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

2014 Island 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 Island Lake. Water samples were taken at two 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 from the report "2013 Island Lake Water Quality Review" by LakePro, Inc.

In this report, we added historical data from Water Quality Investigators. Their report provided annual averages for many of the parameters from 2002 to 2009. Including this data allows us to see more accurate trends in the water quality data. In order to make the analysis easier, we added annual averages for our data and trendlines on the graphs. The trend lines allow us to quickly see which direction each water quality parameter is moving.

Results

Parameter	2014 Season Average	Target Range	Status
Temperature	69.0 ˚F	Less Than 75 ˚F	● Healthy
Dissolved Oxygen	7.7 mg/L	4.0 – 12.0 mg/L	● Healthy
Total Phosphorus	41 ppb	0 – 100 ppb	● Healthy
Phosphate	24 ppb	0 – 100 ppb	● Healthy
Nitrate	392 ppb	0 – 1,000 ppb	● Healthy
Chlorophyll-a	3.3 ppb	0 – 7.3 ppb	● Healthy
Transparency	5.0 feet	More than 6.5 feet	● Low
pH	8.5 S.U.	7.0 – 9.0 S.U.	● Healthy
Total Dissolved Solids	341 ppm	0 – 1,000 ppm	● Healthy
Conductivity	701 ppm	0 – 1,500 ppm	● Healthy
Alkalinity	130 ppm	100 – 250 ppm	● Healthy
Sulfate	12.8 ppm	3 – 30 ppm	● Healthy
Fluoride	0.10 ppm	0.01 – 0.30 ppm	● Healthy
Chloride	127 ppm	0 – 230 ppm	● Healthy

Year-End Discussion

Island Lake's water quality was very good throughout 2014. The season average for most parameters were within the target ranges. The only parameter not within the target range was the Transparency, which is discussed below.

Temperature and Dissolved Oxygen

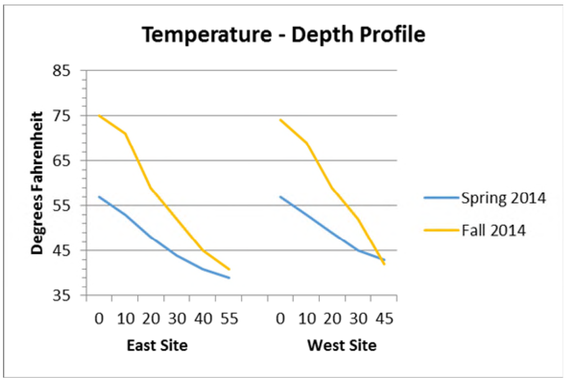
The surface water temperatures in 2014 average was similar to previous years. The previous winter was extremely cold and most Michigan lakes had above average ice and snow cover. This led to cool water temperatures in the spring. Furthermore, the early summer of 2014 brought below average temperatures,

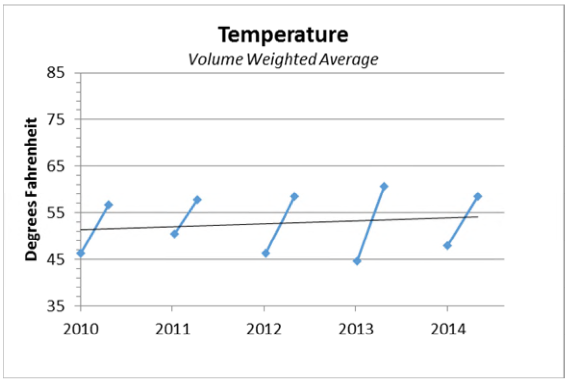
9353 Hill Road • Swartz Creek, MI 48473
(810) 635-4400 • Fax (810) 635-4404
www.lakeproinc.com

further slowing the warm-up of the lake. As a result, the water temperatures later in the summer were not as high as usual (i.e. into the 80's).

We also measure temperature at various depths to create a depth profile. This data shows how the temperature changes with depth and whether or not a thermocline is present in the lake. The first graph below shows the data we collected in 2014. This year, there was not a defined thermocline in the water. Instead, during all our tests, the water temperature decreased steadily from the surface to the lake bottom.

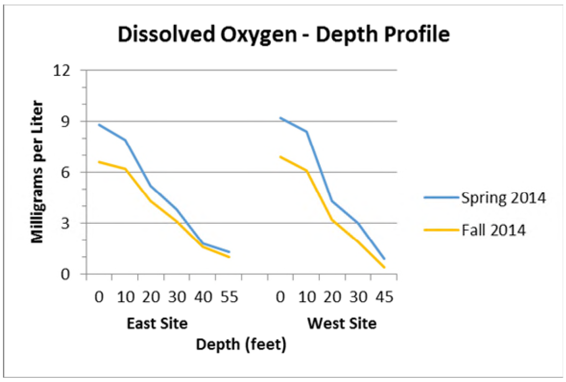
We use the water temperature and volume at each depth to calculate a volume weighted average. The results of those calculations are presented in the second graph below. The trend line shows that over our testing history, the average temperatures of the lake have increased.

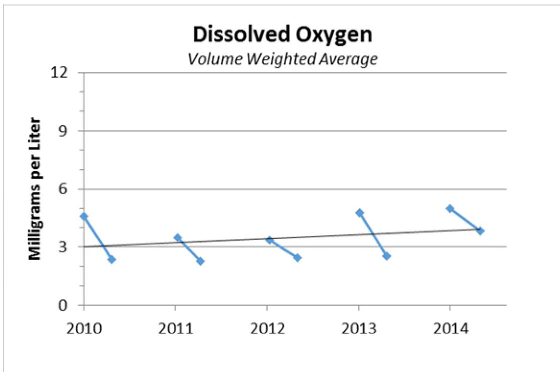




There is a limit on how much dissolved oxygen can be in the water and that limit depends upon water temperature. Because water temperatures were lower this summer, the water was able to hold more dissolved oxygen. In 2014, Island Lake had excellent dissolved oxygen concentrations throughout the summer. Dissolved oxygen is vital for a healthy aquatic ecosystem, so this year's concentrations were a positive for lake.

The depth profile protocol was followed and measurements were also taken for dissolved oxygen. This allowed us to see how the oxygen concentration changes throughout the water column. We also use the dissolved oxygen and volume at each depth to calculate a volume weighted average. The trend line shows that over our testing history, the dissolved oxygen of the lake has increased.





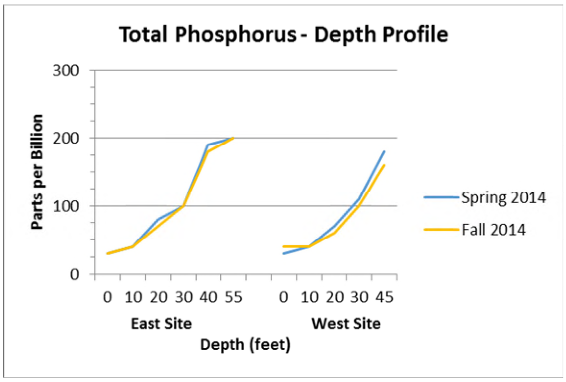
Nutrients, Plant Production, and Transparency

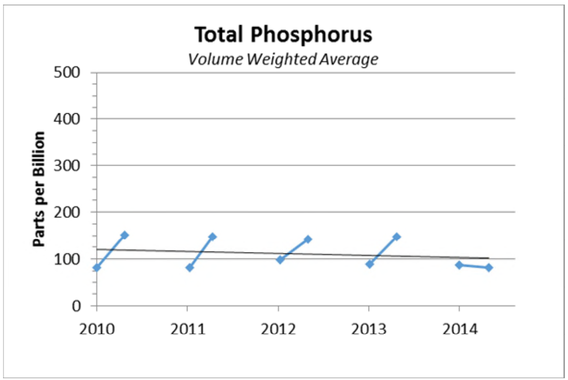
Nutrients in the water are the fuel for plant growth. Monitoring the nutrient concentrations reveals the potential for nuisance plant growth. Phosphorus is one of main nutrients necessary for aquatic plant growth, so it is

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

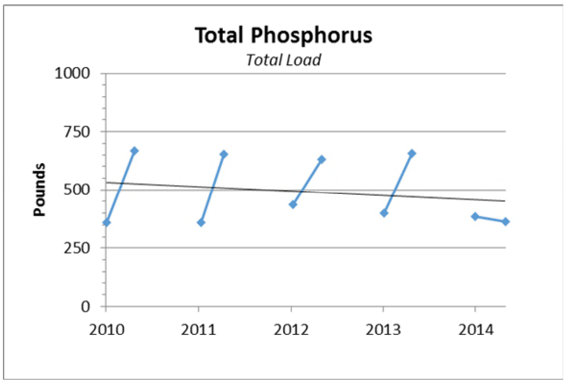
important that this nutrient remains low in the lake. The total phosphorus remained within the target range all year. Phosphate, which is the form of phosphorus usable to plants, was also within the target range for all of 2014.

The depth profile protocol was followed and measurements were also taken for total phosphorus. This allowed us to see how this nutrient concentration changes throughout the water column. We also use the concentration and volume at each depth to calculate a volume weighted average. The trend line shows that over our testing history, the total phosphorus of the lake has decreased slightly.





Finally, we can use the concentration of phosphorus and the water volume of the lake to calculate the lake's phosphorus load. The following graph shows the results of this calculation over the years of our testing. This quantifies the amount of phosphorus in the lake. A generality is that 1 pound of phosphorus can support 500 pounds of plant growth, so the 2014 average load of 375 pounds of phosphorus could support almost 100 tons of plants!



Nitrate is another major nutrient for aquatic plant growth. In 2014, the nitrate concentrations remained within their target range. It is important that residents fertilize and use their land in ways that prevents additional nutrients from entering the lake.

We also measure Chlorophyll concentrations because it is the most direct indicator of plant production. The target for chlorophyll is below 7.2 parts per billion. For all tests in 2014, the chlorophyll concentrations remained below the target level. These results showed that the plants did not grow to excess levels, despite the availability of nutrients.

One of the most important effects of plant growth on the lake is the reduction of water clarity. Before algae forms the green mats of "scum" on the surface, it is suspended in the water column. Algae floating in the water can decrease water clarity, even before you see a tint of green. This year, the water clarity averaged a depth of 5 feet. The April and May measurements were very low, which we determined through third-party testing to be caused by high concentrations of the algae *Planktothrix*.

In order to better understand the relationship between nutrients, plant production, and clarity, limnologists use Trophic State Indices (TSI) to score each category and examine the relationship between them. In general, lower scores indicate a less productive lake. In 2014, the TSIs for Island Lake were:

Category	Water Quality Parameter	Trophic State Index (season average)	Classifciation
Nutrients	Total Phosphorus	57	Eutrophic
Plant Production	Chlorophyll	42	Mesotrophic
Clarity	Transparency	56	Eutrophic

The TSI for Total Phosphorus classified the lake as Eutrophic, or highly productive. This is based on the high availability of nutrients to fuel high plant productivity. The TSI for Chlorophyll, however, is lower than the nutrient score. This suggests that despite the availability of nutrients, the plants did not grow to the levels supported by the nutrients. Finally, the TSI for Transparency classified the lake as Eutrophic. This shows that the water clarity was not as good as expected, based on low chlorophyll concentrations. Normally, this would indicate "muddy" water, made unclear by suspended clay particles. However, because the lake was tested and found to have high levels of *Planktothrix*, the water clarity was limited by this algae. However, because it grows more brown than green, this algae does not inflate the chlorophyll readings.

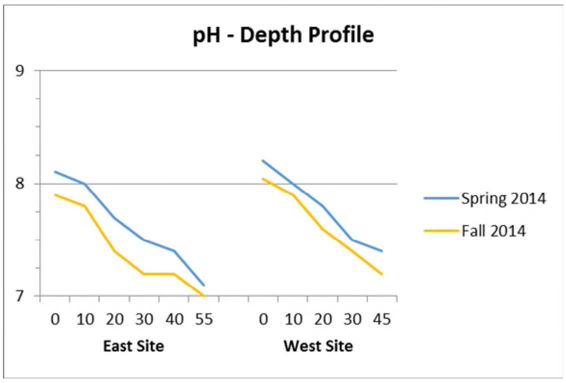
Water Chemistry Parameters

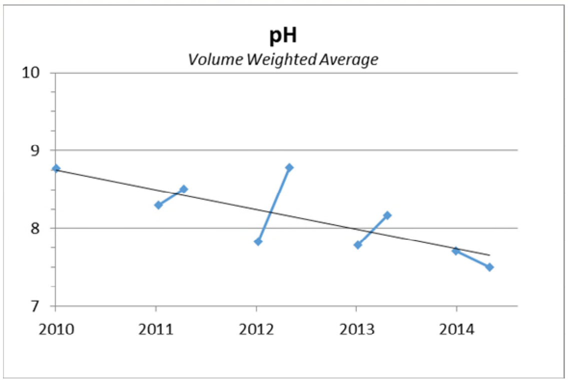
It is important to monitor the basic water chemistry of the lake water. Shifts in these parameters indicate major changes to the lake that may need to be further investigated.

The pH of the lake remained within the target range for most of the year. In May, the pH was slightly elevated, but quickly fell back into the target range by June. This shows that despite changes in dissolved oxygen, alkalinity, and rainfall, the pH did not fluctuate to a point of concern.

The depth profile protocol was followed and measurements were also taken for pH. This allowed us to see how this parameter changes throughout the water column. We also use the readings and volume at each depth to calculate a volume weighted average. The trend line shows that over our testing history, the pH of the lake has decreased.

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





The Total Dissolved Solids (TDS) showed there were low amounts of dissolved substances in the water. This parameter includes nutrients, salts, and other substances, so it is a positive that this parameter has remained low in the lake.

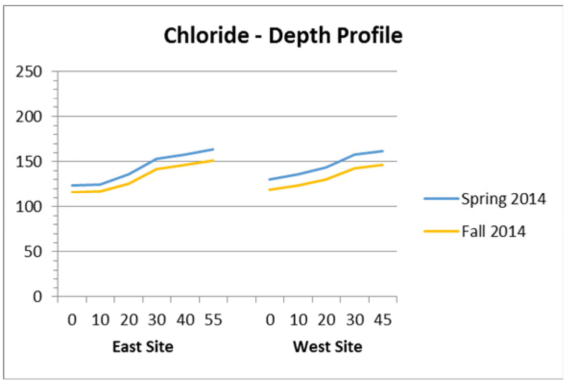
Conductivity, which measures ionic molecules in the water, usually follows the TDS. This parameter measures the ability of molecules in the water to conduct electricity. Thus, it is particularly sensitive to salts, which are excellent conductors. In 2014, the Conductivity was in the middle of the target range, indicating a normal amount of ionic molecules in the lake and no immediate concern of salts.

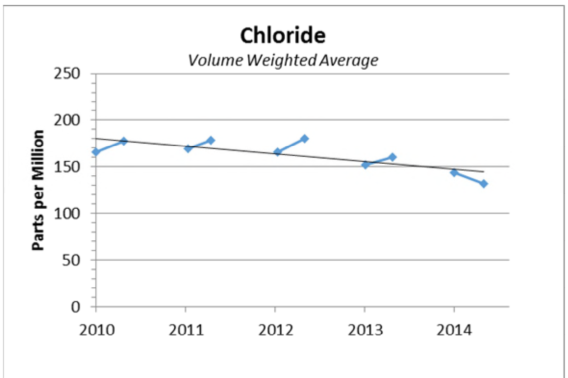
Alkalinity measures the concentration of one salt, Calcium Carbonate, which is beneficial to the aquatic ecosystem. The carbonate ions are able to accept protons from acids, making it a natural buffer. This means that as acidic substances enter the lake, the carbonate is able to buffer against severe changes in pH that could pose a threat to the ecosystem. In 2014, the Alkalinity was at a healthy level for all tests.

Pollutants

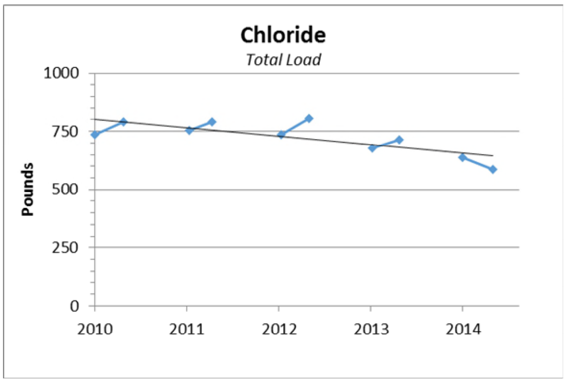
Finally, the lake is tested for Fluoride, Sulfate, and Chloride as indicators of pollution. These molecules should be present in the water naturally, but elevevated levels can indicate pollution from within the watershed and may pose a risk to the ecosystem. All three parameters were within their target ranges for all of 2014.

The depth profile protocol was followed and measurements were also taken for chloride. This allowed us to see how this parameter changes throughout the water column. We also use the readings and volume at each depth to calculate a volume weighted average. The trend line shows that over our testing history, the chloride of the lake has decreased.

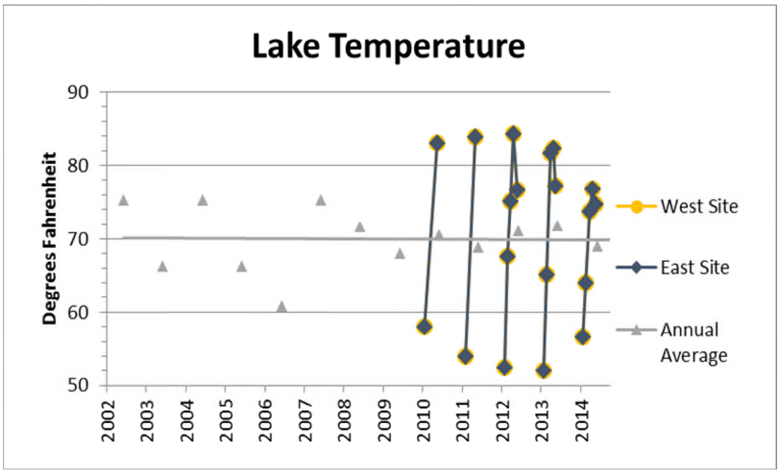




Finally, we can use the concentration of chloride and the water volume of the lake to calculate the lake's chloride load. The following graph shows the results of this calculation over the years of our testing. This quantifies the amount of chloride in the lake.



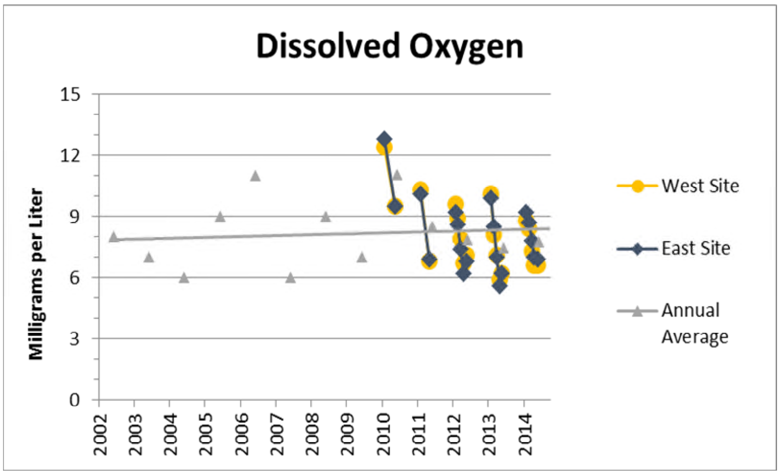
9353 Hill Road • Swartz Creek, MI 48473
(810) 635-4400 • Fax (810) 635-4404
www.lakeproinc.com



Lake Temperature (°F)					
	April	May	June	July	August
West	56.7	64.0	73.8	76.8	74.7
East	56.7	63.6	73.6	75.9	74.2
				Season Average	69.0

Discussion

The long term trend for water temperature is generally flat. The 2014 season average was below the trend. Water temperature is dependent upon air temperatures and the dates selected for testing. For that reason, LakePro tries to select similar dates for testing each year. The main concern with increasing water temperatures is the reduction in dissolved oxygen solubility.

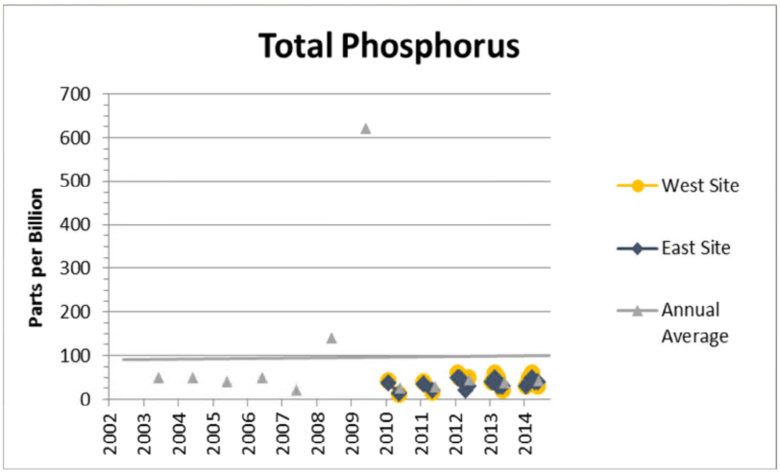


Dissolved Oxygen (mg/L)					
	April	May	June	July	August
West	8.8	8.4	7.3	6.6	6.6
East	9.2	8.7	7.8	7.0	6.9
				Season Average	7.7

Discussion

Without any help from cooler water temperatures, the dissolved oxygen concentrations have slowly increased over time. This is a positive change for the lake, but was helped by higher annual averages in 2005 through 2010. We will look for this trend to continue in the future.

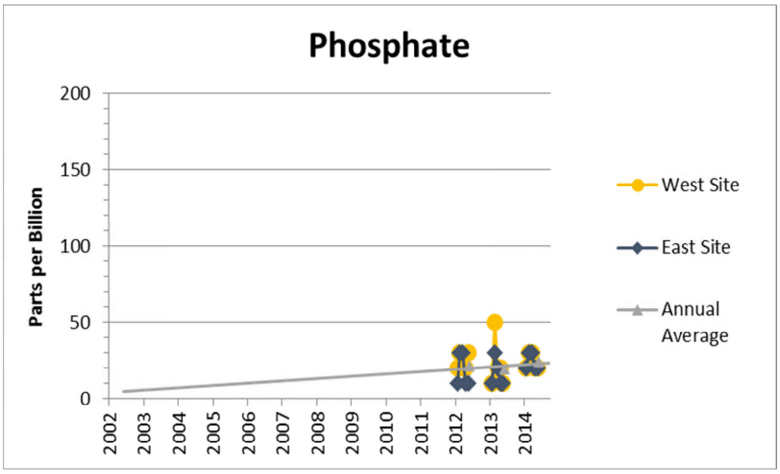
9353 Hill Road • Swartz Creek, MI 48473
(810) 635-4400 • Fax (810) 635-4404
www.lakeproinc.com



Total Phosphorus (ppb)					
	April	May	June	July	August
West	30	50	60	40	30
East	30	40	50	40	40
				Season Average	41
				Trophic State Index	57

Discussion

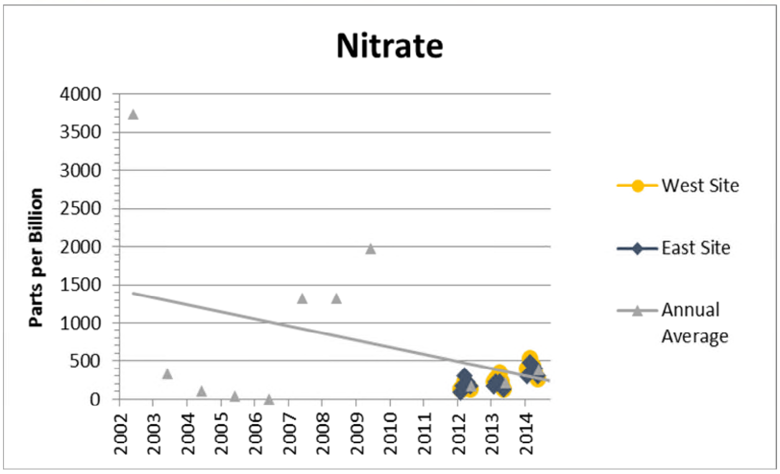
In general, a lake's watershed inputs are much more significant than their outflow. Consequently, lakes tend to accumulate the substances that flow into it. Since testing began in 2003, the trend for Total Phosphorus has increased slightly. The 2008 and 2009 concentrations were much higher than all other years of testing, which helped to turn the trend upward. There are ways to rid a lake of phosphorus, such as mechanical harvesting and heavy rain events that create excess flow. However, it is much easier to prevent excess nutrients from entering the lake. For this reason, it is vital that residents around the lake fertilize and use their land responsibly so as to prevent phosphorus from reaching the lake.



Phosphate (ppb)					
	April	May	June	July	August
West	20	30	30	20	20
East	20	30	30	20	20
				Season Average	24

Discussion

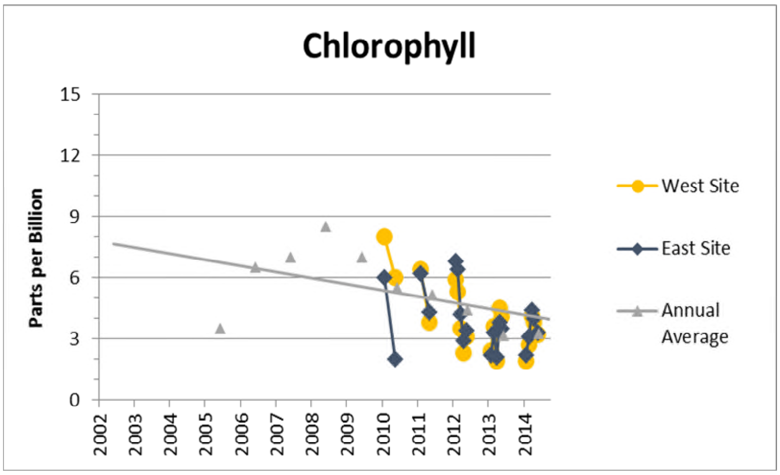
As more total phosphorus accumulates in the lake, so too will the phosphates. There is no historical data available for phosphates, so the trendline reflects the changes during three years of LakePro's testing. The trend is slightly upward, but the phosphate concentrations remained well below the target threshold.



Nitrate (ppb)					
	April	May	June	July	August
West	396	528	440	352	264
East	308	484	440	396	308
			Season Average		392

Discussion

Similar to phosphorus, lakes generally accumulate more nitrate. The historical trend for nitrate is downward, due mostly to extremely high values in 2002 and 2007 through 2009. The past three years show the concentration of nitrate well within the target range, with a slight upward trend due to a higher value in 2014. It is important that residents around the lake fertilize and use their land responsibly so as to prevent nitrate from reaching the lake.

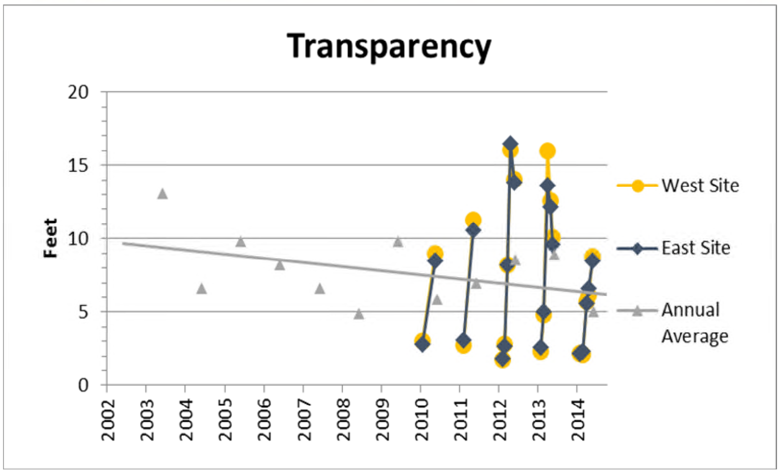


Chlorophyll (ppb)					
	April	May	June	July	August
West	1.9	2.7	4.1	3.8	3.2
East	2.2	3.1	4.4	4.0	3.3
			Season Average		3.3
			Trophic State Index		42

Discussion

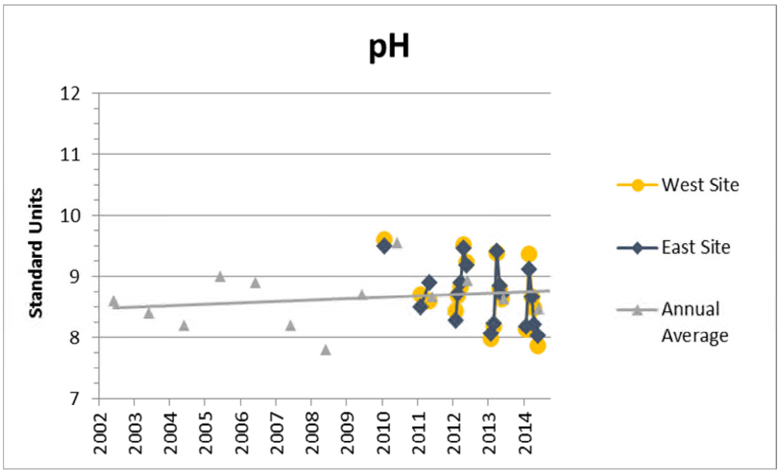
Chlorophyll has trended downward over the testing history. This is most likely a product of decreasing nitrate concentrations and aggressive plant management. Other than 2008, the chlorophyll remained within the target range. Continuing to mechanically harvest will remove plant biomass and the nutrients within it. Responsible land management by residents around the lake will help stifle the source of excess nutrients, preventing further worsening of the plant growth.

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



Transparency (feet)					
	April	**May**	**June**	**July**	**August**
West	2.2	2.1	5.7	6.1	8.8
East	2.2	2.3	5.6	6.6	8.5
			Season Average		5.0
			Trophic State Index		56

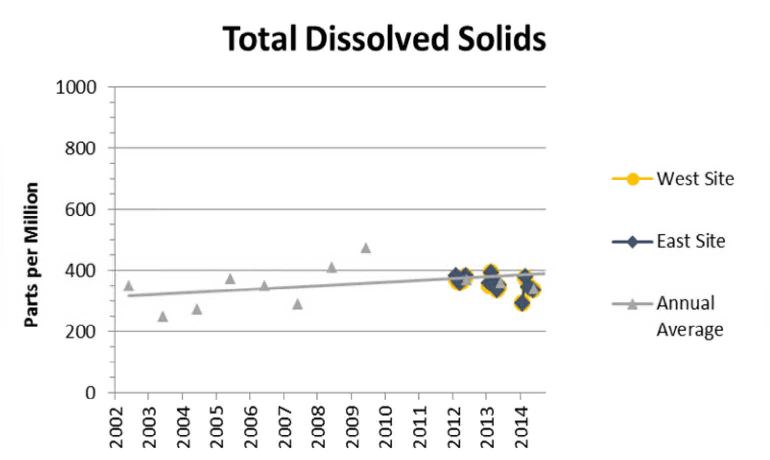
Discussion
Less chlorophyll would normally lead to higher transparency. Despite the downward trend of chlorophyll, the transparency has also trended down. The decreasing water clarity could be due to more rain storms, higher dissolved solids, or higher suspended solids (e.g. sediment). Another reason for lower transparency in 2014 was the high concentration of the algae *Planktothrix*. This algae grows more brown than green, so it did not drastically increase the chlorophyll results. The decreasing transparency a major concern for the lake. It ruins the appearance of the lake and can pose a threat to the safety of the lake, because swimmers cannot accurately judge depth.



pH (Standard Units)					
	April	**May**	**June**	**July**	**August**
West	8.14	9.36	8.66	8.48	7.86
East	8.19	9.11	8.66	8.21	8.04
			Season Average		8.5

Discussion
The pH has increased slightly over the testing history. The shift has moved annual values closer to 9, the top of the target range. This change has not had a major impact on the lake, but it is important to look for this trend to level off. If the pH continues to increase toward 9 or above, it may indicate a larger problem.

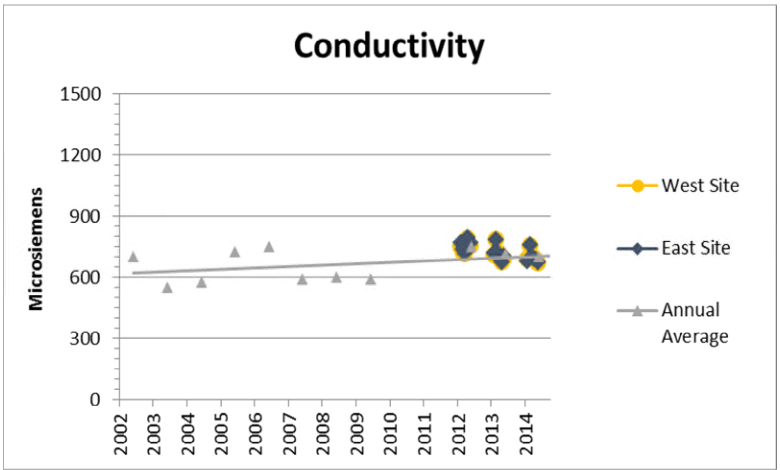
9353 Hill Road • Swartz Creek, MI 48473
(810) 635-4400 • Fax (810) 635-4404
www.lakeproinc.com



Total Dissolved Solids (ppm)					
	April	May	June	July	August
West	293	378	349	345	336
East	295	379	348	344	338
				Season Average	341

Discussion

The total dissolved solids increased over the testing history, showing that the lake is accumulating more substances. The increase has been slow and the past three years have shown a reversal of this trend. This may have been due to increased rainfall, which helped to flush the lake.

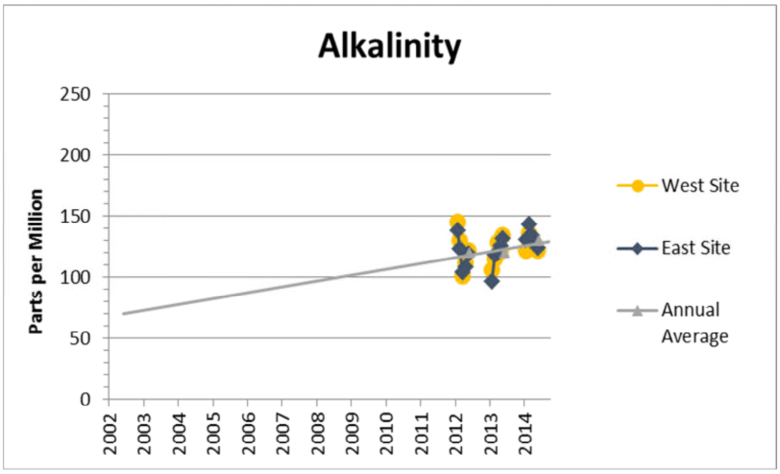


Conductivity (µS)					
	April	May	June	July	August
West	692	755	698	690	671
East	682	758	695	689	676
				Season Average	701

Discussion

Like the TDS, Conductivity increased over the testing history. Conductivity is an extension of TDS and measures the amount of ionic molecules in the water (which conduct electricity, usually salts). We will look for this trend to slow in future years of testing.

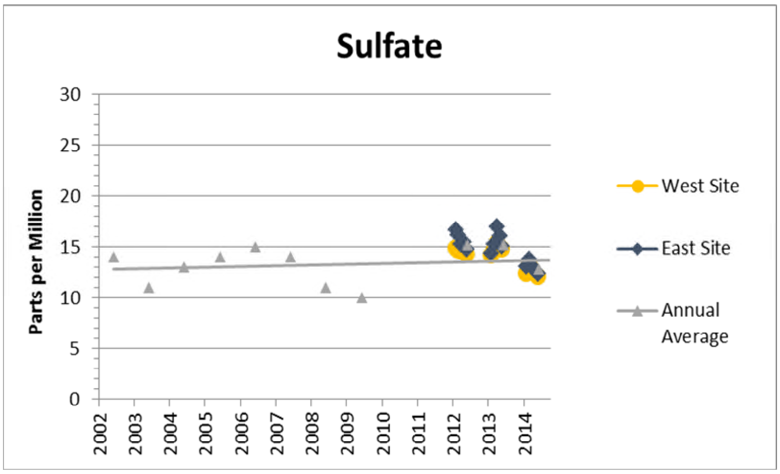
9353 Hill Road • Swartz Creek, MI 48473
(810) 635-4400 • Fax (810) 635-4404
www.lakeproinc.com



Alkalinity (ppm)					
	April	May	June	July	August
West	122	136	131	127	122
East	131	143	134	128	124
			Season Average		130

Discussion

Alkalinity was first included in the testing in 2012, so the historical data is more limited than other parameters. During the past three years, alkalinity has slowly increased. This could be due to above average precipitation in recent years. As snowmelt and rainfall infiltrate the ground, the water will reach the natural groundwater aquifers where it can dissolve calcium carbonate and replenish the alkalinity when it enters the lake.

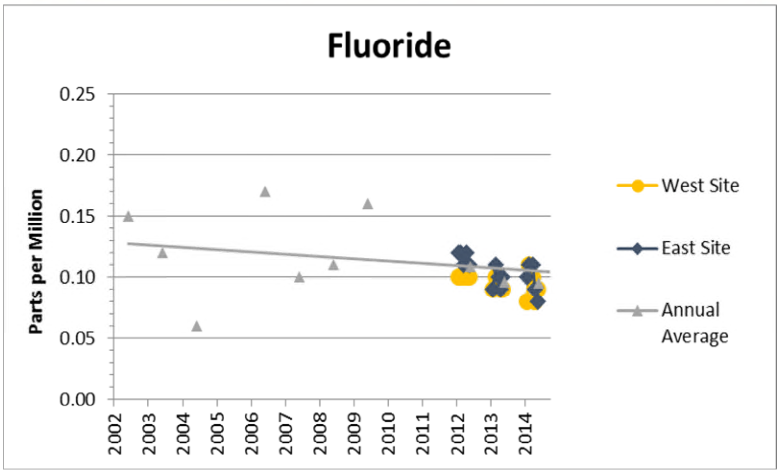


Sulfate (ppm)					
	April	May	June	July	August
West	12.4	13.3	12.8	12.5	12.1
East	13.1	13.8	13.1	12.8	12.4
			Season Average		12.8

Discussion

Sulfate has increased very slightly over the course of testing. The concentration in 2014 was lower than the trend and, therefore, helped to flatten it. It is important that this parameter stay within the target range and any sharp increases are quickly investigated.

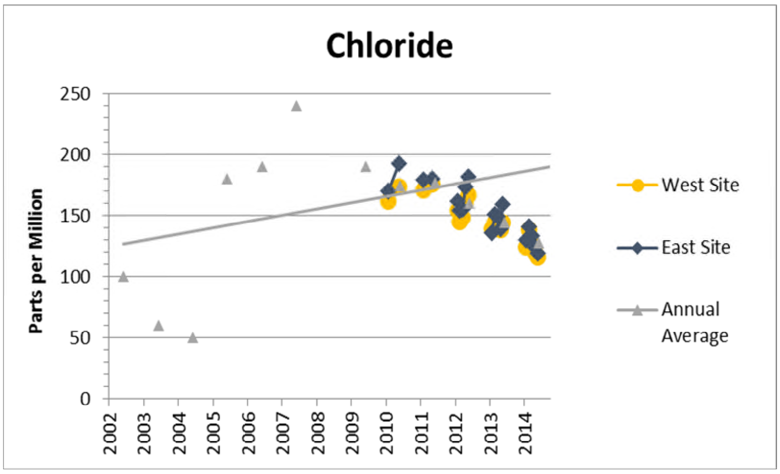
9353 Hill Road • Swartz Creek, MI 48473
(810) 635-4400 • Fax (810) 635-4404
www.lakeproinc.com



Fluoride (ppm)					
	April	May	June	July	August
West	0.08	0.11	0.10	0.08	0.09
East	0.10	0.11	0.11	0.09	0.08
			Season Average		0.10

Discussion

Fluoride has decreased in the lake since testing began in 2002. It is important that this parameter stay within the target range and any sharp increases are quickly investigated.



Chloride (ppm)					
	April	May	June	July	August
West	124	138	127	120	116
East	130	141	133	124	119
			Season Average		127

Discussion

The trend line for Chloride shows a steady increase in Chloride, but the three most recent years of testing are well below the trend. With concerns about road salt entering lakes, it is important that this parameter remain within the target range and any increases are quickly investigated.

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

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.
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.
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.
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 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: