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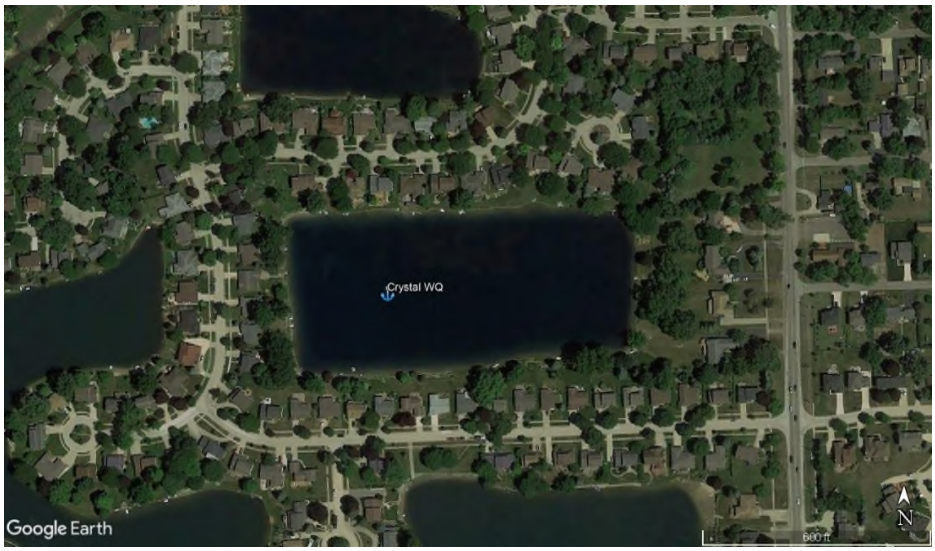
Crystal Lake 2018 Water Quality Review

Introduction

The goals of this testing protocol were to check various water quality parameters of the lake, compare results to historical data, and identify any potential risks to the health of Crystal Lake. LakePro collected a water sample at one location on August 2nd, 2018 and tested 14 parameters. LakePro utilized a Hanna Multiparameter Meter and a LaMotte SMART2 Colorimeter to conduct the tests.

Sampling Location

The following aerial photograph shows the location of the sampling site.



Results

Parameter	August 2nd, 2018	Target Range	Status
Temperature	77.5 ˚F	Less than 75 ˚F	Slightly High
Dissolved Oxygen	7.3 mg/L	4.0 – 12.0 mg/L	Healthy
Total Phosphorus	70 ppb	0 – 100 ppb	Healthy
Phosphate	30 ppb	0 – 100 ppb	Healthy
Nitrate	352 ppb	0 – 1,000 ppb	Healthy
Chlorophyll-α	3.4 ppb	0 – 7.3 ppb	Healthy
Transparency	8.3 feet	More than 6.5 feet	Healthy
pH	7.4	7.0 – 9.0 S.U.	Healthy
Total Dissolved Solids	422 ppm	0 – 1,000 ppm	Healthy
Conductivity	844 µS	0 – 1,500 µS	Healthy
Alkalinity	128 ppm	0 – 250 ppm	Healthy
Hardness	166 ppm	100 – 300 ppm	Healthy
Total Salinity	410 ppm	0 – 500 ppm	Healthy
Chloride	100 ppm	0 – 230 ppm	Healthy

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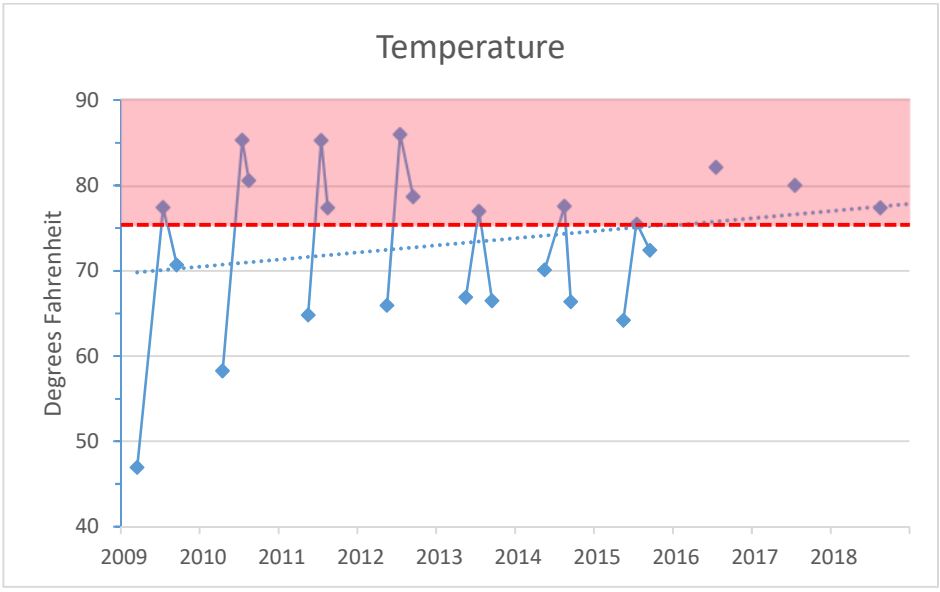
Discussion

Crystal Lake's water quality was excellent at the time of these tests. Most results were within the target ranges, with the exception of temperature. Water temperatures are dependent upon the weather, so seasonal peaks are expected.

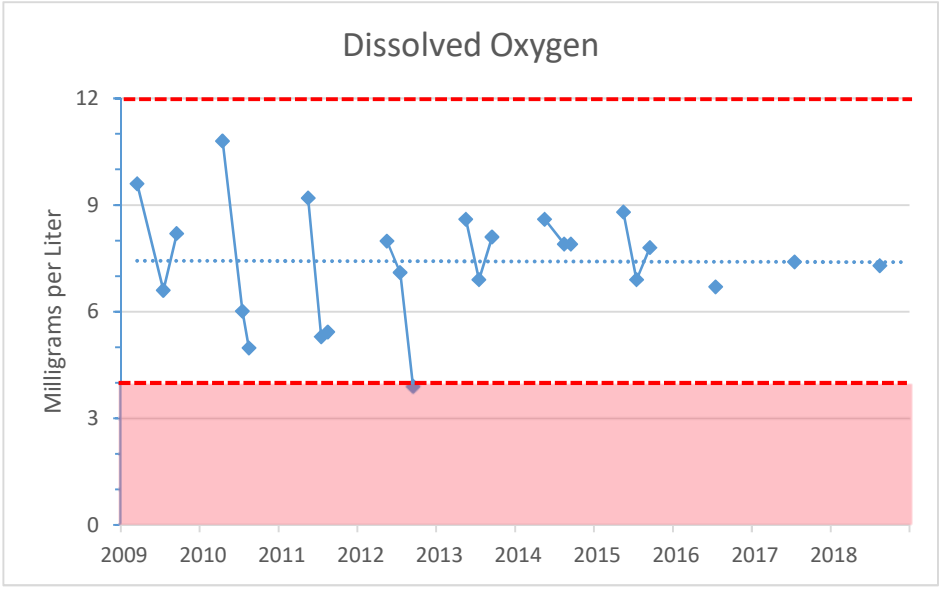
Below we discuss the individual results and relationships between the parameters. The graphs show the historical results along with a trendline to indicate how the lake changed over time. The dashed red lines are the limits of the target range and areas shaded in pink are outside the target range.

Temperature and Dissolved Oxygen

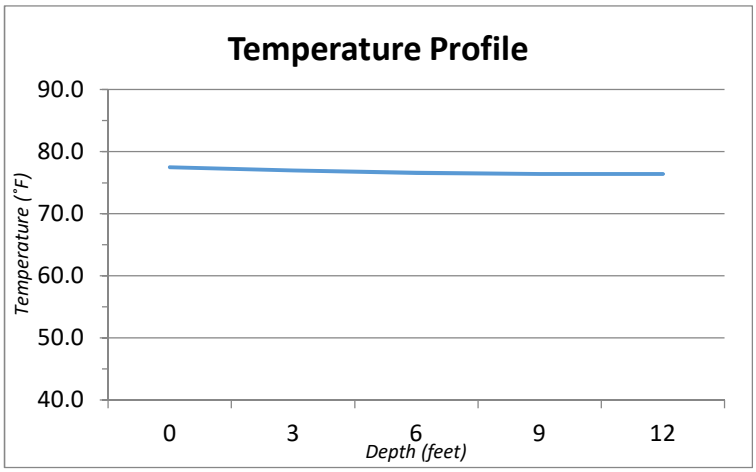
Dissolved oxygen is vital for a healthy aquatic ecosystem. The water temperature determines the greatest amount of oxygen that can be in the water. Colder water can hold more dissolved oxygen, so cooler temperatures are generally better. The water **temperature** was above the target range at the time of this testing.



Higher water temperatures create concern about less dissolved oxygen in the water. Despite warmer water at the time of this test, the **dissolved oxygen** was adequate for a healthy aquatic ecosystem and fishery.

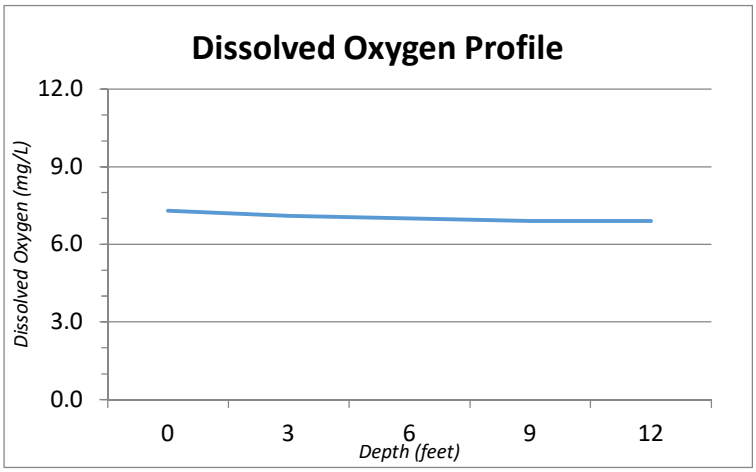


We also measured temperature and dissolved oxygen at three-foot intervals to create a depth profile. This data shows how the parameters changed with depth. The graphs below shows the data we collected in 2018. A thermocline was not present in Crystal Lake, instead the temperature decreased slightly from the surface to the deep water.



Depth (feet)	Temperature (°F)
0	77.5
3	77.0
6	76.6
9	76.4
12	76.4

The dissolved oxygen concentrations mirrored the temperatures. At this time, there was plentiful oxygen at the bottom of the lake, but the lack of cold water at the lake bottom limited the fishery to warm water species, such as panfish and bass.



Depth (feet)	Dissolved Oxygen (mg/L)
0	7.3
3	7.1
6	7.0
9	6.9
12	6.9

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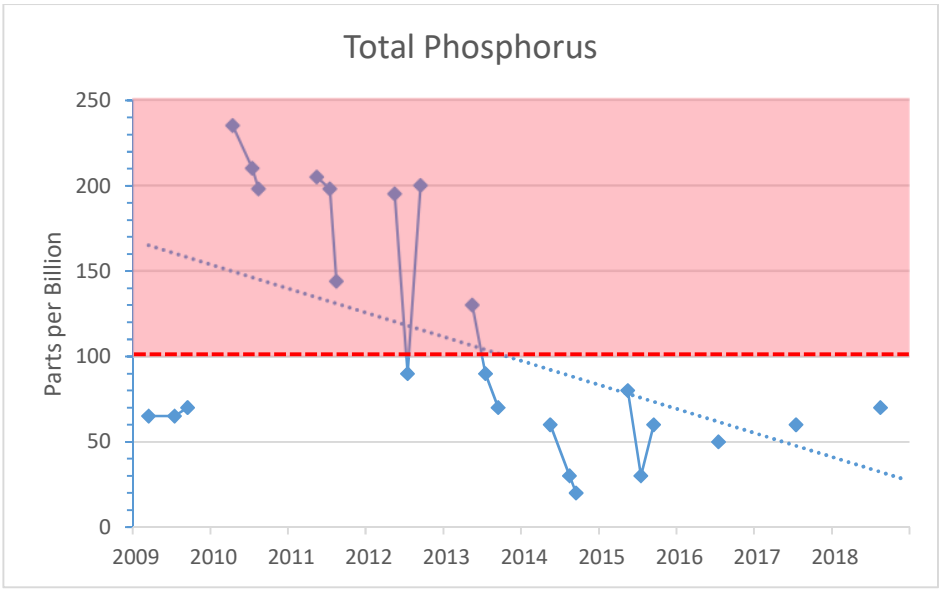
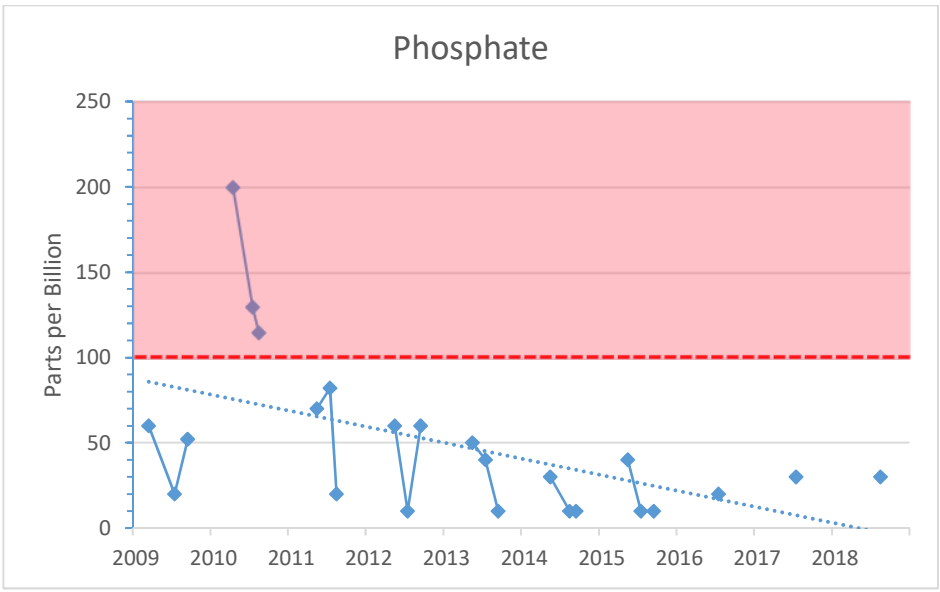
Nutrients, Plant Production, and Transparency

Nutrients in the water are the fuel for plant growth. So, the nutrient data reveals the potential for nuisance plant growth. Phosphorus is a major nutrient for aquatic plant growth, so it is important that this nutrient remains low in the lake. The **phosphorus** was within the target range and continued a downward trend that began in 2011. The active form, **phosphate**, was much lower and comfortably within the target range. The long term trend for phosphate was also downward, although the concentration increased slightly each of the past three years.





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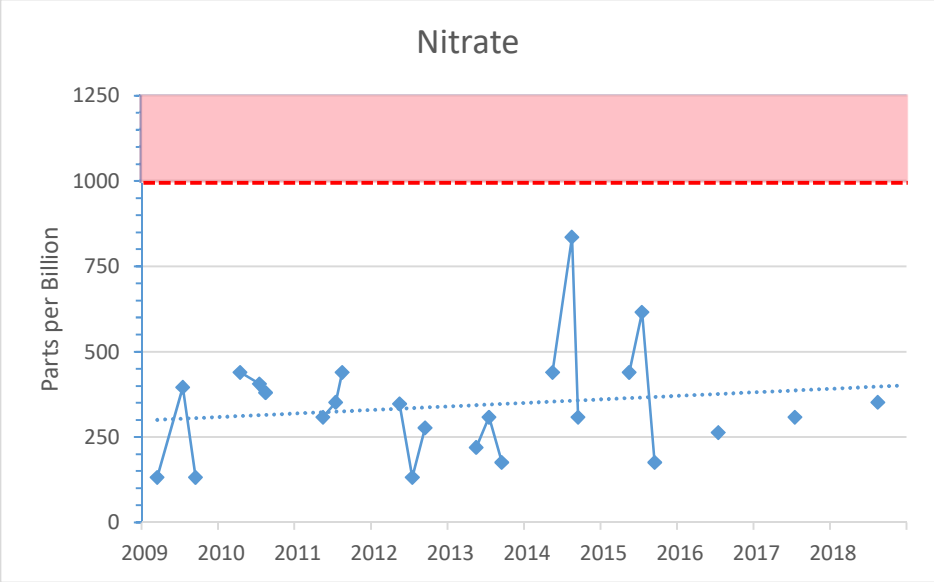
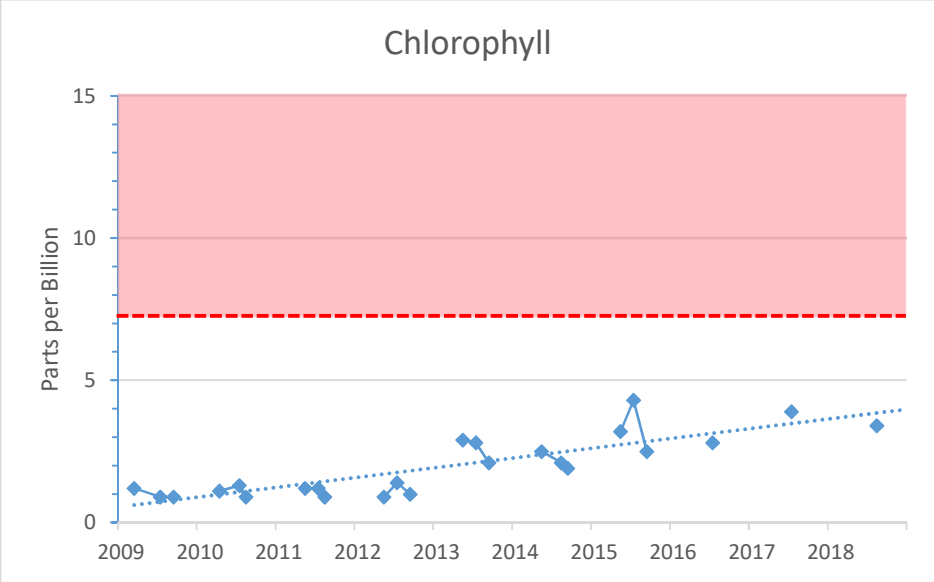
Nitrate is another major nutrient for aquatic plant growth. During this test, the **nitrate** concentration was within the target range. Over the testing history, the concentration tended upward. This shows a slow accumulation of this nutrient in the lake. It is important to fertilize and use the land responsibly to prevent more nutrients from entering the lake. Preventing additional nutrient accumulation now will reduce the need for more aggressive plant management in the future.



We measured the chlorophyll concentration because it is a strong indicator of plant production. The **chlorophyll** concentration was within the target range and categorized the lake as moderately productive. It is important to note that this was not the natural concentration. The plant management with herbicides helped to limit the plant growth throughout the year, causing lower results for this test. Over time, the chlorophyll concentration trended upward, indicating more algae growth over time. LakePro's management goal is to control nuisance algae while leaving some aquatic plant growth for a healthy ecosystem.



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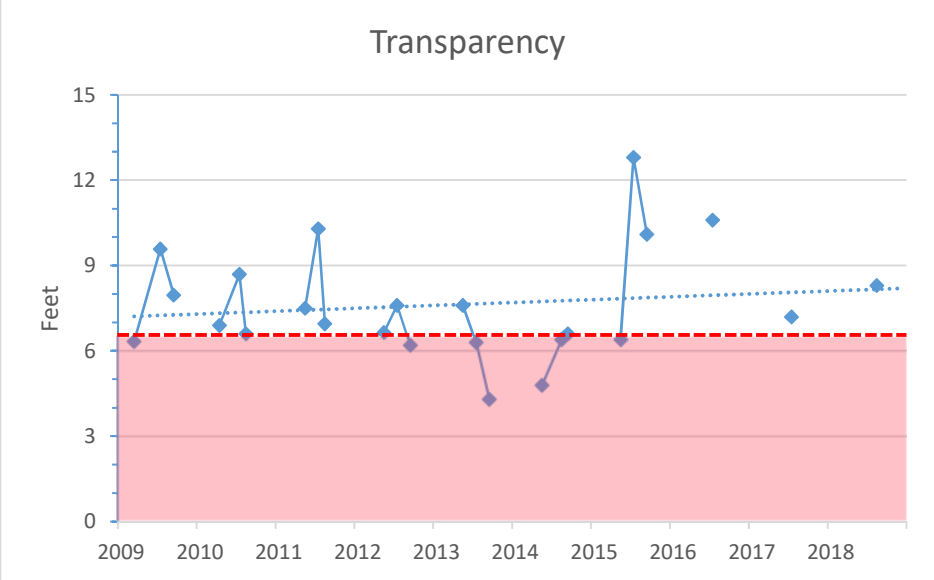
One effect of plant growth on the lake is the reduction of water clarity. Before algae forms green mats of "scum" on the surface, it suspends in the water column. Algae floating in the water can decrease water clarity even before you see a tint of green. This year, the **transparency** measured 8.3 feet. This was in line with previous results, and it is important to remember the addition of water dye altered the natural clarity.



Trophic State Indices

To better understand the relationship between nutrients, plant production, and transparency, limnologists use Trophic State Indices (TSI) to score each category and examine the relationship between them. In general, lower scores represent a less productive lake. In 2018, the TSIs for Crystal Lake were:

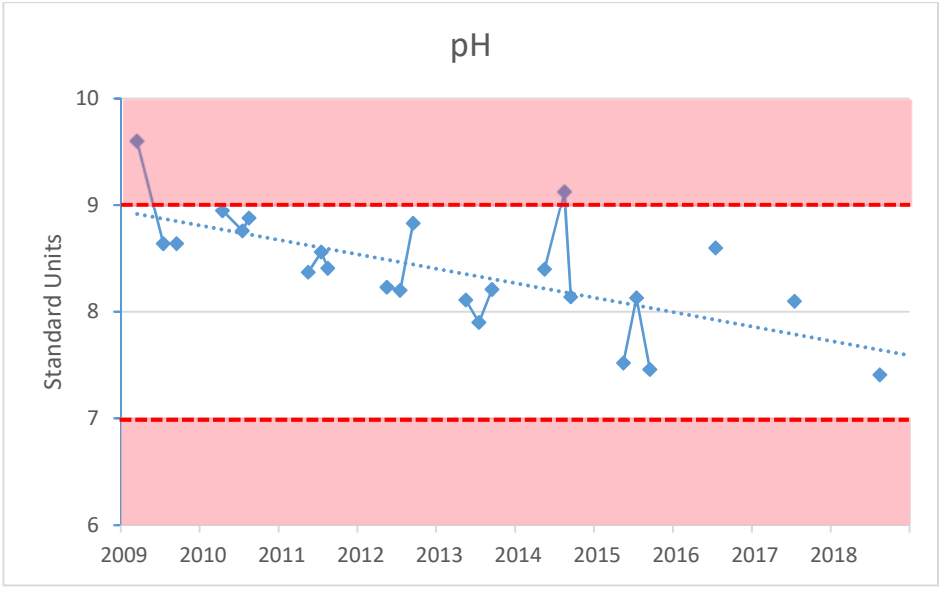
Category	Water Quality Parameter	Trophic State Index (season average)	Classifciation
Nutrients	Total Phosphorus	65	Eutrophic
Plant Production	Chlorophyll	43	Mesotrophic
Clarity	Transparency	47	Mesotrophic

The TSI for total phosphorus classified the lake as eutrophic, or very productive, based on the availability of nutrients to sustain plant growth. The TSI for chlorophyll was lower than the nutrient index, showing that the plants were not at the level predicted by the nutrient concentrations. This was due, in part, to the plant management efforts on the lake. Finally, the TSI for transparency showed the clarity was poorer than the index for plant production. This difference was due to the addition of water dye that is meant to decrease clarity and sunlight penetration.

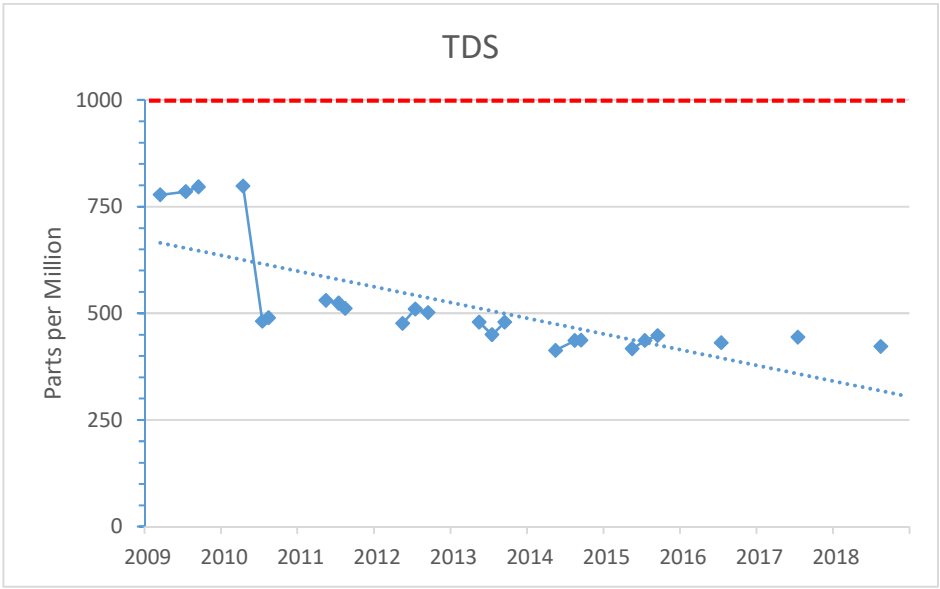
Water Chemistry Parameters

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

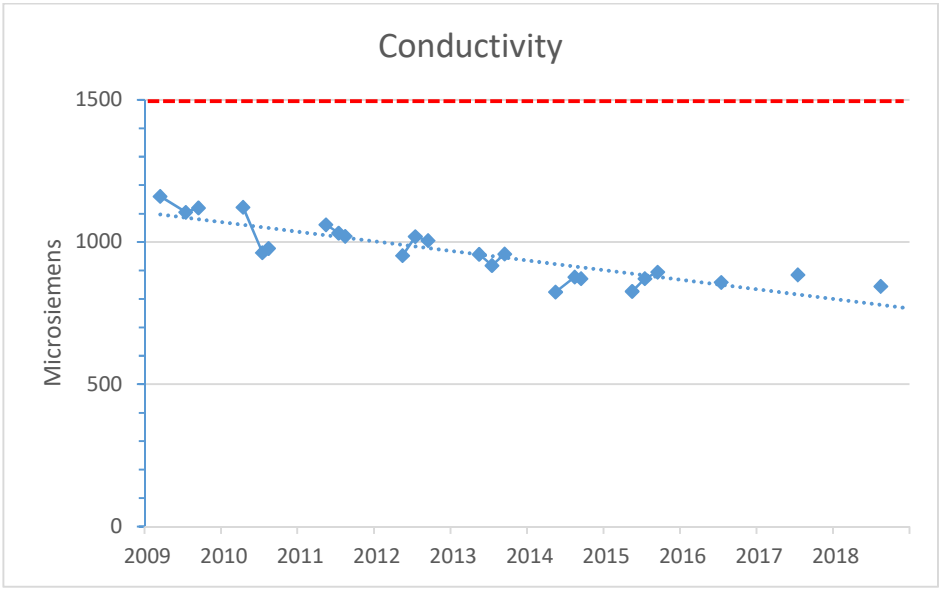
The **pH** of the lake remained within the target range in 2018. This showed that despite changes in dissolved oxygen, alkalinity, and rainfall, the pH did not fluctuate to a point of concern. The historical trend was downward, aided by this year's result. We will closely watch the pH next year and investigate any further decline.



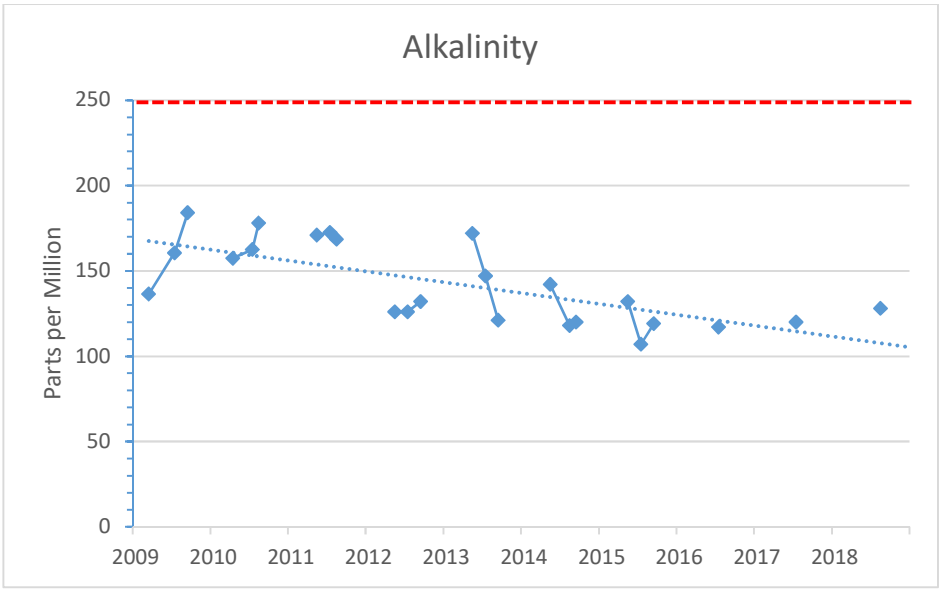
The **total dissolved solids** (TDS) results showed there were low amounts of dissolved substances in the water. This parameter includes nutrients, salts, and other substances, so it is a positive when this parameter remains low. The long term trend for this parameter is downward, but the most recent years of results were steady.



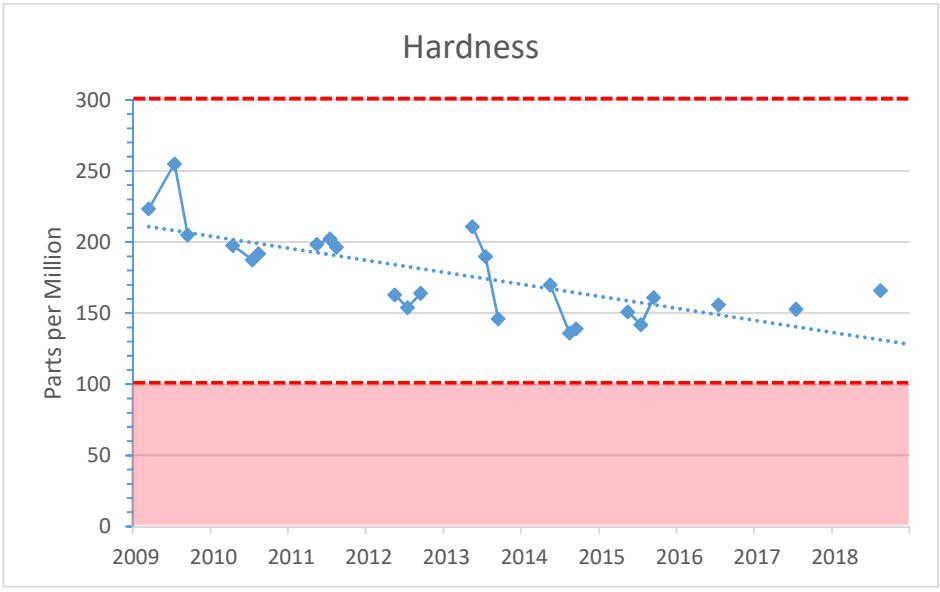
Conductivity measures ionic molecules in the water and usually follows the TDS. This parameter measures the molecules in the water ability to conduct electricity, making it particularly sensitive to conductors such as salts. In 2018, the **conductivity** indicated a normal amount of ionic molecules in the lake and no immediate concern about salts. The long term trend for this parameter is downward, but the most recent years of results were steady.



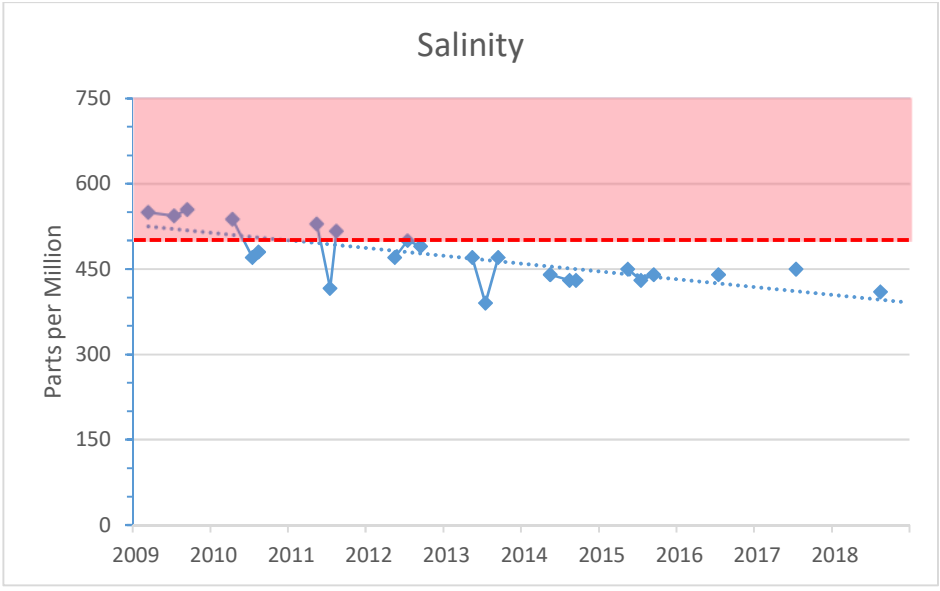
Alkalinity measures the concentration of Calcium Carbonate, a salt that is beneficial to the aquatic ecosystem. The carbonate ions are able to accept protons from acids, making it a natural buffer. As acidic substances enter the lake, the carbonate is able to buffer against severe changes in pH that could pose a threat to the ecosystem. The **alkalinity** was at a healthy level during this test and trended slightly down over the testing history.



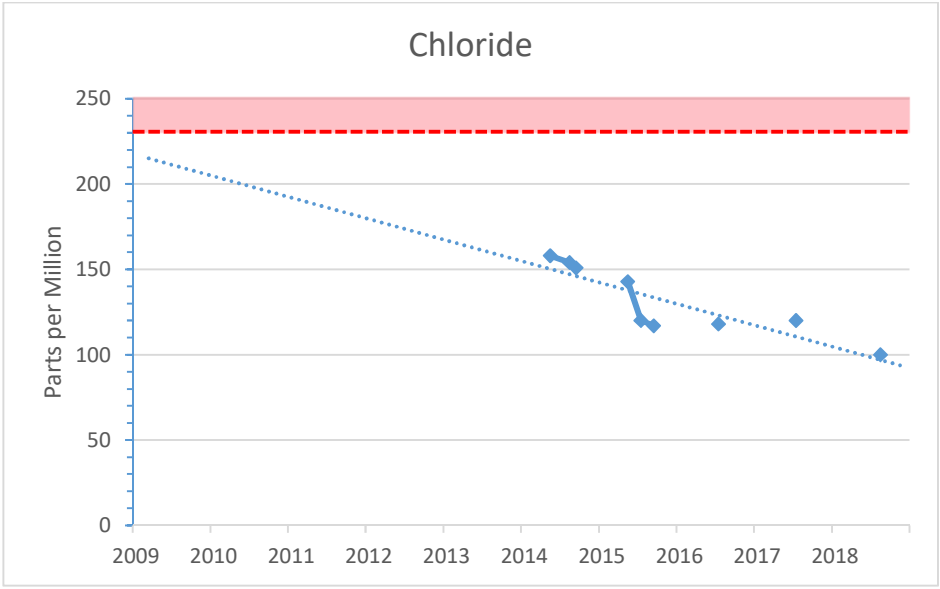
While alkalinity measures the acid neutralizing capacity in the form of carbonate, hardness measures the polyvalent cations, such as calcium. Since one of the most commons salts in the water is Calcium Carbonate, hardness generally follows alkalinity. The **hardness** was at a healthy level during this test, but trended lower over the testing history.



We also tested the lake for total salinity. Salts are naturally present in the water, but elevated levels can indicate pollution from within the watershed and may pose a risk to the ecosystem. The **salinity** was near the top of the target range this year, but moved lower over the testing history. The trend matched the alkalinity and hardness.



Chloride is the anion component of many different salts, the most common of which is Sodium Chloride. Some chloride will be present in ground and surface water, but elevated levels are indicators of pollution. One source of chloride loading is road salt, which enters the lake in the spring as the snow and ice melts off the roads and drainage ditches. This year, the **chloride** concentration was very low and continued a downward trend among the all data points.



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Summary & Conclusions

Overall the water quality of Crystal Lake was excellent in 2018. The results confirmed and quantified several characteristics of the lake. The data also provided insight to how the lake changed from last year. Furthermore, long-term trends are now supported by ten years of data, making them strong indicators of how the lake has changed.

This summer, only one parameter was outside the target ranges. Temperature was higher than preferred, but this characteristic is dependent upon weather and cannot be manipulated. Despite the higher water temperature, the dissolved oxygen remained healthy and adequate to support a healthy ecosystem.

The historical data trends reveal more about how the lake has changed and the direction it may be headed in the future. The temperature trended upward, which may be cause for concern about dissolved oxygen in the future. But, the removal of spring testing removes data that would normally provide lower temperatures and flatten the trend. Also, the dissolved oxygen trend was generally flat, showing that despite higher temperatures, there has not been a decrease in oxygen concentrations.

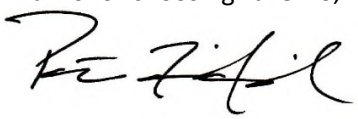
The nutrients trends were mixed. Phosphorus decreased over the testing history, possibly aided by the state's ban on phosphorus-laden fertilizers. Reducing phosphorus will help prevent nuisance algae and plant growth in the future. Nitrate concentrations increased over the testing history. The increased nitrate concentrations will make the lake highly sensitive to any future increases of phosphorus.

The chlorophyll also trended upward, indicating more algae production and matching the nitrate concentrations. Some aquatic plant growth is necessary for healthy ecosystem and the lake management program is designed to stop and control any nuisance algal blooms. And despite higher plant production, the water transparency increased over the testing history.

The water chemistry parameters all trended downward over the past ten years. Despite the trends, the parameters remained within the target ranges for 2018. Moving forward, we will closely monitor these parameters for indications that the trends are flattening.

For now, you should take pride in Crystal Lake as a valuable water resource with excellent water quality and continue your efforts in improving the lake.

Thanks for choosing LakePro,



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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.
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.

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.

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Date	Temperature ˚F	Dissolved Oxygen mg/L	Total Phosphorus ppb	Phosphate ppb	Nitrate ppb	Chlorophyll ppb	Secchi Disk Depth (feet)	pH	TDS ppm	Conductivity µS	Alkalinity mg/L	Hardness mg/L	Salinity ppm	Chloride ppm
3/26/09	46.9	9.6	65	60	132	1.2	6.3	9.6	778	1161	137	224	550	---
7/6/09	77.5	6.6	65	20	396	0.9	9.6	8.6	785	1105	161	255	544	---
9/1/09	70.7	8.2	70	52	132	0.9	8.0	8.6	796	1121	184	205	555	---
4/20/10	58.3	10.8	235	200	440	1.1	6.9	9.0	798	1123	158	198	538	---
7/7/10	85.3	6.0	210	130	406	1.3	8.7	8.8	481	963	163	188	470	---
8/31/10	80.6	5.0	198	115	380	0.9	6.6	8.9	489	978	178	192	480	---
5/12/11	64.8	9.2	205	70	308	1.2	7.5	8.4	530	1061	171	199	530	---
7/6/11	85.3	5.3	198	82	352	1.2	10.3	8.6	524	1032	173	203	416	---
8/30/11	77.5	5.4	144	20	440	0.9	7.0	8.4	511	1021	169	197	517	---
5/11/12	65.9	8.0	195	60	348	0.9	6.7	8.2	476	953	126	163	470	---
7/9/12	86.0	7.1	90	10	132	1.4	7.6	8.2	510	1020	126	154	500	---
9/6/12	78.8	3.9	200	60	277	1.0	6.2	8.8	502	1005	132	164	490	---
5/7/13	66.9	8.6	130	50	220	2.9	7.6	8.1	479	957	172	211	470	---
7/10/13	77.1	6.9	90	40	308	2.8	6.3	7.9	450	918	147	190	390	---
9/24/13	66.5	8.1	70	10	176	2.1	4.3	8.2	479	958	121	146	470	---
5/23/14	70.1	8.6	60	30	440	2.5	4.8	8.4	413	825	142	170	440	158
8/5/14	77.7	7.9	30	10	836	2.1	6.4	9.1	436	877	118	136	430	154
9/23/14	66.4	7.9	20	10	308	1.9	6.6	8.1	437	872	120	139	430	151
5/6/15	64.2	8.8	80	40	440	3.2	6.4	7.5	417	827	132	151	450	143
7/15/15	75.6	6.9	30	10	616	4.3	12.8	8.1	436	872	107	142	430	120
9/16/15	72.4	7.8	60	10	176	2.5	10.1	7.5	448	895	119	161	440	117
7/25/16	82.2	6.7	50	20	264	2.8	10.6	8.6	431	859	117	156	440	118
7/19/17	80.1	7.4	60	30	308	3.9	7.2	8.1	444	885	120	153	450	120
8/2/18	77.5	7.3	70	30	352	3.4	8.3	7.4	422	844	128	166	410	100