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2024 Rainbow Lake Water Quality Report

Gratiot County, Michigan

Introduction

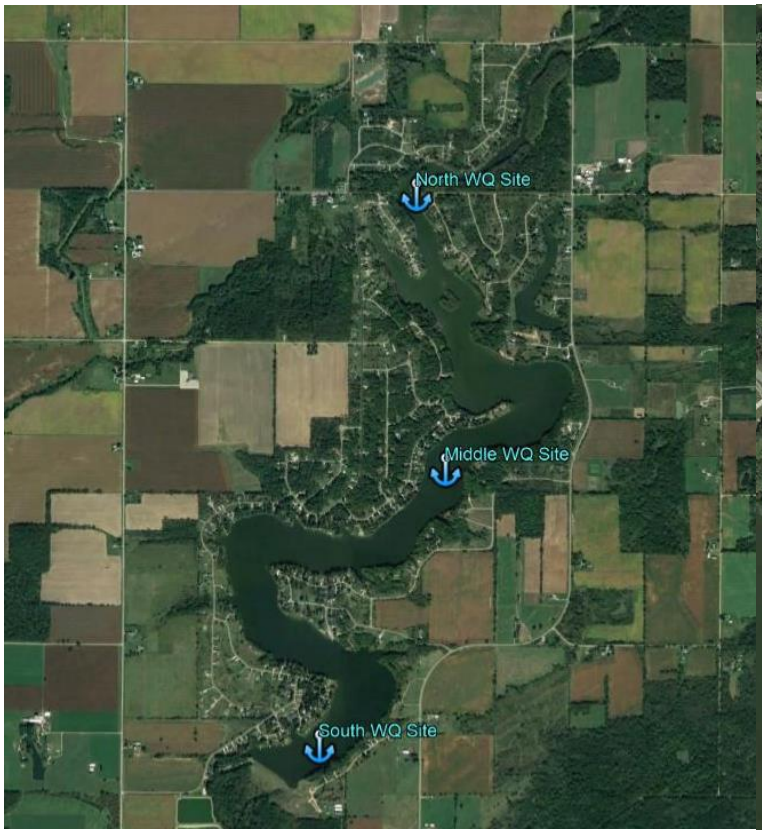
The goal of this testing program was to monitor various water quality parameters of the lake, compare results to historical data, and identify any potential risks to the health of Rainbow Lake. Water samples were taken at three different locations and tested for 12 different parameters. Tests were conducted with a Hanna Nutrient Specific Calorimeters and YSI ProDSS Multiparameter Water Quality Meter and a Hach DR1900 spectrophotometer. Test results were compared to the historical data in "2024 Rainbow Lake Water Quality Report" by LakePro, Inc.

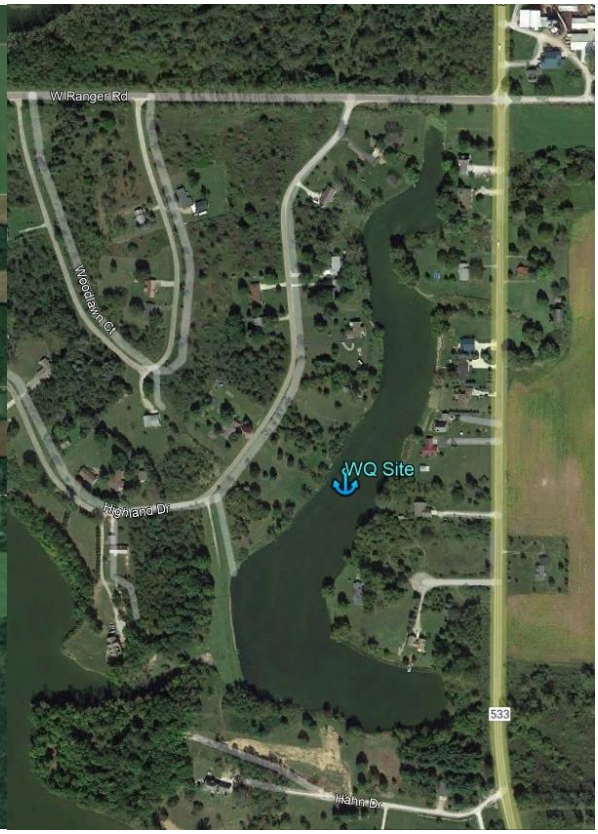
Testing Dates

Field tests and water samples were taken on April 30th, 2024, and August 19th 2024. Laboratory tests were completed on September 15th, 2024. This report describes conditions at the times the samples were taken. Historical testing dates are at the end of this report.

Water Quality Sampling Sites

The following maps show the water quality sampling locations on both Big and Little Rainbow Lakes.





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Water Quality Results

Parameter	Test Date	North	Middle	South	Target Range
Temperature	April 30th	58.5 ˚F	58.7 ˚F	59.9 ˚F	Less Than 75 ˚F
	August 19th	75.0 ˚F	74.6 ˚F	75.0 ˚F	
Dissolved Oxygen	April 30th	8.0 mg/L	7.6 mg/L	8.2 mg/L	4.0 – 12.0 mg/L
	August 19th	9.0 mg/L	9.1 mg/L	9.3 mg/L	
Total Phosphorus	April 30th	● 115 ppb	● 119 ppb	100 ppb	0 – 100 ppb
	August 19th	● 115 ppb	● 105 ppb	90 ppb	
Phosphate	April 30th	50 ppb	45 ppb	40 ppb	0 – 100 ppb
	August 19th	62 ppb	65 ppb	63 ppb	
Nitrate	April 30th	952 ppb	825 ppb	837 ppb	0 – 1,000 ppb
	August 19th	● 1,010 ppb	990 ppb	995 ppb	
Chlorophyll-α	April 30th	2.6 ppb	2.7 ppb	5.7 ppb	0 – 7.3 ppb
	August 19th	● 26.5 ppb	● 25.3 ppb	● 24.1 ppb	
Transparency	April 30th	● 1.8 feet	● 1.6 feet	● 1.7 feet	More than 6.5 feet
	August 19th	● 1.1 feet	● 1.2 feet	● 1.3 feet	
pH	April 30th	8.6	8.5	8.5	7.0 – 9.9 S.U.
	August 19th	8.7	8.8	8.2	
Total Dissolved Solids	April 30th	327 ppm	328 ppm	330 ppm	0 – 1,000 ppm
	August 19th	225 ppm	263 ppm	254 ppm	
Conductivity	April 30th	504 µS	505 µS	507 µS	0 – 1,500 ppm
	August 19th	423 µS	435 µS	438 µS	
Alkalinity	April 30th	153 ppm	149 ppm	154 ppm	0 – 250 ppm
	August 19th	167 ppm	164 ppm	171 ppm	
Total Salinity	April 30th	240 ppm	250 ppm	250 ppm	0 – 500 ppm
	August 19th	220 ppm	220 ppm	230 ppm	

Discussion

We performed the tests in early and late summer to capture the water quality at the start of the season and during the stress of warm water conditions. Each testing event captured a snapshot of the water quality when the sample was pulled. Water quality parameters can change from morning to night, day to day, and year to year. The discussion below focused on the results listed above.

This year's testing results indicated that Rainbow Lake continues to exhibit some nutrient enrichment (Total Phos., Nitrates, Chlorophyll-a), consistent with previous findings. Also, the water clarity was below the target range, similar to historical results. Moreover, the water chemistry parameters have all maintained relatively stable levels within the desired target ranges.

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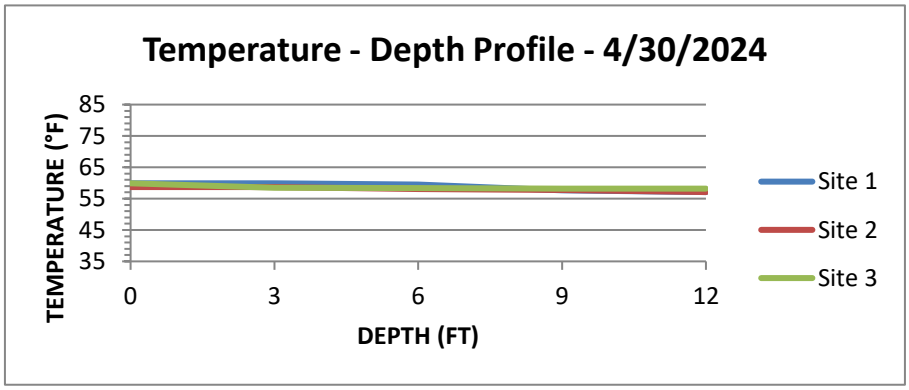
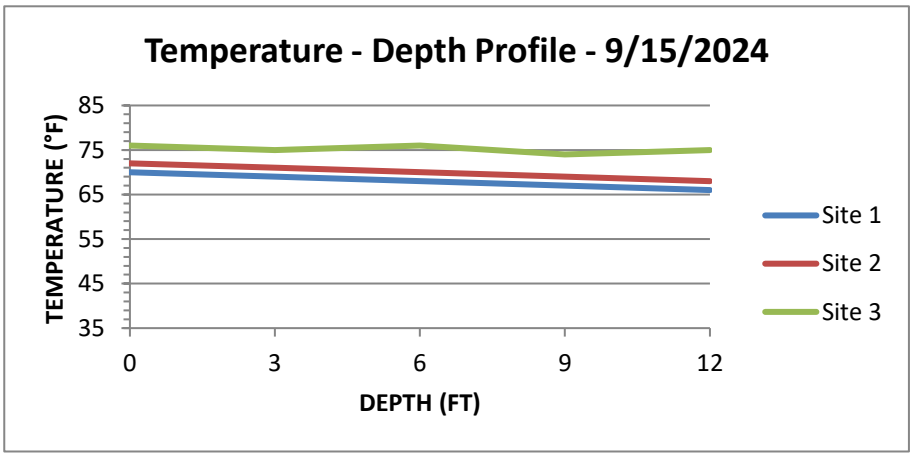
This was the tenth year that LakePro tested the lake water. This historical data has enabled us to distinguish between parameters that exhibit natural variations and those that demonstrate consistent trends. With each successive year of testing, we can enhance the precision of our trend analysis even further.

The **Temperature** was similar to last year in the spring however, temperatures in the summer were much lower than what was recorded last year. Cooler water can hold more oxygen, so lower surface temperatures are better for the lake.

We also measured temperature at different depths to create a **depth profile**. This data shows how the temperature changed with depth and whether or not a thermocline was present in the lake. The graph below shows the data we collected this year. A thermocline was not present in the water this year in either the spring or summer tests. Instead, the water temperature decreased steadily from the surface to the lake bottom.





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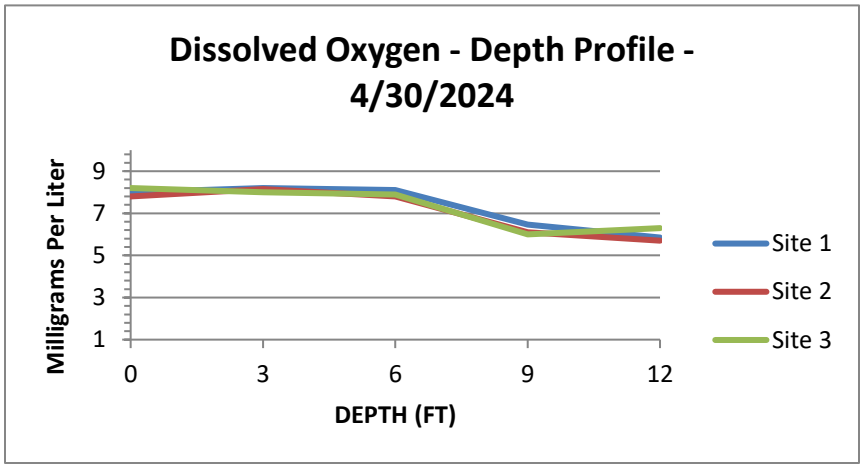
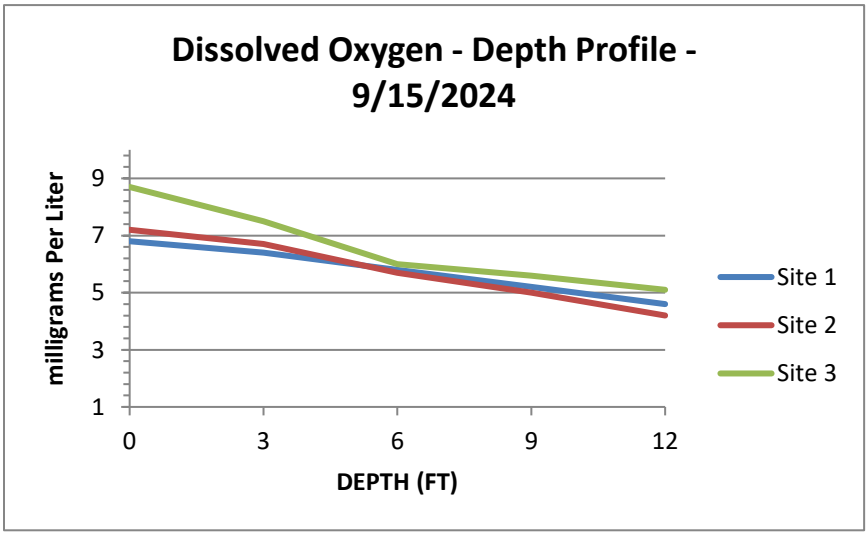
During both tests, the **Dissolved Oxygen** concentrations were sufficient levels to support a healthy fishery. We also measured dissolved oxygen at different depths to create a **depth profile**. This data shows how the oxygen concentration changed with depth. The graph depicted below illustrates the data we gathered this summer. In both sampling instances, we observed a decline in dissolved oxygen levels from the lake's surface to its bottom. Importantly, the results from both tests indicated that there was an ample supply of oxygen to sustain a thriving fishery across the entire water column.





During the spring tests, the **Total Phosphorus** concentrations were above the target range. These concentrations stayed relatively steady throughout the summer. Total Phosphorus is lost to dilution, flushing, and plant uptake. Additionally, we conducted tests for o-Phosphate, the form of phosphorus essential for plant growth. It's noteworthy that the levels of Phosphate fell within the designated target range during both testing sessions, with a decrease observed from the initial to the subsequent sampling.

Another major nutrient, **Nitrate,** was above the target range at the north sampling location during the second test. The concentrations increased over the summer, most likely due to run off from precipitation, and other non-point source factors. The target range for natural, freshwater lakes is less than 1 ppm (1,000 ppb). The EPA's standard for drinking water is 10 ppm (10,000 ppb). During the spring and summer test, all sites were below the drinking water limit. Swimming restrictions in this case are not needed and recreational activities are safe to participate in.

Chlorophyll, which is tested to quantify plant production, was within the target range during the April test. By August, the chlorophyll increased dramatically showing the lake supported abundant plant and algae growth. High chlorophyll levels in a body of water can indicate an overabundance of algae and phytoplankton, and while these organisms are essential for the aquatic food web, excessive chlorophyll can lead to environmental issues

Transparency was below the target range at all sites and during both tests. The low clarity was caused mostly by turbidity. With the low transparency, swimmers and boaters should use caution because they may not accurately judge depth or see underwater obstructions.

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. This summer's TSIs for Rainbow Lake were:

Category	Water Quality Parameter	Trophic State Index (season average)	Classifciation
Nutrients	Total Phosphorus	71.5	Hypereutrophic
Plant Production	Chlorophyll	52.5	Mesotrophic
Clarity	Transparency	72.0	Hypereutrophic

The TSI for total phosphorus classified the lake as hypereutrophic, or highly productive, based on the availability of nutrients to fuel plant growth. The TSI for chlorophyll was lower than the nutrient index, showing that the plants did not grow to the levels predicted by the nutrient concentrations. Finally, the TSI for transparency showed the clarity was worse than predicted by the plant production. This was most likely due to the turbidity.

pH increased on average from last year and remained within the target range. pH is a broad indicator of lake health that can show changes based on rainfall, dissolved oxygen, groundwater inputs, and pollution. It is important this parameter stay within the target range.

The **Total Dissolved Solids** and **Conductivity** both slightly increased from last year, showing the lake gained a partially higher amount of substances. The results were still within the target ranges.

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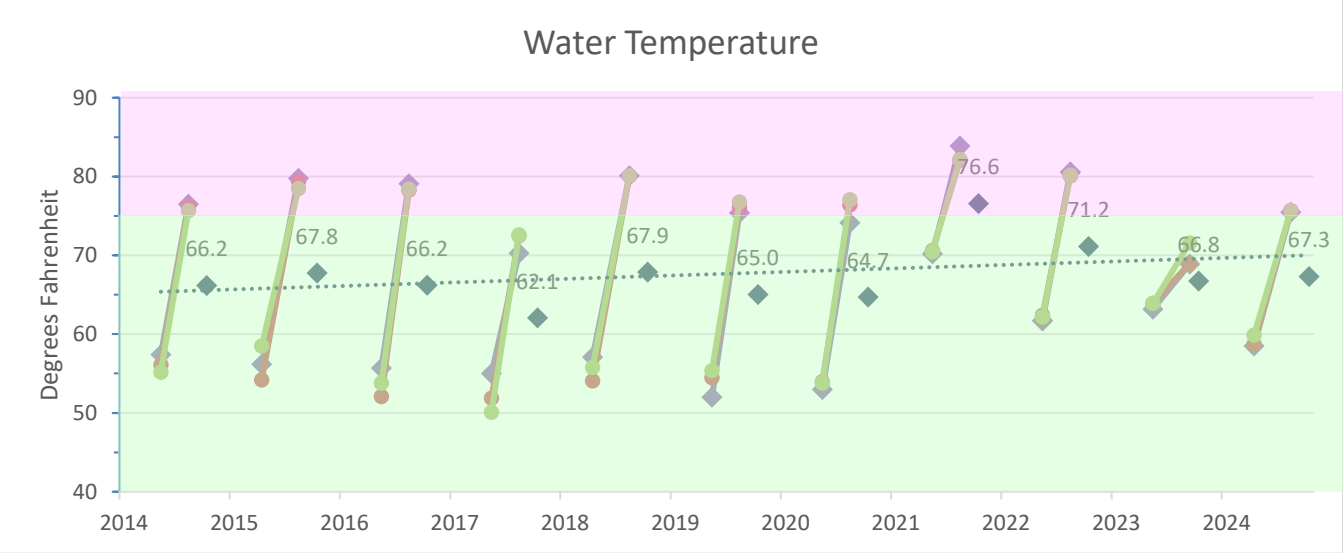
The **Alkalinity** was at very healthy concentrations during both tests. Calcium carbonate is the main constituent of these parameters. Calcium carbonate enters the lake with groundwater that coursed along limestone deposits. The carbonate ions buffer against shifts in the pH caused by other substances, so having sufficient alkalinity was beneficial to the lake.

The **Salinity** was at normal levels in the water and showed a slight decrease from last year. These results were consistent with the increases of TDS and Conductivity.

Long-Term Trends

LakePro began testing the water quality of Rainbow Lake in 2014. 2024 was the Eleventh year of testing, which allowed us to compare annual averages. Each successive year of water quality data will provide more insight into how the lake changed on a long-term scale.



Target Range: Less than 75°F

The lake temperature has not changed significantly over the testing history. The lake temperature was affected by the dates selected for testing and the particular weather of each year.

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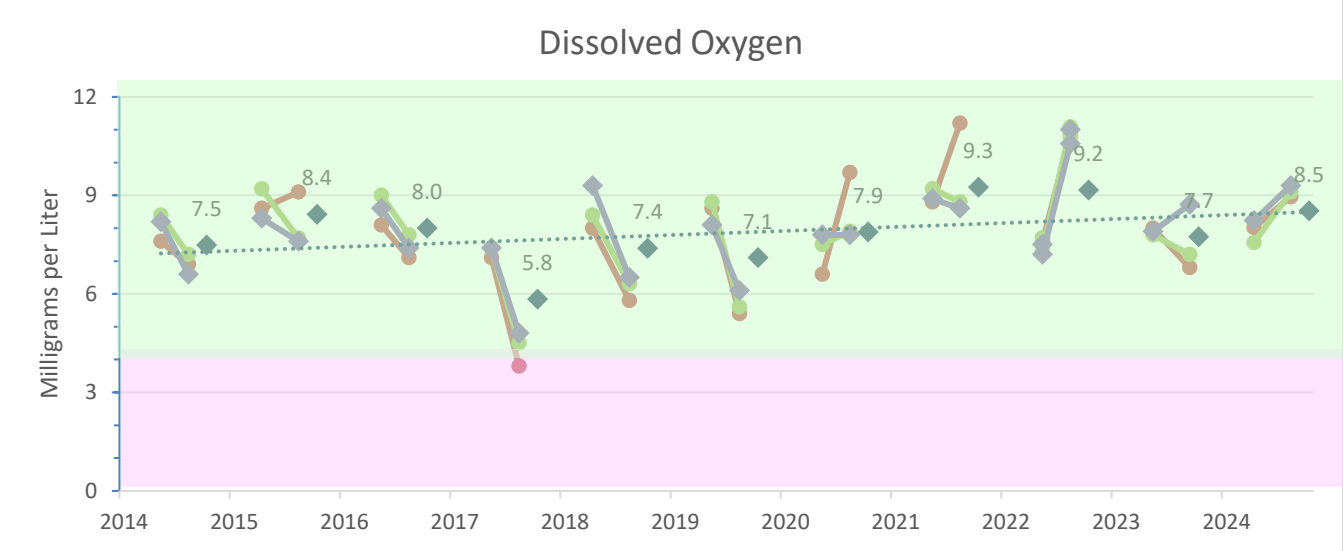
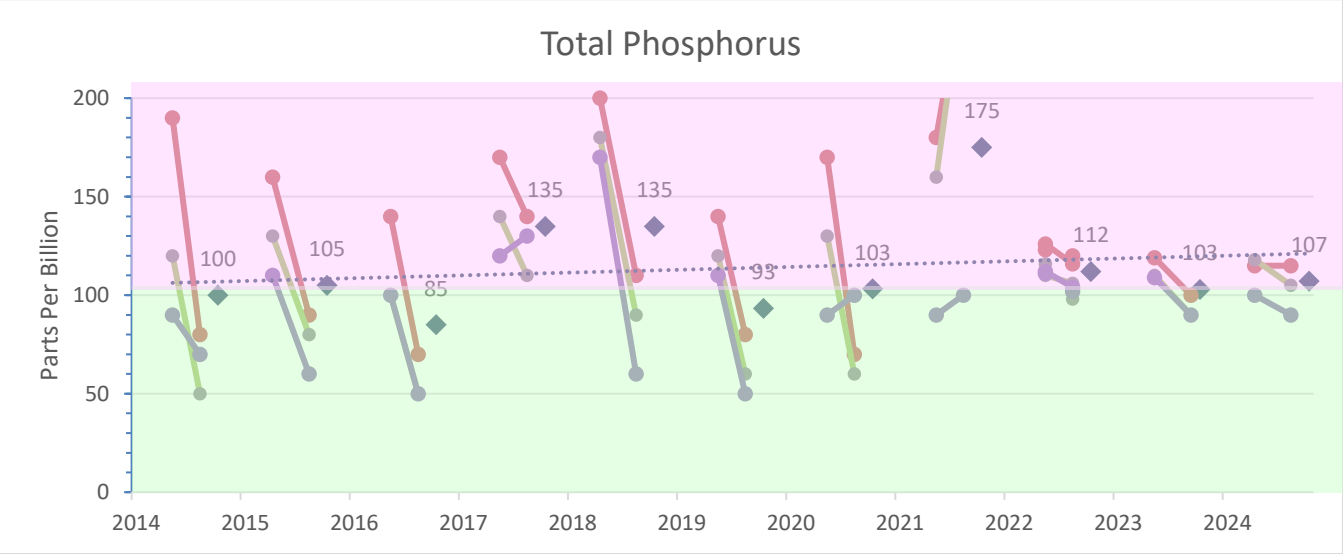


Target Range: 4.0 – 12.0 mg/L

The dissolved oxygen increased slightly over the testing history, but remains within the target range. This could be due to eutrophication of the lake.



Target Range: 0 – 100 ppb

The total phosphorus concentration showed a slight upward trend over the testing history. Additional phosphorus can enter the lake with runoff, from Pine Creek, or by leaching from the bottom sediment during periods of low oxygen. This year and last year have showed a slight incline.

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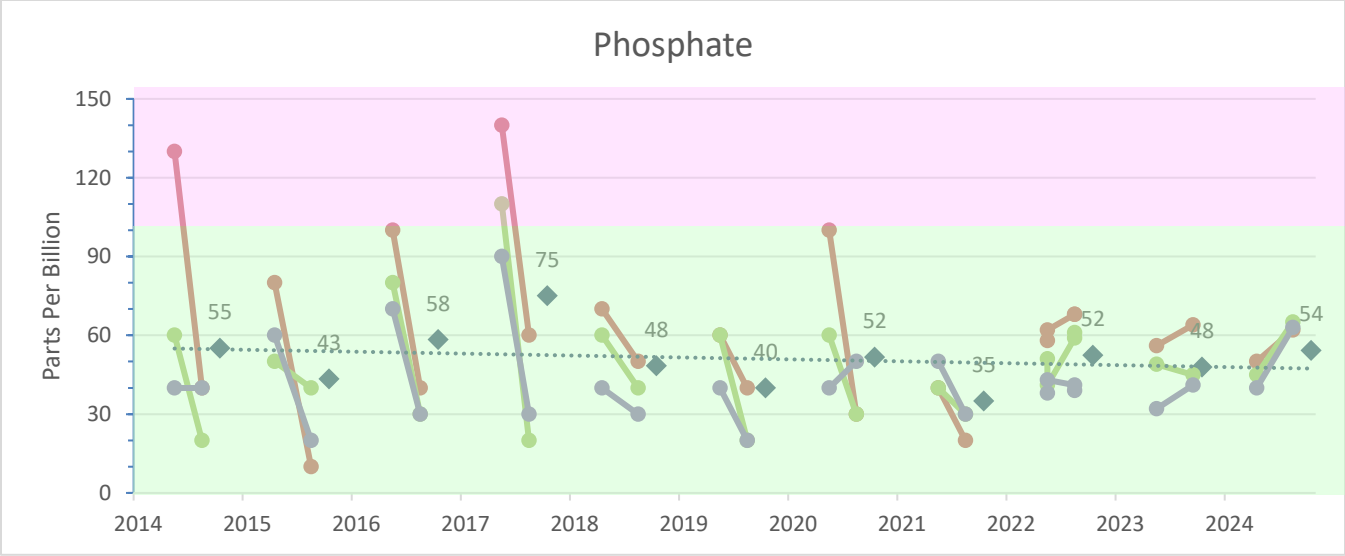
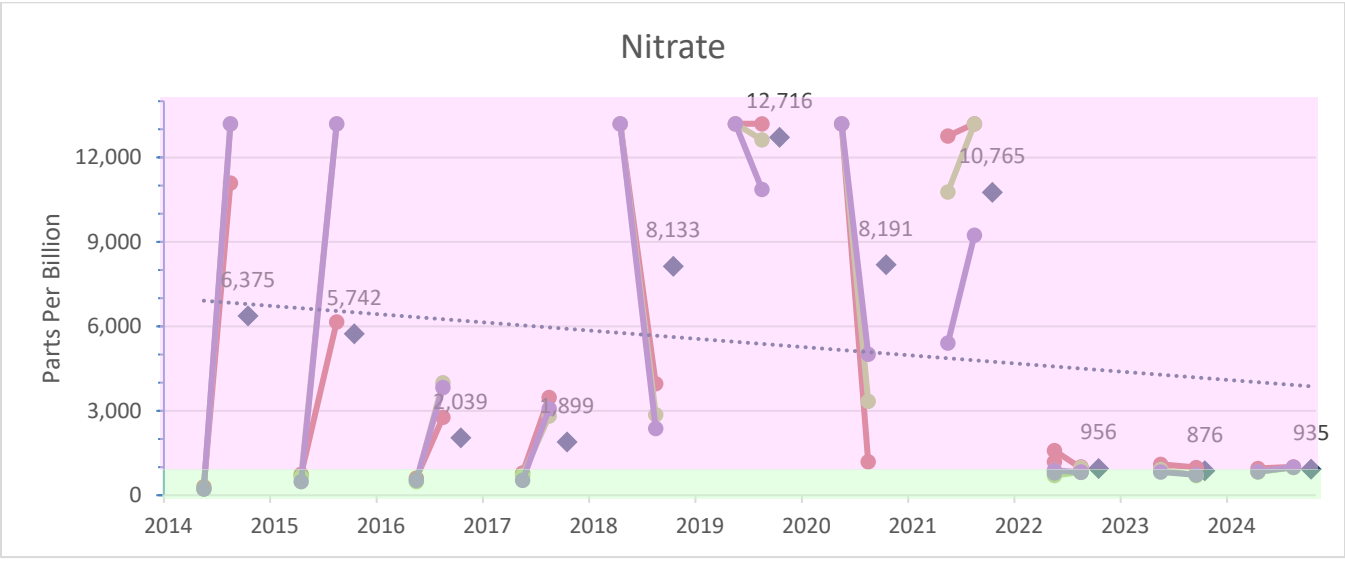


Target Range: 0 – 100 ppb

Although there was an increase in total phosphorus, the trend for o-phosphate exhibited a slight decline throughout our testing history. This could be attributed to increased plant uptake of o-phosphate or a shift towards other forms of phosphorus in the ecosystem.



Target Range: 0 – 1,000 ppb

Nitrate showed an upward trend over the testing history. The excess nitrates in the past have posed a public health risk however, the last three years have showed a healthy decrease. The excess nitrate could also lead to nuisance algae and plant growth, kept in check by the phosphate concentration and low water clarity.

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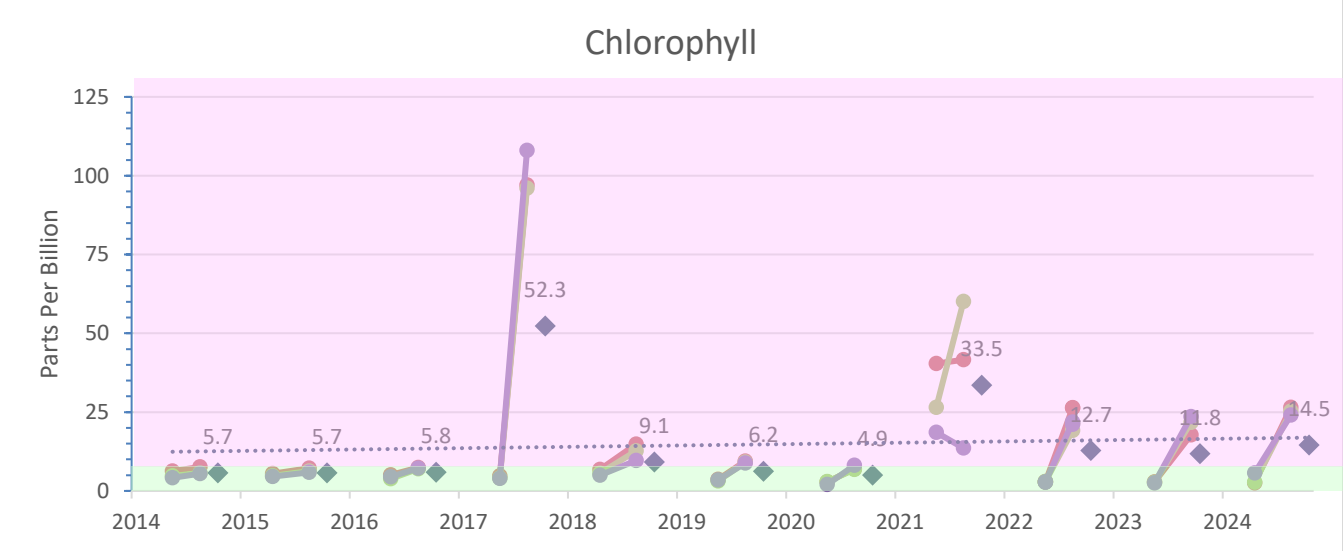
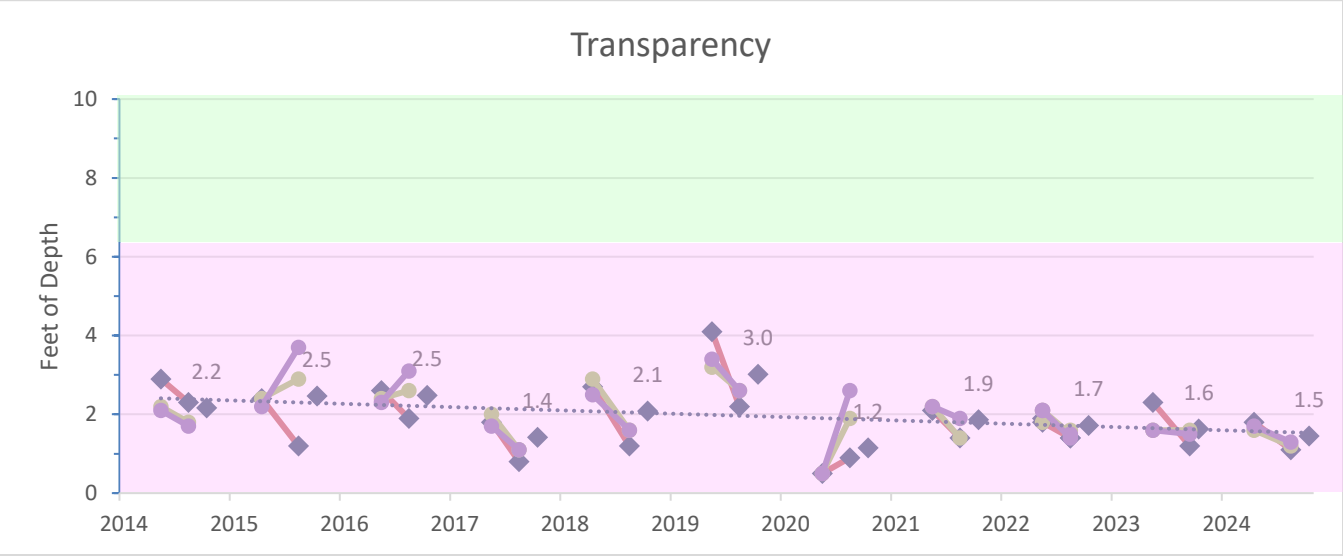


Target Range: 0 – 7.3 ppb

Despite the lake-wide algae bloom in 2017, the chlorophyll concentrations have been steady over the testing history. Low water clarity helped to slow the plant and algae growth in the water.



Target Range: More than 6.5 feet

The Transparency showed a slightly downward trend, a continuing trend since 2020. The transparency of Rainbow Lake is primarily affected by the turbidity of the water.

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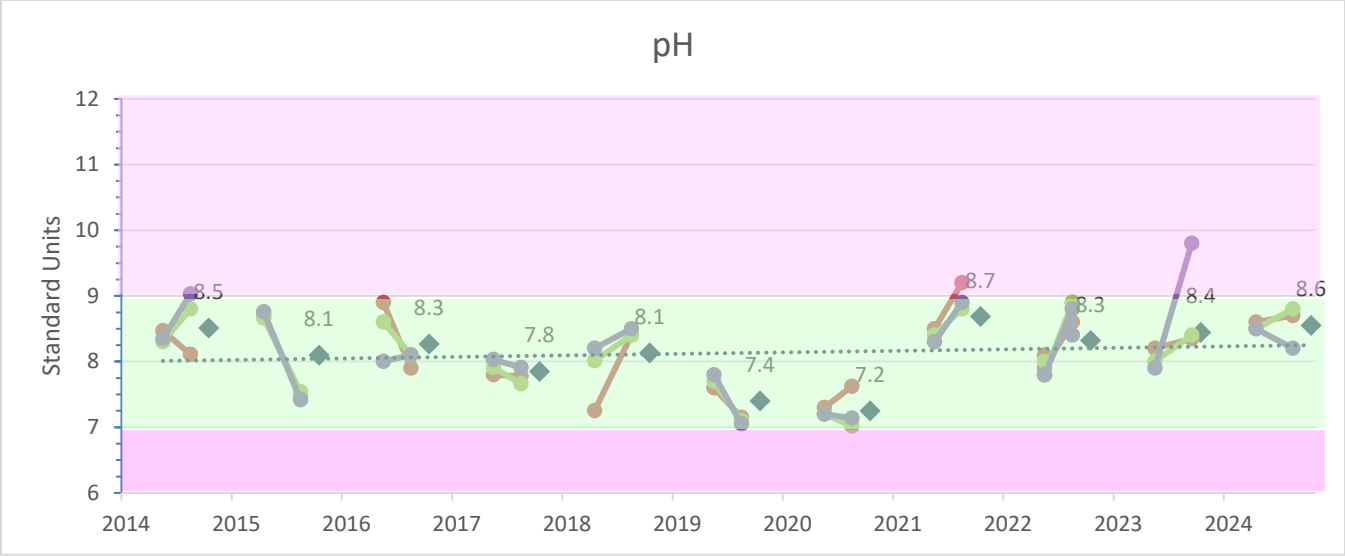
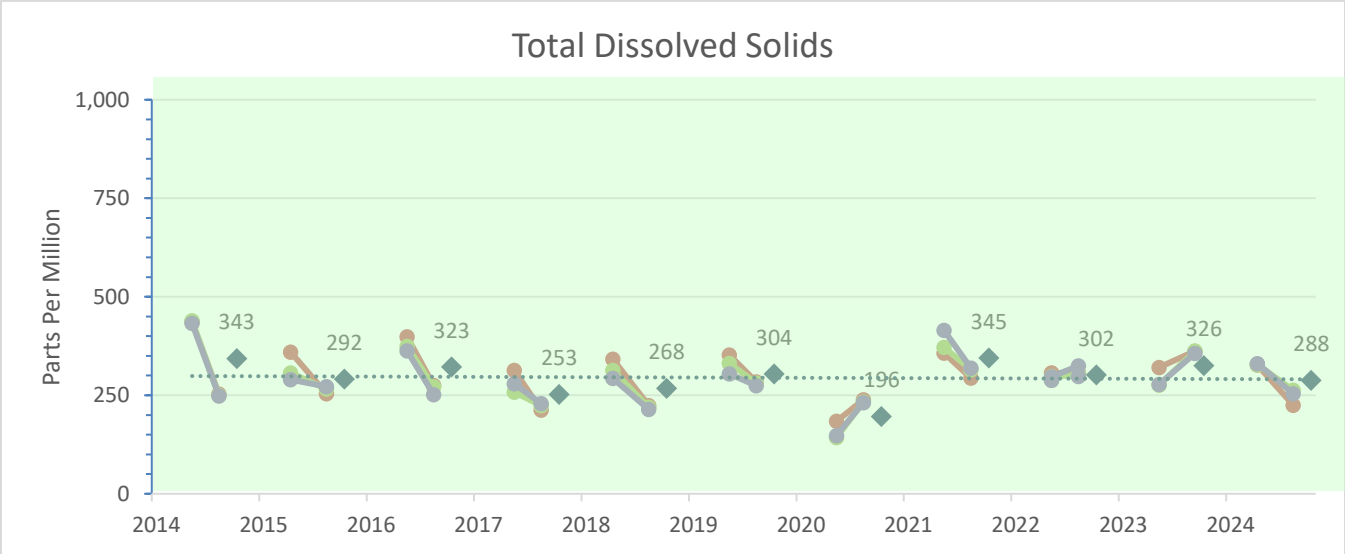


Target Range: 7.0 – 9.0

The pH showed a downward trend over the testing, but all results are within the target range. The pH fluctuates with many different factors, including rainfall, groundwater inputs, and plant productivity. This years average was slightly higher than last year.



Target Range: 0 – 1,000 ppm

The TDS decreased slightly over the testing history, showing the lake lost substances at a slow rate. This is a positive for the lake that we look to continue in future years.

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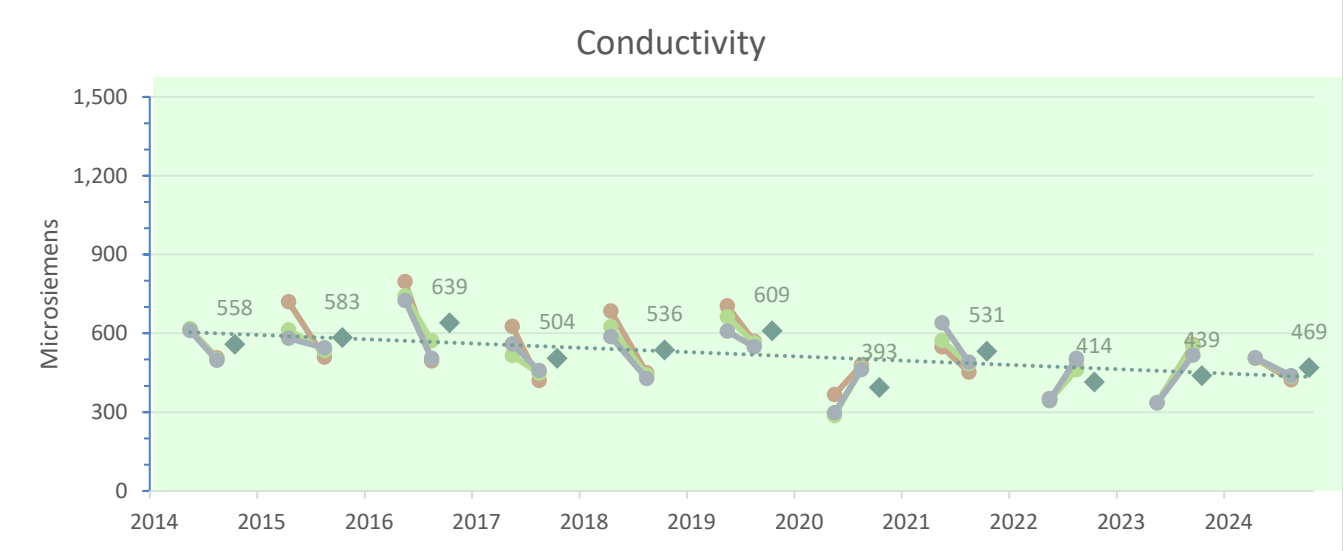
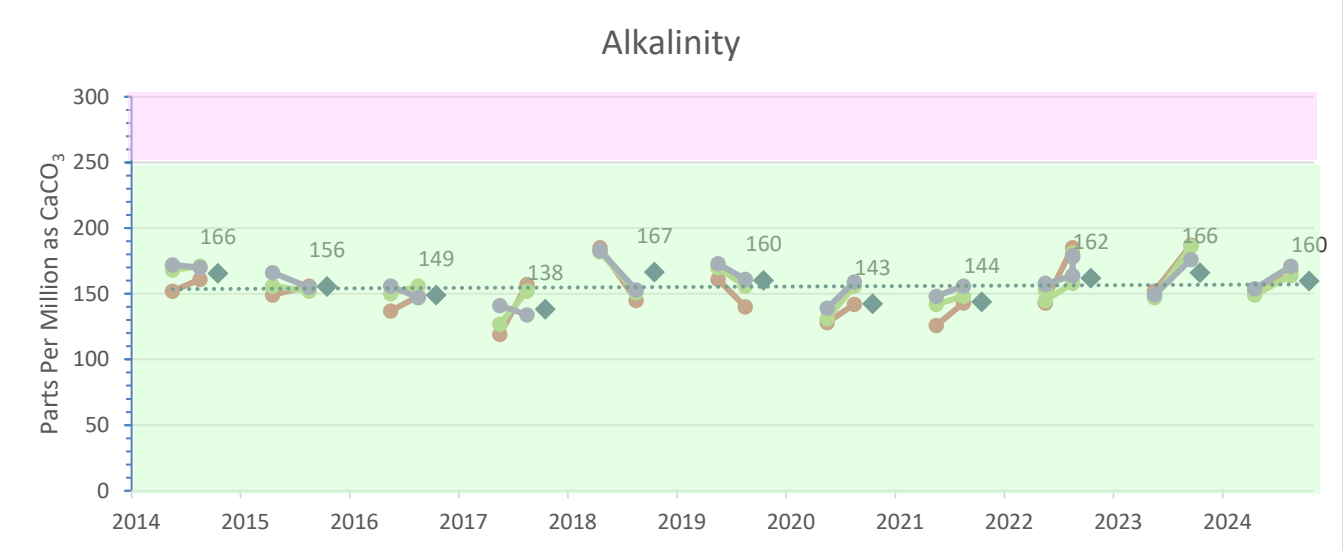


Target Range: 0 – 1,500 µS

Conductivity is an extension of TDS and measures the amount of ionic molecules in the water (which conduct electricity). The conductivity also decreased slightly over the testing history, matching the TDS even with slight upticks this year.



Target Range: 0 – 250 ppm

The Alkalinity has not changed significantly over the testing history. Alkalinity works as a buffer to stabilize the pH when foreign substances enter the lake, such as acidic rainwater. The alkalinity will help stabilize the lower pH values from the summer.

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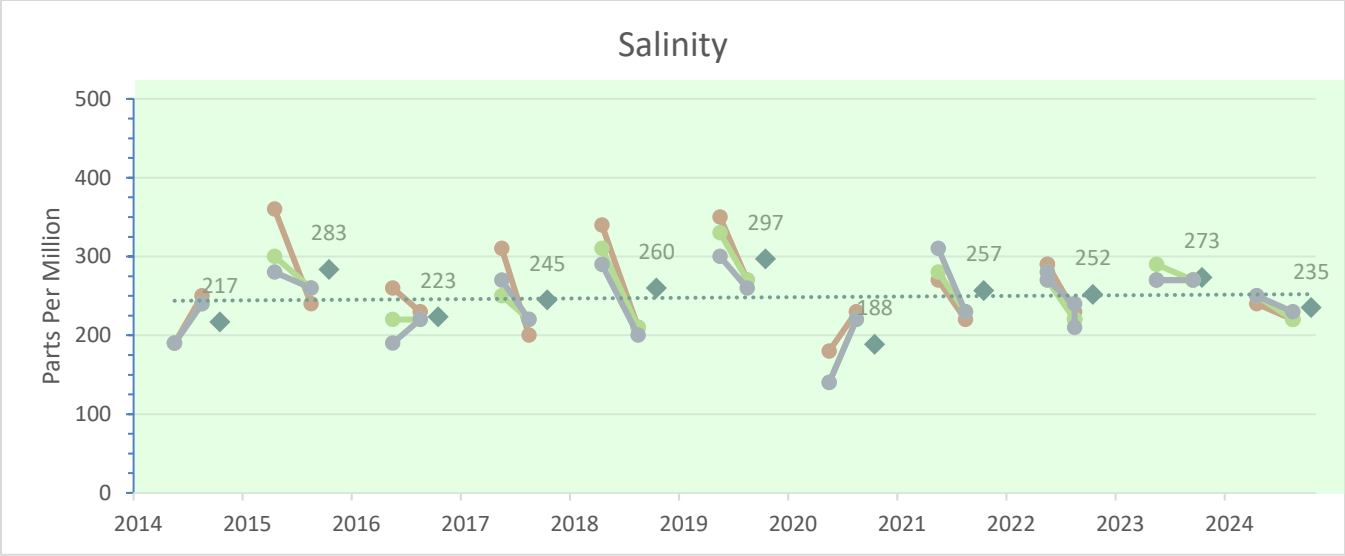

Target Range: 0 – 500 ppm
The salinity fluctuated but has not significantly changed during the testing history, consistent with the alkalinity and despite a small decrease in the TDS.

Little Rainbow Values

Parameter	April 30th, 2024	August 19th, 2024	Target Range
Temperature	62.8 ˚F	74.8 ˚F	Less than 75 ˚F
Dissolved Oxygen	7.3 mg/L	8.2 mg/L	4.0 – 12.0 mg/L
Total Phosphorus	102 ppb	100 ppb	0 – 100 ppb
Phosphate	56 ppb	67 ppb	0 – 100 ppb
Nitrate	654 ppb	743 ppb	0 – 1,000 ppb
pH	8.1	8.5	7.0 – 9.0 S.U.
Total Dissolved Solids	315 ppm	358 ppm	0 – 1,000 ppm
Conductivity	407 µS	436 µS	0 – 1,500 µS
Transparency	3.1 feet	2.9 feet	6.5 feet or above
Chlorophyll-a	3.4 ppb	5.6 ppb	0-7.3 ppb
Phycocyanin	1.9 RFU	1.3 RFU	0.0 – 5.0 RFU
Alkalinity	153 ppm	172 ppm	0 – 250 ppm
Total Salinity	180 ppm	197 ppm	0 – 500 ppm

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Conclusion

There are two major issues with the water quality of Rainbow Lake: Total phosphorus impairment, high chlorophyll-a in late summer and low transparency. The lack of clarity is tied to the morphology of the lake and the watershed. It is unlikely that the transparency will significantly increase in the future due to the suspended sediment particulates in the water as well as high concentrations of chlorophyll in late summer.

The high concentrations may also continue to fuel late-season algal blooms that turn the lake green with planktonic algae. Even though they were not as high as last year, nitrate concentrations need to be a focus as well. My recommendations from last year are still viable options to help reduce nutrient loading. I have included them below:

The nitrate levels of the lake have begun to stabilize over the course of the last three years to a safer threshold that poses less of a threat to recreational swimmers, pets, and children. To ensure these levels stay trending in a positive trajectory for the health of the lake and its residents, we recommend continued season monitoring of the water quality to identify key factors that impact nutrient levels. This paired with our developing database of annual data from Rainbow Lake will allow us to make predictive lake management measures in the future.

This year, the remaining water quality parameters of Rainbow Lake were quite favorable and in line with expectations for a waterbody of this kind. While the lake faces a challenge due to its expansive watershed, efforts to reduce nutrient input will ultimately enhance water quality, aligning it with the lake's other favorable attributes.

Completed and Certified by: _____ Date: September 15th, 2024

Michael Smith
Assistant Lake Manager

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Historical Water Quality Data

Date	Site	Temperature (°F)	Dissolved Oxygen (mg/L)	Total Phosphorus (ppb)	Phosphate (ppb)	Nitrate (ppb)	Chlorophyll (ppb)	Transparency (ft.)	pH	Total Dissolved Solids (ppm)	Conductivity (µS)	Alkalinity (ppm)	Salinity (ppm)
5/16/2014	North	57.4	7.6	190	130	308	6.3	2.9	8.5	437	615	152	190
	Middle	56.1	8.4	120	60	220	4.8	2.2	8.3	439	618	168	190
	South	55.2	8.2	90	40	220	4.2	2.1	8.4	433	610	172	190
8/15/2014	North	76.5	6.9	80	40	11,100	7.6	2.3	8.1	253	507	161	150
	Middle	76.2	7.2	50	20	13,200	5.7	1.8	8.8	250	500	171	240
	South	75.7	6.6	70	40	13,200	5.5	1.7	9.0	248	497	170	240
4/29/2015	North	56.2	8.6	160	80	748	5.5	2.4	8.7	360	720	149	360
	Middle	54.2	9.2	130	50	660	4.8	2.4	8.7	307	613	156	300
	South	58.5	8.3	110	60	484	4.6	2.2	8.8	290	581	166	280
8/19/2015	North	79.8	9.1	90	10	6,160	7.2	1.2	7.5	254	509	156	240
	Middle	79.4	7.7	80	40	13,200	6.3	2.9	7.5	266	533	152	260
	South	78.5	7.6	60	20	13,200	5.9	3.7	7.4	272	544	155	260
5/3/2016	North	55.7	8.1	140	100	616	5.1	2.6	8.9	399	797	137	260
	Middle	52.1	9.0	100	80	484	3.8	2.4	8.6	374	742	150	220
	South	53.8	8.6	100	70	528	4.5	2.3	8.0	363	725	156	190
8/31/2016	North	79.1	7.1	70	40	2,772	7.4	1.9	7.9	275	495	148	230
	Middle	78.3	7.8	50	30	4,004	7.0	2.6	8.1	272	571	156	220
	South	78.4	7.4	50	30	3,828	7.2	3.1	8.1	252	504	147	220
5/2/2017	North	55.0	7.1	170	140	792	4.8	1.8	7.8	313	626	119	310
	Middle	51.9	7.4	140	110	704	4.1	2.0	7.9	258	515	127	250
	South	50.1	7.4	120	90	528	4.0	1.7	8.0	279	559	141	270
8/25/2017	North	70.3	3.8	140	60	3,476	97.0	0.8	7.8	213	420	157	200
	Middle	72.5	4.5	110	20	2,816	96.0	1.1	7.7	224	448	152	220
	South	72.6	4.8	130	30	3,080	108.0	1.1	7.9	229	458	134	220
4/26/2018	North	57.1	8.0	200	70	13,200	6.8	2.7	7.3	342	684	185	340
	Middle	54.1	8.4	180	60	13,200	5.6	2.9	8.0	313	625	182	310
	South	55.8	9.3	170	40	13,200	5.0	2.5	8.2	293	587	183	290
8/17/2018	North	80.1	5.8	110	50	3,960	14.8	1.2	8.4	224	449	145	210
	Middle	80.1	6.3	90	40	2,860	12.7	1.6	8.4	220	441	151	210
	South	80.1	6.5	60	30	2,376	9.6	1.6	8.5	214	427	153	200
5/14/2019	North	52.0	8.6	140	60	13,200	3.6	4.1	7.6	352	704	161	350
	Middle	54.5	8.8	120	60	13,200	36.1	3.2	7.7	331	662	170	330
	South	55.4	8.1	110	40	13,200	3.4	3.4	7.8	304	608	173	300
8/15/2019	North	75.4	5.4	80	40	13,200	9.4	2.2	7.2	284	569	140	270
	Middle	76.1	5.6	60	20	12,628	9.1	2.6	7.1	281	563	156	270
	South	76.8	6.1	50	20	10,868	8.8	2.6	7.1	274	548	161	260
5/19/2020	North	52.97	7	170	100	13200	2.8	0.5	7.3	184	367	128	180
	Middle	53.98	8	130	60	13200	2.9	0.5	7.2	143	286	131	140
	South	53.82	8	90	40	13200	2	0.5	7.2	148	297	139	140
8/20/2020	North	74.2	9.7	70	30	1188	7.0	0.9	7.6	239	479	142	230
	Middle	76.4	7.9	60	30	3344	6.8	1.9	7.0	233	467	156	220
	South	77.1	7.8	100	50	5016	8.1	2.6	7.1	231	461	159	220
5/27/21	North	70.2	8.8	180	40	12760	40.4	2.1	8.5	357	548	126	270
	Middle	70.6	9.2	160	40	10780	26.5	2.2	8.4	372	572	142	280
	South	70.5	8.9	90	50	5412	18.6	2.2	8.3	415	640	148	310
8/26/21	North	83.9	11.2	260	20	13200	41.6	1.4	9.2	294	452	143	220
	Middle	82.1	8.8	260	30	13200	60.1	1.4	8.8	315	484	148	230
	South	82.2	8.6	100	30	9240	13.6	1.9	8.9	319	490	156	230
5/26/22	1	61.7	7.7	123	58	1188	2.9	1.9	8.1	306	351	143	290
	2	62	7.7	116	51	880	2.7	1.8	8	288	350	153	280
	3	62.2	7.5	111	38	792	2.7	2.1	7.8	288	350	158	280
	4	61.7	7.6	126	62	1584	2.8	1.8	7.9	307	351	144	290
	5	62.4	7.3	110	41	704	2.9	2.1	7.8	298	344	145	270
	6	62.2	7.2	112	43	880	2.8	2.1	7.8	297	343	157	270
8/25/22	1	80.6	10.9	116	68	968	26.3	1.4	8.6	306	470	185	230
	2	80.2	11.1	106	59	832	19.2	1.5	8.9	301	462	158	220

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	3	80.1	10.6	104	41	818	21.8	1.4	8.8	325	504	164	240
	4	80.5	10.6	120	68	1008	26.4	1.4	8.9	306	472	178	220
	5	80.1	10.8	98	61	986	21.3	1.6	8.8	304	471	181	220
	6	80.2	11.0	102	39	832	21.1	1.5	8.4	298	498	179	210
	1	63.2	8.0	119	56	1097	2.8	2.3	8.2	321	335	152	270
5/26/2023	2	63.9	7.8	110	49	914	2.6	1.6	8.0	276	336	149	290
	3	63.9	7.9	109	32	829	2.5	1.6	7.9	278	335	149	270
	1	68.9	6.8	124	64	989	17.8	1.2	8.4	362	557	187	270
9/15/2023	2	69.0	7.2	103	45	701	21.7	1.6	8.4	362	556	186	270
	3	71.6	8.7	114	41	724	23.5	1.5	9.8	356	517	176	270
	1	58.5	8.0	115	50	952	2.6	1.8	8.6	327	504	153	240
4/30/2024	2	58.7	7.6	118	45	825	2.7	1.6	8.5	328	507	149	250
	3	59.9	8.2	100	40	837	5.7	1.7	8.5	330	505	154	250
	1	75.5	9.0	115	62	1010	26.5	1.1	8.7	225	423	167	220
8/19/2024	2	75.7	9.1	105	65	990	25.3	1.2	8.8	263	435	164	220
	3	75.7	9.3	90	63	995	24.1	1.3	8.2	254	438	171	230