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Pebble 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 Pebble 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	79.1 ˚F	Less than 75 ˚F	Slightly High
Dissolved Oxygen	7.7 mg/L	4.0 – 12.0 mg/L	Healthy
Total Phosphorus	80 ppb	0 – 100 ppb	Healthy
Phosphate	40 ppb	0 – 100 ppb	Healthy
Nitrate	440 ppb	0 – 1,000 ppb	Healthy
Chlorophyll-α	3.3 ppb	0 – 7.3 ppb	Healthy
Transparency	3.3 feet	More than 6.5 feet	Low
pH	7.9	7.0 – 9.0 S.U.	Healthy
Total Dissolved Solids	364 ppm	0 – 1,000 ppm	Healthy
Conductivity	731 µS	0 – 1,500 µS	Healthy
Alkalinity	108 ppm	0 – 250 ppm	Healthy
Hardness	145 ppm	100 – 300 ppm	Healthy
Total Salinity	340 ppm	0 – 500 ppm	Healthy
Chloride	103 ppm	0 – 230 ppm	Healthy

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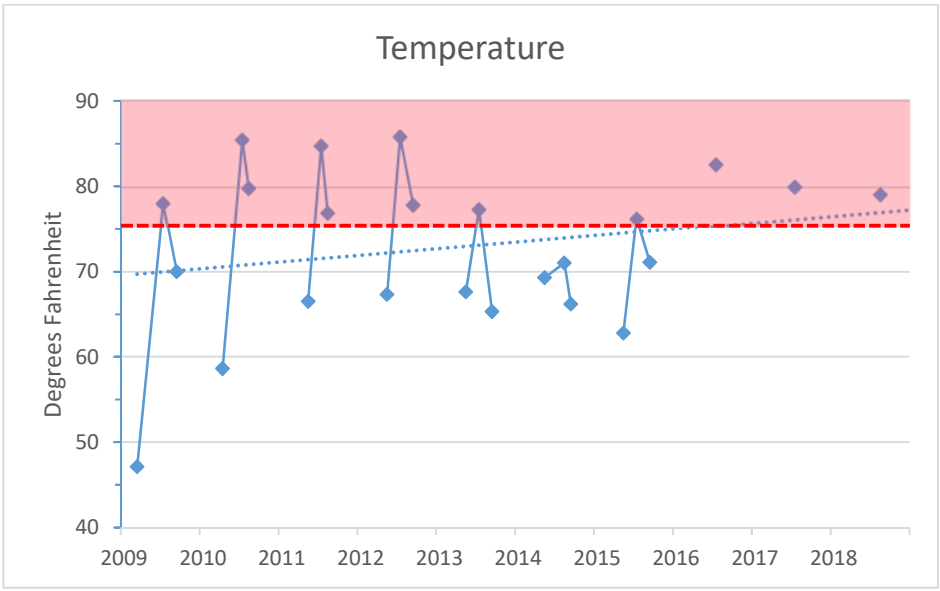
Discussion

Pebble Lake's water quality was excellent at the time of these tests. Most results were within the target ranges, with the exceptions of temperature and transparency. Water temperatures are dependent upon the weather, so seasonal peaks are expected. Water dye was added to the lake as part of the lake management program, so the transparency result was low by design.

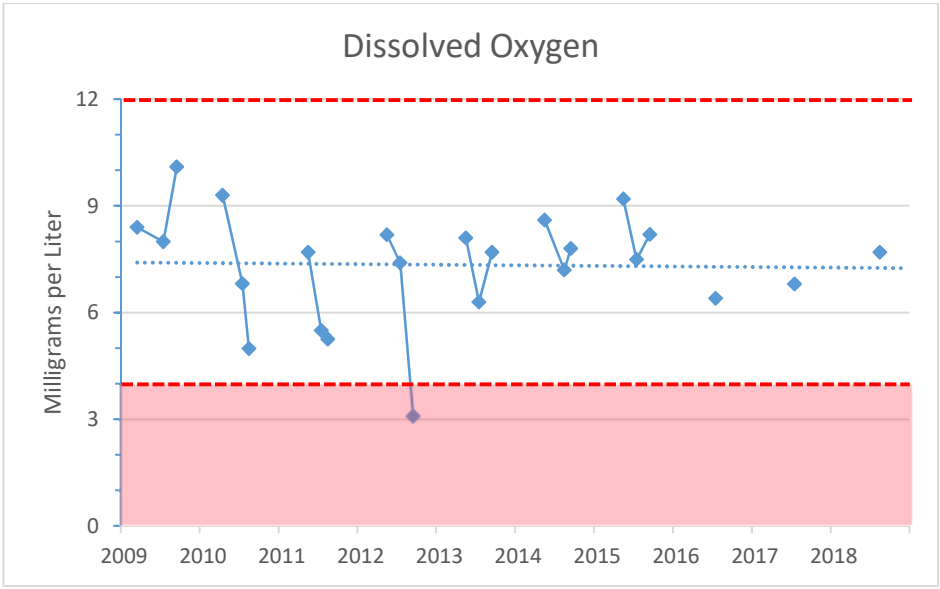
Below we discuss the individual results and relationships between the parameters. The graphs show the historical results along with a trendline to indicate how the lake changed over time. The dashed red lines are the limits of the target range and areas shaded in pink are outside the target range.

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.



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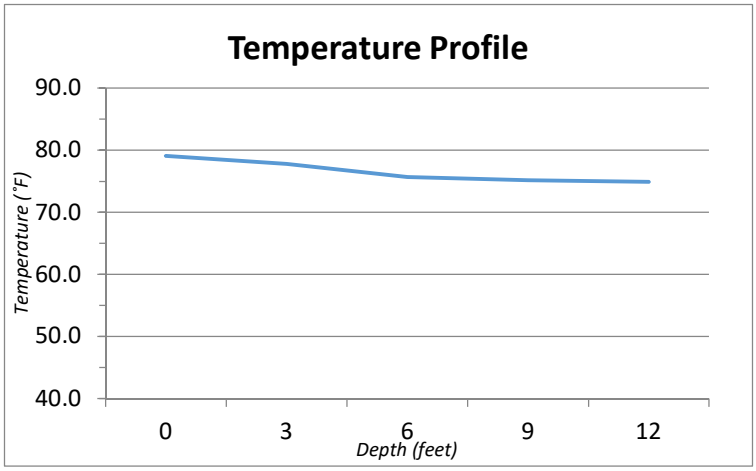
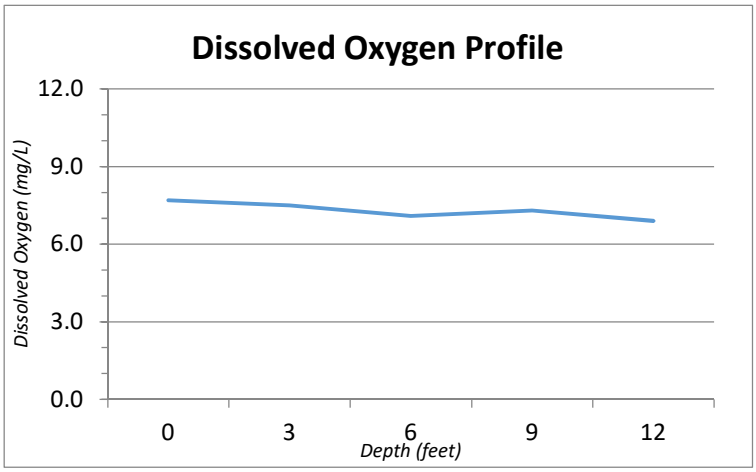
We also measured temperature and dissolved oxygen at three-foot intervals to create a depth profile. This data shows how the parameters changed with depth. The graphs below shows the data we collected in 2018. A thermocline was not present in Pebble Lake, instead the temperature decreased slightly from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



Depth (feet)	Temperature (°F)
0	79.1
3	77.8
6	75.7
9	75.2
12	74.9

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	7.7
3	7.5
6	7.1
9	7.3
12	6.9

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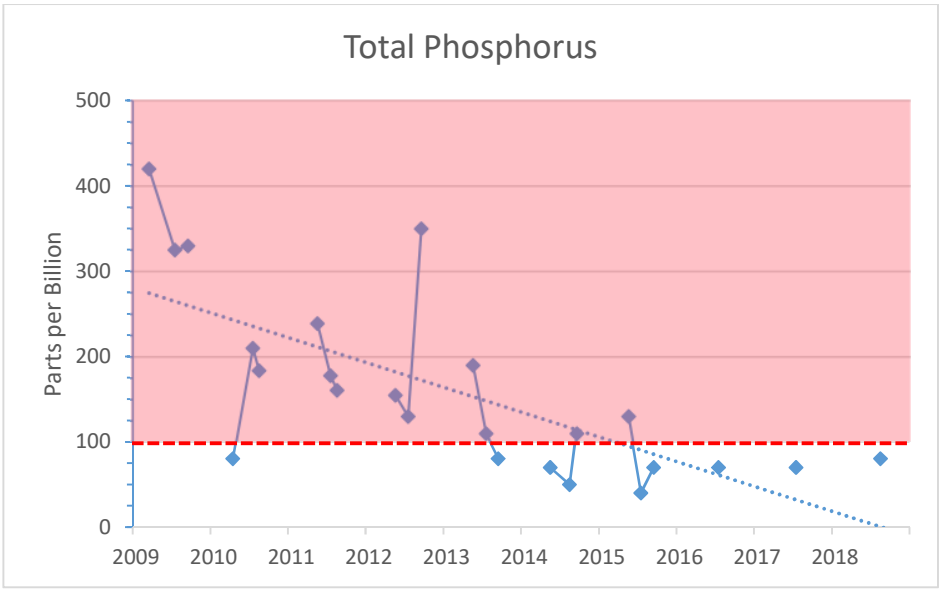
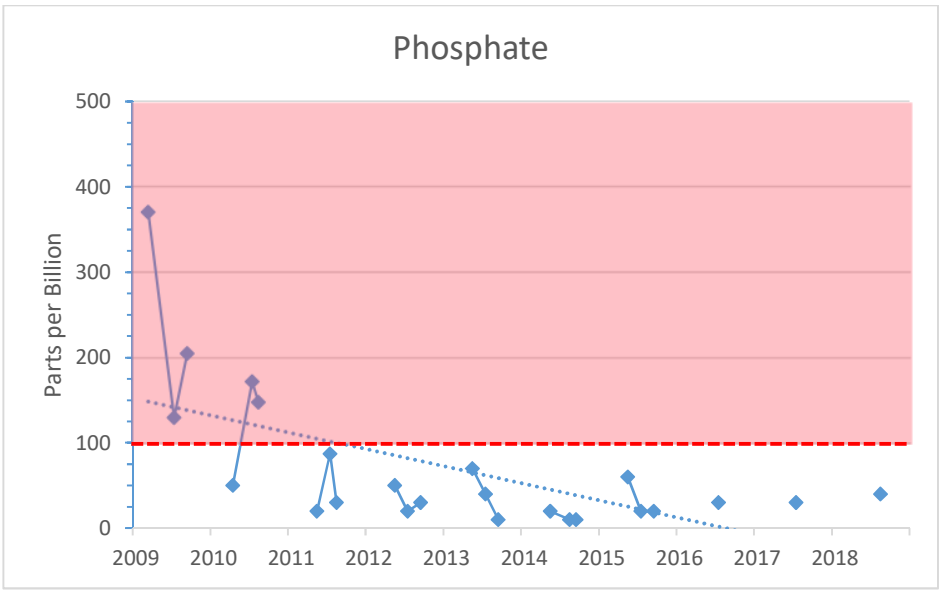
Nutrients, Plant Production, and Transparency

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 2010. 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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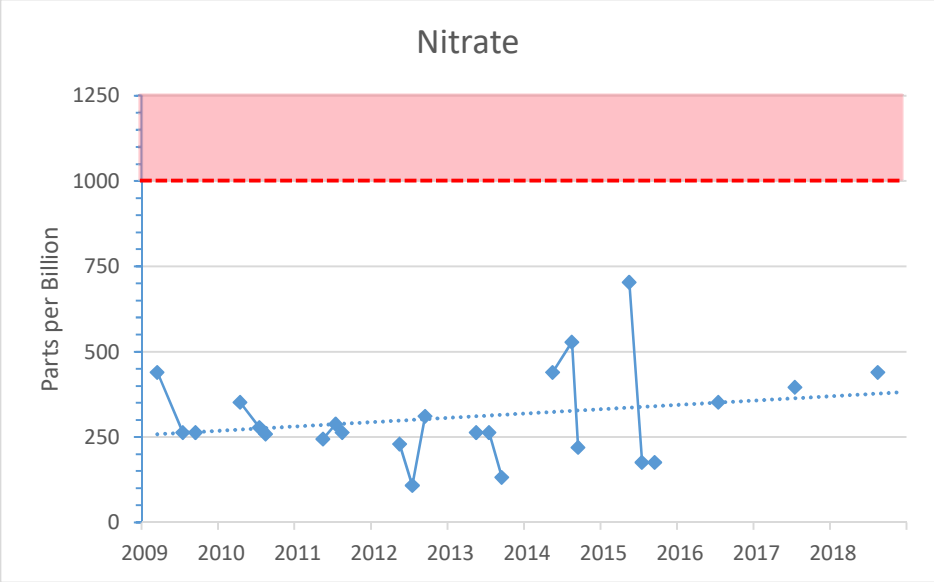
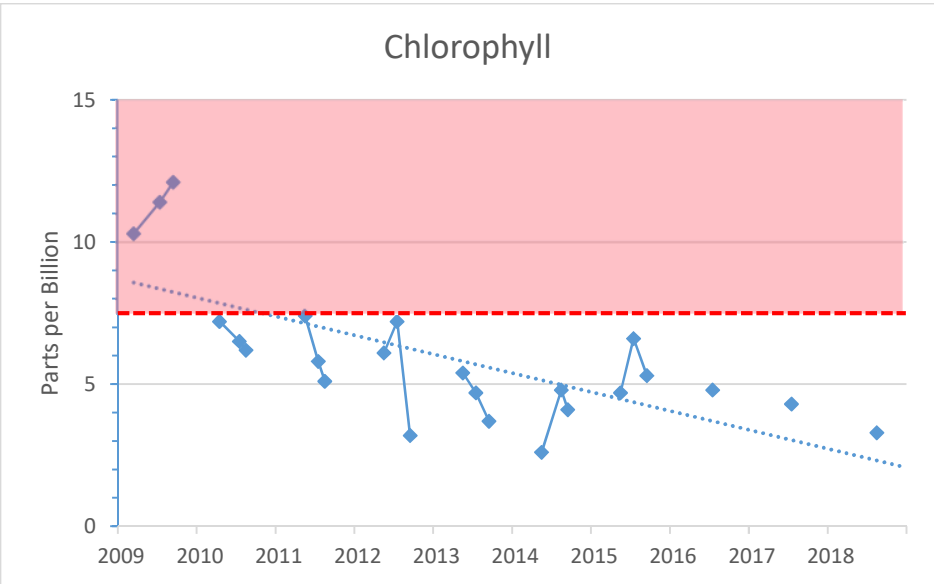
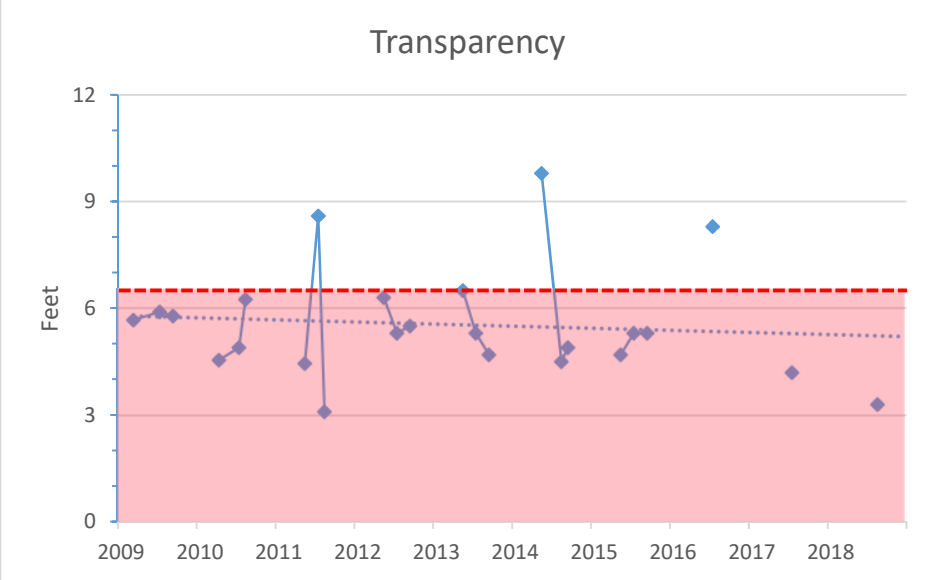
Nitrate is another major nutrient for aquatic plant growth. During this test, the **nitrate** concentration was within the target range. Over the testing history, the concentration trended upward. This shows a slow accumulation of this nutrient in the lake. It is important to fertilize and use the land 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 downward, with a large decrease in 2010. Since then, the chlorophyll concentrations decreased slightly. LakePro's management goal is to control nuisance algae while leaving some aquatic plant growth for a healthy ecosystem.



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 3.3 feet. This was lower than recent years but 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 Pebble Lake were:

Category	Water Quality Parameter	Trophic State Index (season average)	Classifciation
Nutrients	Total Phosphorus	67	Eutrophic
Plant Production	Chlorophyll	42	Mesotrophic
Clarity	Transparency	60	Eutrophic

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.

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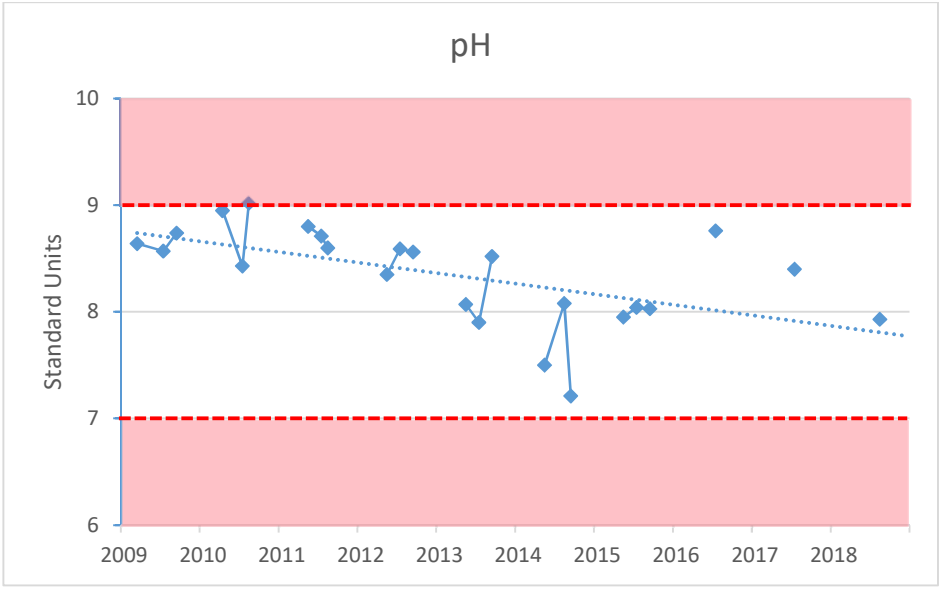
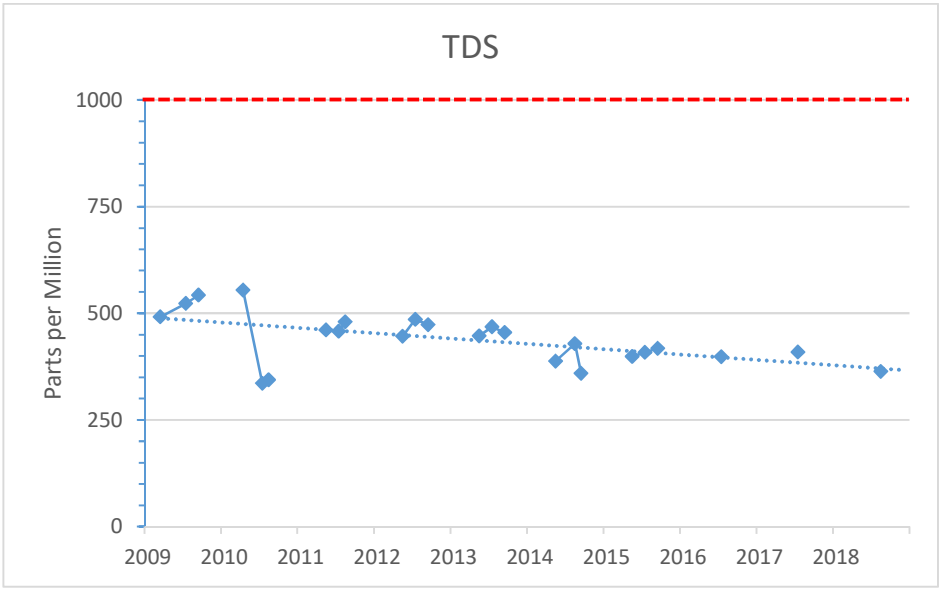
Water Chemistry Parameters

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.

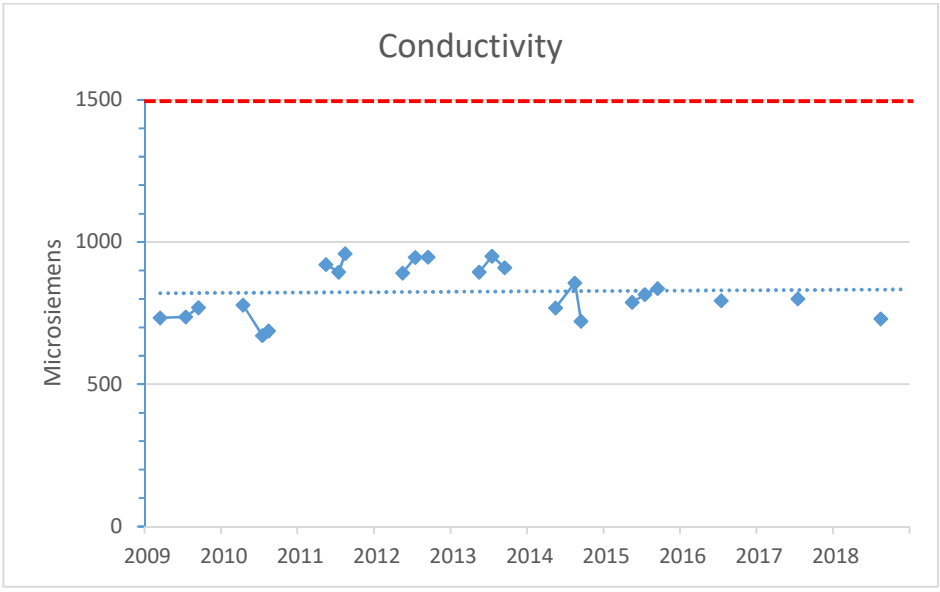
The **pH** of the lake remained within the target range in 2018. This showed that despite changes in dissolved oxygen, alkalinity, and rainfall, the pH did not fluctuate to a point of concern. The historical trend was downward. We will closely watch the pH to flatten in future years of testing.



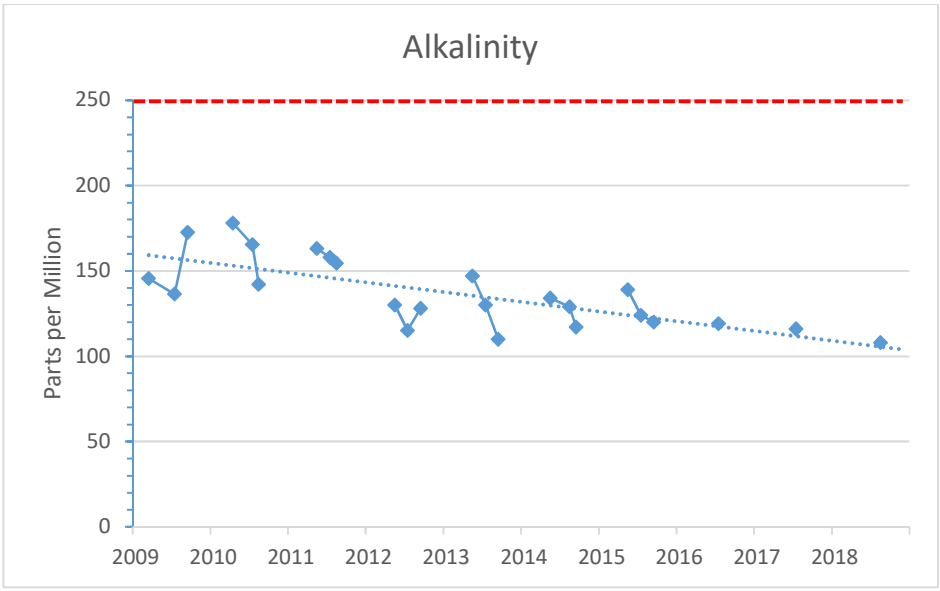
The **total dissolved solids** (TDS) results showed there were low amounts of dissolved substances in the water. This parameter includes nutrients, salts, and other substances, so it is a positive when this parameter remains low. The longterm trend is downward, helped by this year's result.



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. Over the testing history, this parameter fluctuated but showed no significant changes.



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.



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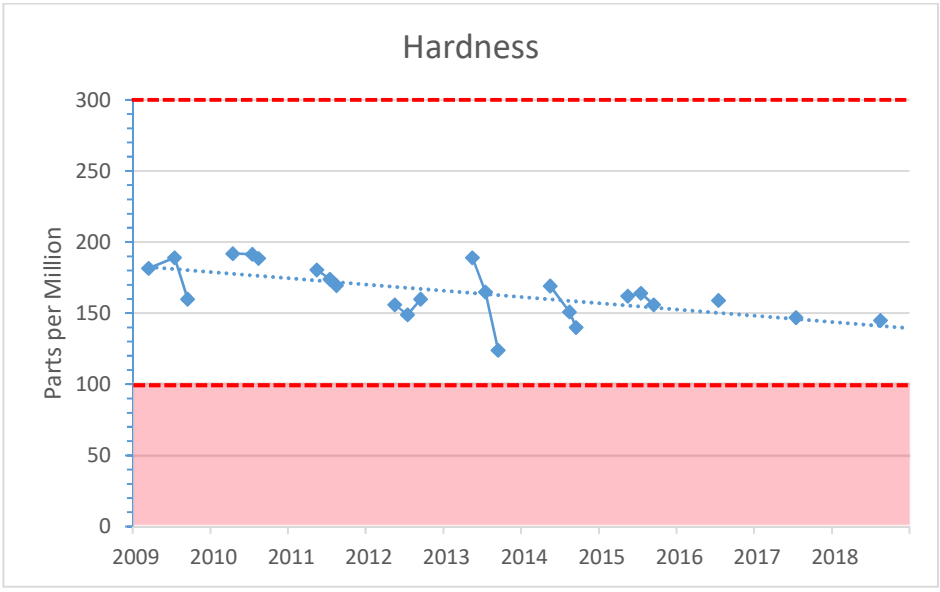
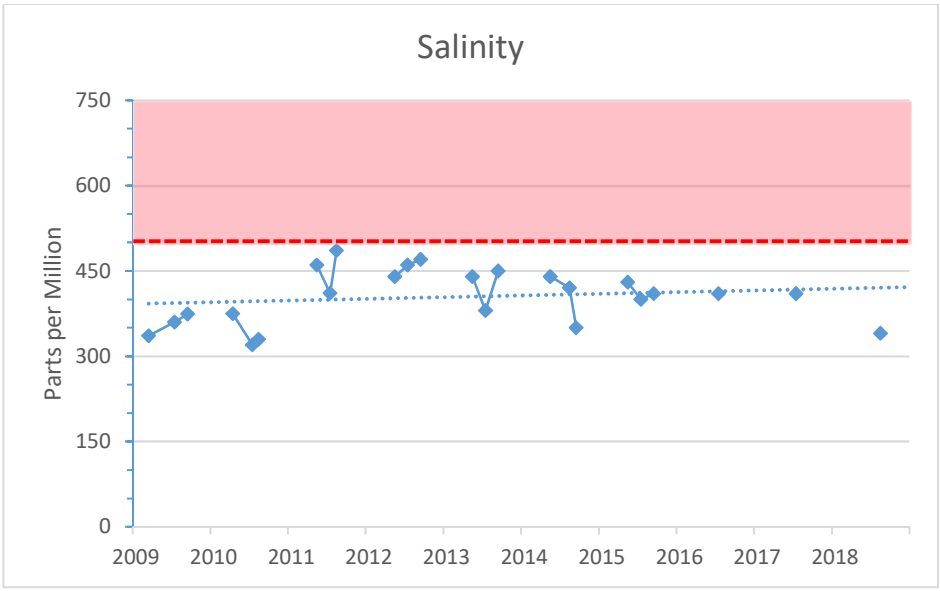
While alkalinity measures the acid neutralizing capacity in the form of carbonate, hardness measures the polyvalent cations, such as calcium. Since one of the most commons salts in the water is Calcium Carbonate, hardness generally follows alkalinity. The **hardness** was at a healthy level during this test and trended slightly down 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 in the middle of the target range this year, but trended upward over the testing history. Considering alkalinity and hardness are trending downward, the extra salts may be coming off the roads and accumulating in the lake.



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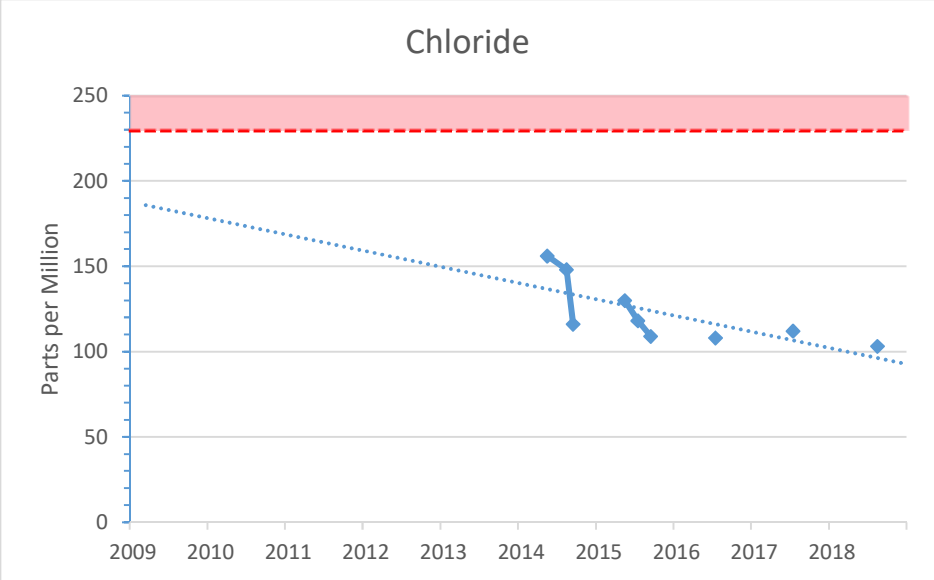
Chloride is the anion component of many different salts, the most common of which is Sodium Chloride. Some chloride will be present in ground and surface water, but elevated levels are indicators of pollution. One source of chloride loading is road salt, which enters the lake in the spring as the snow and ice melts off the roads and drainage ditches. This year, the **chloride** concentration was low and continued a relatively flat trend among the summer data points. The spring data from 2014 and 2015 were higher, as expected, so the total long-term trend is downward now that spring results are no longer included.



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Summary & Conclusions

Overall the water quality of Pebble 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 two parameters were 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 transparency was lower than that target depth. However, this lake characteristic was altered by the addition of water dye as part of the lake management program.

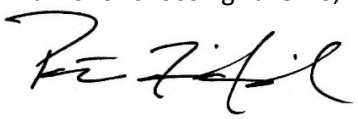
The historical data trends reveal more about how the lake has changed and the direction it may be headed in the future. The temperature trended upward, which may be cause for concern about dissolved oxygen in the future. But, the removal of spring testing removes data that would normally provide lower 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 water chemistry parameters showed variable trends over the past ten years. Despite the trends, the parameters remained within the target ranges for 2018. Moving forward, we will closely monitor two parameters: pH and Salinity. pH trended downward to approach the lower limit of the target range. In 2019, the tests will confirm another decrease or a rebound to a higher result. We will also continue to monitor the upward trend for salinity. The salinity increased despite decreases in both alkalinity and chloride. If the salinity continues upward, we will investigate other salts and sources to determine the reason for the increases.

For now, you should take pride in Pebble 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
3/26/2009	46.9	9.7	60	50	968	0.8	6.1	9.7	438	653	135	168	300	---
7/6/2009	78.4	6.1	75	60	396	0.8	6.3	8.8	417	589	156	191	286	---
9/1/2009	71.4	7.9	70	41	308	0.8	6.2	8.8	462	612	146	164	312	---
4/20/2010	59.4	10.3	110	100	308	0.6	9.8	8.8	454	638	121	162	306	---
7/7/2010	86.8	6.1	114	108	324	1.3	6.3	8.7	273	546	142	173	260	---
8/31/2010	81.2	5.2	112	86	292	0.9	6.1	8.5	356	641	141	165	270	---
5/12/2011	66.6	8.6	85	20	240	1.1	7.0	8.2	509	1006	143	167	265	---
7/6/2011	86.0	4.8	105	49	265	1.8	6.8	8.3	489	969	145	171	226	---
8/30/2011	78.4	5.2	88	10	396	0.9	4.6	8.3	509	719	141	167	347	---
5/11/2012	67.8	7.8	120	40	296	1.7	7.7	8.7	286	572	125	148	280	---
7/9/2012	86.0	6.5	70	10	308	1.1	4.7	8.3	326	653	132	168	310	---
9/6/2012	77.7	4.6	100	20	506	0.9	5.4	8.4	371	738	140	171	360	---
5/7/2013	69.2	7.9	50	20	308	6.1	6.5	8.2	423	857	169	210	470	---
7/10/2013	77.6	7.1	60	20	484	4.2	5.2	7.7	432	879	153	194	390	---
9/24/2013	66.9	7.6	40	20	176	3.1	4.0	8.1	531	1046	148	166	420	---
5/23/2014	71.3	8.1	40	20	308	1.4	5.6	8.0	296	590	150	183	370	112
8/5/2014	73.5	6.8	30	10	352	1.7	5.0	8.5	307	613	117	134	300	93
9/23/2014	66.2	9.0	30	10	308	1.1	6.1	8.0	305	610	132	162	300	88
5/6/2015	64.2	9.0	50	30	308	4.1	8.4	8.1	355	702	131	154	380	112
7/15/2015	75.6	6.8	40	10	220	3.0	6.7	8.1	305	611	121	160	300	81
9/16/2015	72.8	7.6	50	10	132	1.5	9.6	8.0	313	613	114	155	290	78
7/25/2016	81.8	7.2	60	30	308	2.1	10.0	8.6	306	598	121	165	290	79
7/19/2017	79.8	6.6	80	40	484	4.6	7.2	8.2	325	641	128	154	280	86
8/2/2018	79.0	7.0	70	40	440	3.9	5.7	7.4	356	713	122	160	350	81