque. Little plant growth is restricted to invasive plants. The only fish that can survive this environment are rough fish, such as carp, catfish, and mudminnows.

Sample Sites: