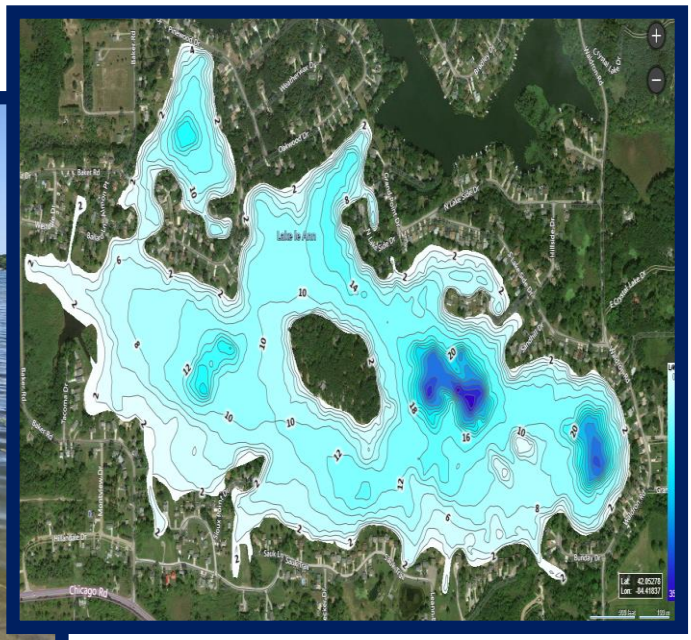
Lake LeAnn 2022 LFA
Evaluation Data, Conclusions to Date, and 2023 Management Recommendations
Hillsdale County, Michigan



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1.0 PROJECT INTRODUCTION, SUMMARY, & OVERALL CONCLUSIONS

Lake LeAnn is located in Somerset Township in Hillsdale County, Michigan (T.5S, R.1W, sections 3,4,5,8,9, and 10; Figures 1 and 2). The north lake basin is comprised of 200.3 acres and the south lake basin consists of 268 acres (RLS, 2019). The lake is a man-made impoundment with a dam located at the north end of the north basin with a second dam on the south lake. The north lake basin has 1 area of water influx which includes 1 drain, and the south lake basin has 3 drainage areas. The north lake basin has nearly 6.4 miles of shoreline and the south lake basin has nearly 7.3 miles of shoreline. The mean depth of the north lake basin is approximately 7.6 feet, and the mean depth of the south lake basin is approximately 9.7 feet. The maximum depth of the north lake basin is approximately 22.5 feet, and the maximum depth of the south lake basin is approximately 39.0 feet (RLS, 2022 bathymetric scan data; Figures 1 and 2). The north lake basin also has a fetch (longest distance across the lake) of around 0.8 miles and the south lake basin has a fetch of around 1.2 miles (RLS, 2019). The north basin of Lake LeAnn has an approximate water volume of 1,927.3 acre-feet and the south lake basin has an approximate water volume of 2,555.7 acre-feet (RLS, 2022 bathymetric data).

The immediate watershed (which is the area directly draining into the lakes) differs for each basin with the north being approximately 3,582 acres and the south being approximately 1,515 acres. This is about 7.6 times the size of the lake, which is moderately large. Legal lake levels have been established for both lakes with the summer and winter levels for the north lake at elevations of 1041.25’ and 1040.50 feet, respectively, and summer and winter levels for the south lake at elevations of 1046.85’ and 1046.40 feet, respectively.

Based on the current study, Lake LeAnn contains 5 invasive aquatic plant species which includes the submersed hybrid Eurasian Watermilfoil (EWM), Curly-leaf Pondweed (CLP), and Starry Stonewort and the emergents Purple Loosestrife and Phragmites. Continued surveys and vigilance are needed to assure that additional invasives do not enter Lake LeAnn. Aquatic herbicide treatments are recommended on a spot-treatment basis to effectively reduce the invasives over time. Algaecides should only be used on green algal blooms since many treatments can exacerbate blue-green algae

blooms. The blue-green algae, *Microcystis* sp. was the most prevalent algae in the lake which is an indicator of poor water quality. A bloom in early October 2019 proved to have total microcystins at 55 µg/L which is well above the EPA standard for microcystin at 8.0 µg/L and a no contact advisory was issued by the Michigan Department of Health and Human Services (MDHHS). In 2020-2021 more cyanobacteria blooms were present and toxins were measured in 2021-2022 with concentrations exceeding 8 µg/L at the access sites. Although chlorophyll-a composite concentrations have increased, in situ measurements of chlorophyll-a have significantly declined since LFA began.

It may take years for the LFA technology and bioaugmentation to reduce the prominent cyanobacterial blooms on Lake LeAnn. The lake is highly impaired with multiple nutrient sources that are difficult to reduce—including abundant septic systems, use of lawn fertilizers, numerous drains, and lack of shoreline emergent vegetation.

RLS and the LLPOA are working diligently with Lake LeAnn property owners to reduce these sources and assist with maximizing the efficacy of the current LFA program. It is important to realize that the external loading of nutrients to Lake LeAnn has resulted in the condition of internal loading which is exacerbated by reduced dissolved oxygen concentrations in the deep basins.

Fortunately, the LFA system has resulted in some declines in nutrients such as phosphorus and total inorganic nitrogen as well as increased dissolved oxygen. There have also been significant improvements with reductions in invasive submersed milfoil and Curly-leaf Pondweed with targeted herbicide treatments. There have been modest reductions in the highest biovolume cover categories (60-80% and >80%) with time in both basins. Zooplankton in the lake have also increased. The LFA system should aim to increase water clarity which would require a reduction in blue-green algae.

As stated in the 2019 Lake LeAnn Lake Management Plan report, reduction of nutrients from the CSA's is critical. CSA #1A has demonstrated reduced TP and TIN and CSA #2A has demonstrated reduced TP but an increased TIN. In 2022, only CSA #1A, #1B, #2A, and #2B were flowing during sampling events. The efficacy of the LFA system will be greatly reduced if such loads are not also reduced.

The LFA system has provided the most benefit to the lake bottom. The relative hardness of sediments in the north basin has slightly increased over time and the softest bottom category has decreased slightly over time for both basins. There has been a significant reduction in sediment % organic matter and % fines for both north and south basins.

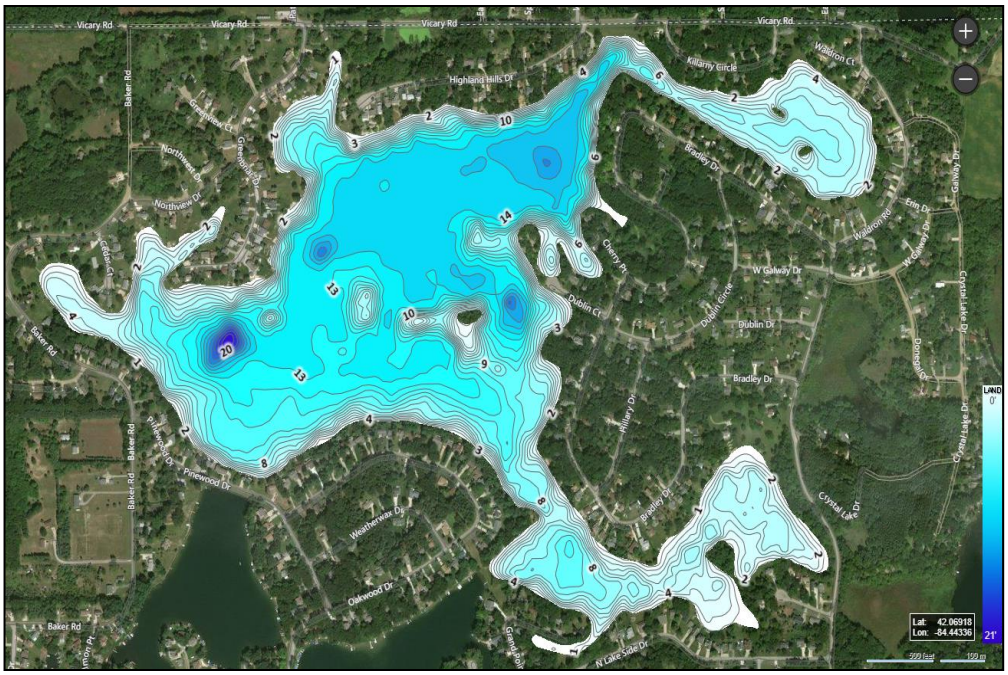

Figure 1. Lake LeAnn (north basin) depth contour map (RLS, 2022).

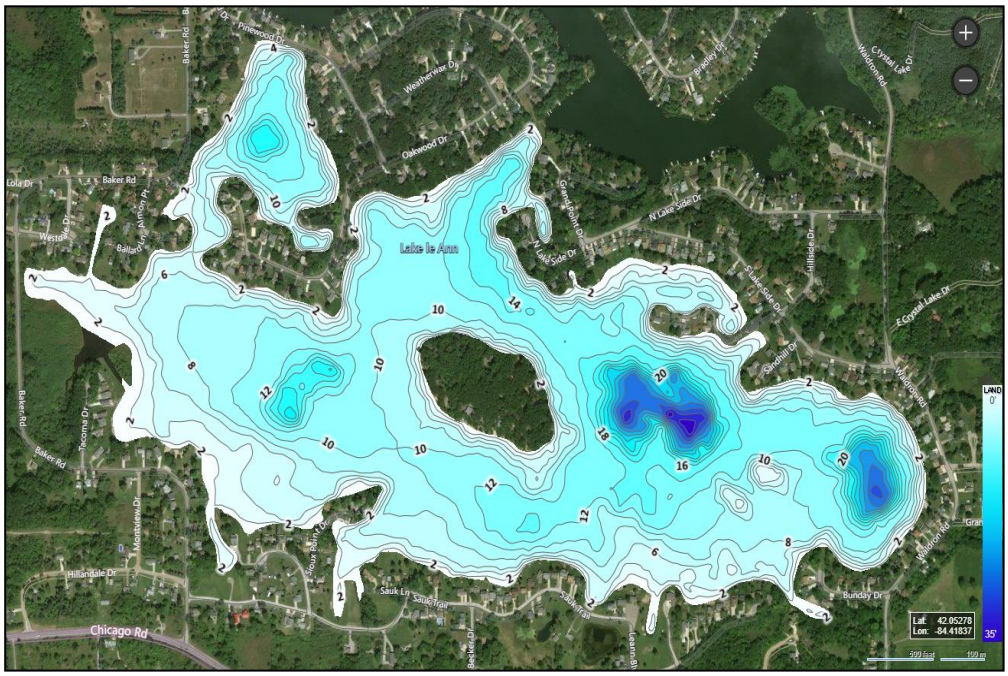

Figure 2. Lake LeAnn (south basin) depth contour map (RLS, 2022).

1.1 Summary of Lake LeAnn Aeration Operations:

This report serves as the baseline data requirement for the EGLE aeration permit for the lake. This sampling guidance protocol is required by the State of Michigan Department of Environment, Great Lakes, and Energy (EGLE). This report represents a statistical analysis of the first set of baseline data for 2019 and Year 1 (2021) as well as 2022. This sampling occurs once in April/May, June/July, and August/September of each year. One sampling location per 50 acres of surface area is recommended in stratified basins and sampling at mid-depth in basins with shallow depths (< 10 feet). The sampling consists of the physical water quality parameters, water depth (measured in 0.5-meter increments), water temperature (measured in °C), dissolved oxygen (measured in mg/L), pH (measured in Standard Units), specific conductivity (measured in mS/cm), and secchi disk transparency (in feet). Additionally, at each site, chemical water quality parameters are included: total and ortho-phosphorus (mg/L), total Kjeldahl nitrogen and total inorganic nitrogen (both in mg/L), total suspended solids (in mg/L), and chlorophyll-a in micrograms per liter. In lakes such as Lake LeAnn with high surface blue-green algae blooms, the use of an *in situ* fluorimeter is much more accurate than a composite chlorophyll-a sampler and thus that metric is used to measure chlorophyll-a in hyper-eutrophic waters as an additional method.

1.2 Summary of Aeration Operation Purpose/Goals:

Lake LeAnn is a well-recreated lake and is utilized by many for fishing, swimming, boating, and waterfront living. In recent years, the lake has become dominated by aggressive invasive aquatic vegetation such as Curly-leaf Pondweed and Eurasian Watermilfoil. In addition, the lake has become mucky in many areas and is also experiencing toxic cyanobacteria blooms and watershed inputs of nutrients and solids. The residents have desired a more holistic approach to addressing both the aquatic plant and algae issues as well as the muck reduction. The residents desired a lake restoration strategy that would make the lake healthier and accomplish the following objectives:

The primary objectives of the implemented LFA/bioaugmentation system for Lake LeAnn include:

1) Reduction of nuisance toxic cyanobacteria algae throughout the lake.
2) Increase in water clarity/transparency
3) Increase in water column dissolved oxygen
4) Reduction of muck in problem areas.
5) Reduction of nuisance rooted submersed aquatic vegetation such as Eurasian Watermilfoil and Curly-leaf Pondweed.
6) Reduction of lake water column nutrients

2.0 LAKE LEANN SAMPLING METHODS & PARAMETERS

2.1 Sampling Dates and Methods:

Restorative Lake Sciences sampled 9 locations for baseline data in 2019, 2021, and 2022 (5 in the south basin and 4 in the north basin) as well as the drains entering both basins. In 2019, the Mirror Lake Outlet was not sampled but was added to the EGLE permit for 2021 and was thus sampled in 2021 and 2022. The drains will be sampled at least twice per season as RLS recommends continual monitoring of these drains as they contribute significant nutrient loads to both basins. In 2019 (baseline year), both lake basins and drains were sampled on April 26, 2019, July 24, 2019 and September 11, 2019. In 2021, both lake basins were sampled on April 28, 2021, July 19, 2021, and September 16, 2021. In 2019 a total of 9 sediment samples were collected but that number was increased to 13 samples in 2021 by EGLE. In 2021, 13 sediment samples were collected on September 15, 2021. In 2022, both lake basins were sampled on May 10, 2022, July 12, 2022, and September 15, 2022. Through the ice samples were also collected on March 21, 2022 as ice conditions were safe over the deep basins in 2022. In 2022, a total of 13 sediment samples were collected in the basins on September 15, 2022.

All sampling location maps for the lake basins, sediment sampling, and drains are shown below in Figures 3-5.

All chemical water samples were collected at the specified depths (one each at the top, middle, and bottom depths of the deep basin sampling sites and at mid-depth for shallow sites) using a 4-liter VanDorn horizontal water sampler with weighted messenger (Wildco® brand). Water quality physical parameters (such as water temperature, dissolved oxygen, conductivity, and pH) were measured with a calibrated Eureka Manta 2® multi-probe meter as a profile through the water column at the sampling sites. All water samples were maintained on ice in a large cooler prior to being placed into the laboratory fridge. Total phosphorus was titrated and analyzed in the laboratory according to method SM 4500-P E. Ortho-phosphorus was titrated and analyzed in the laboratory according to method SM 4500-P E. Total suspended solids were analyzed for each sample using SM 2540 D-97. Sediment samples were collected with an Ekman hand dredge and placed into glass jars before being placed on ice and transported to the laboratory for analysis. Sediment organic matter was analyzed using method ASTM D2974. All the aforementioned chemical parameters were analyzed at Trace Analytical Laboratories in Muskegon, Michigan.

Chlorophyll-*a* was analyzed in situ with a calibrated Turner Designs® fluorimeter used to measure algal pigment in lakes with blue-green algal blooms. This gives a more accurate assessment of the actual chl-a versus a profile reading that may skew chl-a results to a much lower concentration. Prior to analysis of the samples as described above, water samples were placed in clean, unpreserved polyethylene bottles for ortho-phosphorus and total suspended solids and placed in H_2SO_4-preserved, clean, polyethylene bottles for total phosphorus analysis. Algal community samples were placed in glass brown, amber 1-liter bottles as recommended in the EGLE Guidance and analyzed within 72

hours after collection. Samples used for microscopic analysis of algal community composition were counted with a Sedgewick Rafter® Counting Cell under high power objective on a bright-field Zeiss® compound microscope. Multiple 1 micro-liter (µL) aliquots were used to determine the relative abundance of algal genera in the samples. Zooplankton samples were rinsed into the collection bottle from the collection tow net, where an Alka Seltzer® tablet was then placed along with 70% ethyl alcohol solution. The sample was then quantified for zooplankton community composition using a Ward counting wheel under a Zeiss® dissection microscope.

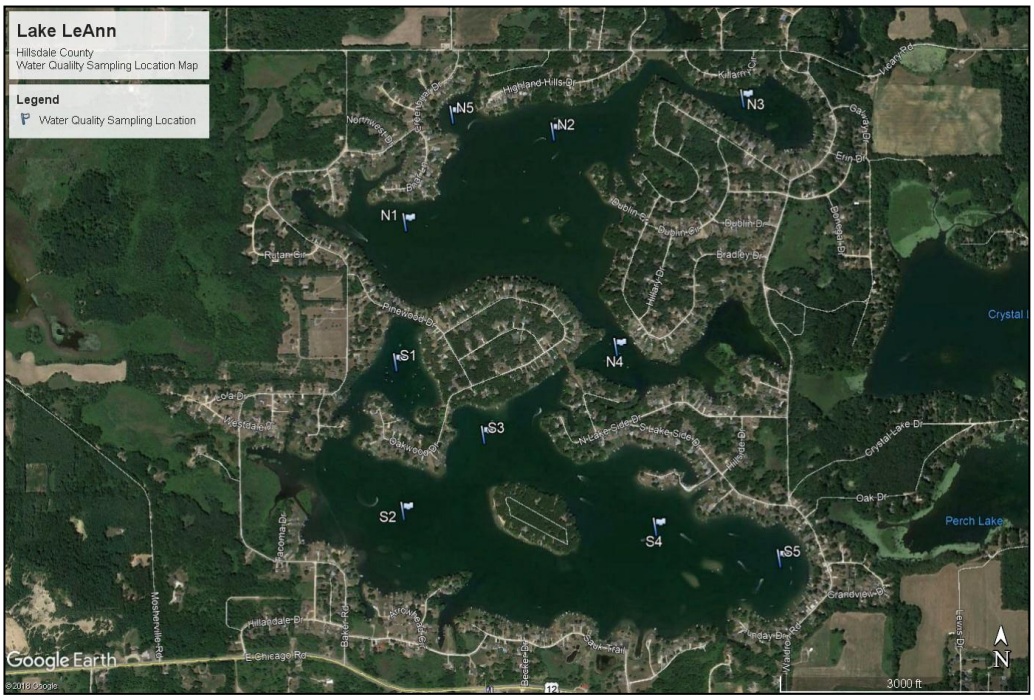

Figure 3. 2021-2022 water quality sampling locations on Lake LeAnn.

Figure 4. 2021-2022 sediment sampling locations on Lake LeAnn.

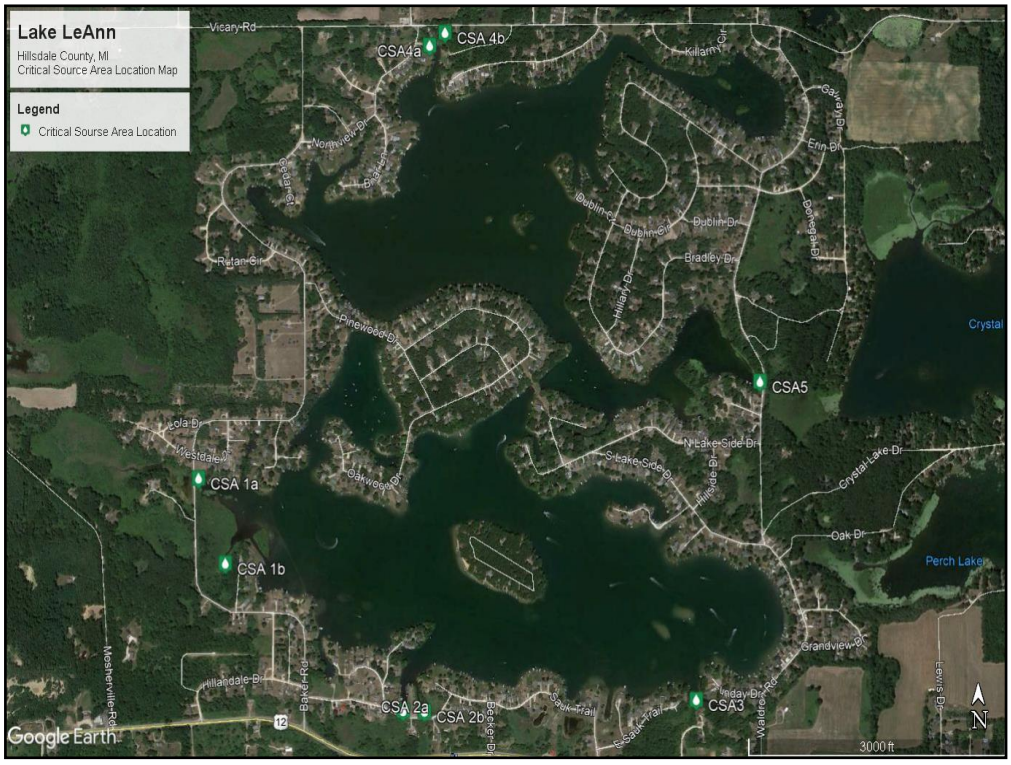

Figure 5. 2019-2022 drain sampling locations on Lake LeAnn.

3.0 LAKE LEANN 2022 WATER QUALITY SAMPLING RESULTS

All 2022 deep basin physical water quality data is shown in Tables 1-35 of Section 3.1 below. 2022 chemical water quality data is shown in Tables 36-70 of Section 3.2 below. 2022 drain physical and chemical water quality data is shown below in Table 72 of Section 3.3 below. NOTE: Drain sampling is not usually required as a condition of the LFA permit; however, the data is being collected to evaluate current and future measurements to determine mitigation implementation efficacy.

3.1 Lake LeAnn 2022 Deep Basin Physical Water Quality Data Tables:

Table 1. Lake LeAnn physical water quality parameter data collected at deep basin north #1 (March 21, 2022)

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	7.84	11.29	8.17	501.0	320.5	8.25
0.5	7.59	11.32	8.18	501.0	320.9	
1.0	7.39	11.25	8.18	500.8	320.4	
1.5	7.28	11.32	8.18	500.9	320.5	
2.0	7.23	11.32	8.19	500.7	320.4	
2.5	7.22	11.34	8.19	500.6	320.2	
3.0	7.18	11.32	8.18	852.1	540.9	
3.5	7.18	11.31	8.18	846.0	538.7	
4.0	7.16	11.31	8.18	826.4	525.6	
4.5	7.11	11.30	8.18	816.8	522.2	
5.0	7.06	11.19	8.17	811.0	518.8	
5.5	7.05	11.15	8.16	800.4	509.2	
6.0	7.03	11.03	8.15	762.2	486.5	
6.5	7.02	10.91	8.15	757.7	500.5	
7.0	7.05	10.70	8.09	777.0	492.0	

Table 2. Lake LeAnn physical water quality parameter data collected At deep basin South #4 (March 21, 2022)

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	8.01	12.82	8.34	536.7	343.5	10.75
0.5	7.98	12.60	8.34	536.8	343.6	
1.0	7.83	12.60	8.35	536.5	343.5	
1.5	7.39	12.60	8.35	536.5	343.3	
2.0	7.15	12.60	8.35	537.1	343.1	
2.5	7.13	12.61	8.35	536.5	343.3	
3.0	7.13	12.60	8.36	536.3	343.3	
3.5	7.07	12.59	8.36	536.5	343.3	
4.0	7.03	12.56	8.35	536.6	343.4	
4.5	6.99	12.50	8.35	538.1	343.9	
5.0	6.97	12.49	8.35	536.4	343.3	
5.5	6.92	12.43	8.34	536.5	343.3	
6.0	6.85	12.43	8.33	536.7	343.3	
6.5	6.80	12.41	8.33	536.6	343.4	
7.0	6.76	12.39	8.33	548.0	378.3	
7.5	6.73	12.37	8.33	630.6	343.6	
8.0	6.72	12.35	8.33	788.7	344.3	
8.5	6.69	12.33	8.32	540.0	343.7	
9.0	6.67	12.25	8.31	577.3	494.1	
9.5	6.67	12.17	8.31	715.4	386.6	

Table 3. Lake LeAnn physical water quality parameter data collected at deep basin north #1 (May 10, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	15.46	9.85	8.10	507.6	324.8	4.42
0.5	15.50	9.83	8.11	507.4	324.8	
1.0	15.41	9.90	8.10	507.4	324.8	
1.5	14.94	9.86	8.10	507.6	325.0	
2.0	14.60	9.84	8.10	507.1	324.7	
2.5	14.63	9.74	8.09	507.4	324.5	
3.0	14.42	9.68	8.09	507.1	324.7	
3.5	14.35	9.65	8.09	507.1	324.5	
4.0	14.30	9.60	8.08	507.1	324.5	
4.5	14.29	9.53	8.08	507.2	324.6	
5.0	14.28	9.50	8.07	507.2	324.5	
5.5	14.21	9.35	8.04	799.6	501.6	
6.0	14.13	9.15	8.01	868.1	536.5	
6.5	13.55	8.80	8.00	791.0	501.1	

Table 4. Lake LeAnn physical water quality parameter data collected at deep basin north #2 (May 10, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	15.73	9.78	8.08	508.0	325.0	5.83
0.5	15.76	9.87	8.09	507.7	324.8	
1.0	15.76	9.89	8.09	507.7	325.0	
1.5	15.71	9.99	8.11	507.7	325.0	
2.0	15.62	10.01	8.11	507.7	324.9	
2.5	15.26	10.01	8.13	507.5	324.5	
3.0	15.15	10.01	8.14	507.2	324.5	
3.5	14.47	10.00	8.12	506.7	324.3	
4.0	14.38	10.00	8.12	506.8	323.4	

Table 5. Lake LeAnn physical water quality parameter data collected at deep basin north #3 (May 10, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	17.13	9.34	8.01	506.1	324.0	5.08
0.5	17.11	10.66	8.03	506.1	323.9	
1.0	16.35	10.64	8.05	506.1	323.7	
1.5	15.95	10.65	8.05	506.1	323.8	
2.0	15.46	10.62	8.06	505.5	323.9	
2.5						

Table 6. Lake LeAnn physical water quality parameter data collected at deep basin north #4 (May 10, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	16.17	10.07	8.21	813.7	520.9	4.66
0.5	16.04	10.08	8.21	871.5	546.2	
1.0	16.02	10.08	8.22	868.2	554.9	
1.5	15.30	10.08	8.21	862.3	552.1	
2.0	14.66	10.04	8.16	861.2	530.0	
2.5	14.37	9.91	8.12	848.2	546.2	
3.0	14.20	9.89	8.10	847.7	540.4	

Table 7. Lake LeAnn physical water quality parameter data collected at deep basin north #5 (May 10, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	16.60	9.90	8.11	511.4	327.2	3.5
0.5	16.36	9.93	8.12	510.6	326.8	
1.0	15.82	10.01	8.13	509.1	325.8	
1.5	15.80	10.01	8.13	508.5	325.5	
2.0	15.75	10.00	8.13	508.4	325.4	
2.5	15.61	10.00	8.14	508.3	325.5	
3.0	15.52	9.99	8.13	509.3	325.9	

Table 8. Lake LeAnn physical water quality parameter data collected at deep basin north Outflow (May 10, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	17.42	8.80	8.07	508.4	325.7	N/A

Table 9. Lake LeAnn physical water quality parameter data collected at deep basin south #1 (May 10, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	17.03	9.22	8.33	821.2	525.0	4.5
0.5	17.00	10.65	8.31	802.1	513.2	
1.0	16.27	10.69	8.33	806.2	517.3	
1.5	16.17	10.69	8.33	811.0	517.8	
2.0	15.54	10.70	8.37	831.9	521.7	
2.5	15.26	10.69	8.37	831.2	534.9	
3.0	15.08	10.69	8.37	835.1	535.8	
3.5	14.93	10.67	8.37	831.1	535.9	
4.0	14.90	10.64	8.37	833.0	537.8	
4.5	14.74	10.59	8.35	840.8	537.8	
5.0	14.62	10.57	8.34	802.0	525.7	
5.5	14.48	10.47	8.33	834.9	532.8	
6.0	14.37	10.38	8.32	805.9	522.2	

Table 10. Lake LeAnn physical water quality parameter data collected at deep basin south #2 (May 10, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	16.59	11.05	8.34	864.3	552.7	3.25
0.5	16.55	11.19	8.35	864.0	552.9	
1.0	16.52	11.19	8.34	865.9	555.1	
1.5	16.21	11.18	8.34	866.2	554.2	
2.0	16.07	11.19	8.35	867.1	555.2	
2.5	15.19	11.15	8.35	866.6	556.2	
3.0	15.09	11.15	8.35	868.2	555.7	
3.5	15.06	11.15	8.35	868.5	557.7	
4.0	14.98	11.15	8.35	872.1	557.6	
4.5	14.85	11.19	8.34	858.4	548.9	
5.0	14.76	11.18	8.34	877.2	553.1	
5.5	14.69	11.14	8.34	849.8	540.2	
6.0	14.63	11.13	8.32	820.1	536.8	
6.5	14.51	11.03	8.29	904.1	563.3	
7.0	14.12	10.84	8.23	802.0	534.4	

Table 11. Lake LeAnn physical water quality parameter data collected at deep basin south #3 (May 10, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	16.72	10.91	8.35	872.2	559.0	4.0
0.5	16.61	11.11	8.35	858.1	549.6	
1.0	16.17	11.07	8.36	861.5	551.2	
1.5	16.08	11.08	8.36	862.2	551.9	
2.0	16.00	11.07	8.36	861.6	551.6	
2.5	15.04	11.08	8.37	858.8	549.9	
3.0	14.91	11.08	8.36	856.7	547.7	

Table 12. Lake LeAnn physical water quality parameter data collected at deep basin south #4 (May 10, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	15.65	11.54	8.35	637.3	384.0	3.25
0.5	15.62	11.55	8.35	832.7	527.9	
1.0	15.61	11.55	8.35	836.7	540.8	
1.5	15.55	11.58	8.35	851.6	537.6	
2.0	15.40	11.56	8.36	850.5	540.3	
2.5	15.32	11.54	8.36	836.9	538.4	
3.0	14.62	11.55	8.36	835.8	539.1	
3.5	14.23	11.55	8.36	801.7	521.0	
4.0	14.11	11.55	8.36	556.6	362.3	
4.5	13.84	11.55	8.36	532.3	340.7	
5.0	13.60	11.53	8.35	539.8	347.3	
5.5	13.41	11.51	8.34	533.4	341.6	
6.0	12.76	11.43	8.33	533.9	341.8	
6.5	12.22	11.32	8.33	534.2	341.9	
7.0	11.58	10.97	8.32	535.8	342.3	
7.5	11.50	10.69	8.28	537.1	343.7	
8.0	11.44	9.85	8.25	537.6	344.2	
8.5	11.40	9.68	8.21	538.6	344.6	
9.0	11.36	9.24	8.18	539.2	345.1	
9.5	11.29	8.81	8.11	540.4	346.0	
10.0	11.20	7.10	7.99	542.7	347.4	
10.5	11.13	6.12	7.90	544.1	348.3	
11.0	11.11	5.61	7.84	544.6	348.5	
11.5	11.07	5.11	7.80	545.6	349.1	

Table 13. Lake LeAnn physical water quality parameter data collected at deep basin south #5 (May 10, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	16.01	11.17	8.35	534.4	342.0	3.75
0.5	15.90	11.43	8.35	534.6	342.2	
1.0	15.14	11.45	8.35	533.7	341.1	
1.5	14.71	11.45	8.36	533.3	341.4	
2.0	14.30	11.45	8.37	533.2	341.1	
2.5	13.96	11.43	8.37	532.8	340.9	
3.0	13.75	11.44	8.37	532.6	340.8	
3.5	13.50	11.43	8.36	533.3	341.3	
4.0	13.48	11.43	8.36	533.0	341.1	
4.5	12.78	11.40	8.36	533.5	341.2	
5.0	12.21	11.34	8.35	533.7	341.5	
5.5	11.86	11.27	8.34	534.8	342.3	
6.0	11.52	11.14	8.33	584.5	410.1	
6.5	11.35	11.01	8.30	539.0	344.5	
7.0	11.24	9.97	8.26	727.8	488.6	
7.5	11.11	8.35	8.10	714.9	477.2	
8.0	11.01	7.13	7.99	632.1	414.0	
8.5	10.91	4.98	7.84	549.0	349.8	
9.0	10.88	4.36	4.76	560.6	364.5	

Table 14. Lake LeAnn physical water quality parameter data collected at deep basin north #1 (July 12, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	26.02	7.70	8.16	809.3	513.1	3.17
0.5	26.02	7.51	8.16	808.5	517.5	
1.0	26.00	7.46	8.16	808.1	517.2	
1.5	25.89	7.37	8.11	809.4	518.3	
2.0	25.83	7.15	8.08	808.6	517.5	
2.5	25.75	6.96	8.04	808.8	517.8	
3.0	25.17	6.58	8.00	809.0	517.6	
3.5	25.70	6.24	7.98	808.9	517.9	
4.0	25.67	6.14	7.97	808.3	517.4	
4.5	25.66	6.14	8.00	807.7	517.6	
5.0	25.57	5.89	7.93	807.5	516.8	
5.5	25.48	5.59	7.88	807.7	517.0	
6.0	25.41	5.21	7.84	807.9	517.1	
6.5	25.34	3.97	7.71	854.3	547.0	

Table 15. Lake LeAnn physical water quality parameter data collected at deep basin north #2 (July 12, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	25.99	8.02	8.21	785.0	494.0	3.0
0.5	26.01	8.01	8.22	788.0	510.2	
1.0	26.01	8.01	8.22	801.2	512.6	
1.5	26.00	8.00	8.22	782.3	489.5	
2.0	25.99	8.00	8.22	801.8	509.8	
2.5	25.96	7.98	8.22	797.7	503.8	
3.0	25.91	7.95	8.20	797.9	512.0	
3.5	25.90	7.79	8.18	793.6	509.2	
4.0	25.88	7.75	8.17	776.3	494.0	
4.5	25.83	7.67	8.16	777.0	516.9	

Table 16. Lake LeAnn physical water quality parameter data collected at deep basin north #3 (July 12, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	26.25	8.13	7.55	836.2	532.7	2.66
0.5	26.25	8.12	7.36	838.8	536.3	
1.0	26.24	8.12	7.27	837.4	535.1	
1.5	26.24	8.11	7.23	837.8	536.7	
2.0	26.22	8.11	7.20	834.0	533.6	

Table 17. Lake LeAnn physical water quality parameter data collected at deep basin north #4 (July 12, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	26.46	9.39	8.21	482.7	309.8	5.42
0.5	26.41	9.39	8.20	484.3	319.9	
1.0	26.32	9.38	8.21	484.5	309.3	
1.5	26.27	9.40	8.22	477.9	304.5	
2.0	26.11	9.38	8.22	514.8	320.5	
2.5	26.01	9.28	8.21	479.5	316.4	
3.0	25.68	9.01	7.91	514.0	323.9	

Table 18. Lake LeAnn physical water quality parameter data collected at deep basin north #5 (July 12, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	26.32	8.19	8.22	592.7	372.4	3.17
0.5	26.11	8.14	8.22	563.3	371.9	
1.0	26.04	8.09	8.23	550.1	392.3	
1.5	25.99	8.02	8.19	560.1	351.7	
2.0	25.97	7.88	8.18	668.3	419.7	
2.5	25.92	7.74	8.18	550.3	353.6	
3.0	25.77	7.23	8.04	589.7	369.9	

Table 19. Lake LeAnn physical water quality parameter data collected at deep basin north Outflow (July 12, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	26.24	8.13	8.24	819.5	524.7	N/A

Table 20. Lake LeAnn physical water quality parameter data collected at deep basin south #1 (July 12, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	26.64	8.27	8.26	611.3	404.2	4.42
0.5	26.65	8.28	8.25	613.6	396.2	
1.0	26.53	8.27	8.23	581.7	368.6	
1.5	26.44	8.26	8.24	597.2	363.1	
2.0	26.37	8.27	8.23	617.9	384.8	
2.5	26.26	8.19	8.21	587.1	375.8	
3.0	26.22	8.10	8.21	606.7	372.8	
3.5	26.03	8.00	8.19	579.3	365.8	
4.0	26.01	7.85	8.19	655.1	415.8	
4.5	26.00	7.81	8.19	637.4	367.4	
5.0	26.00	7.80	8.18	597.0	392.4	
5.5	25.99	7.69	8.17	579.3	347.0	
6.0	25.92	7.61	8.12	515.2	330.0	
6.5	25.74	6.60	7.99	845.9	478.9	

Table 21. Lake LeAnn physical water quality parameter data collected at deep basin south #2 (July 12, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	26.03	8.18	8.18	526.8	337.2	4.75
0.5	26.06	8.20	8.19	526.9	337.3	
1.0	26.02	8.20	8.19	527.0	337.2	
1.5	26.02	8.19	8.19	526.8	337.2	
2.0	26.03	8.20	8.19	526.9	337.2	
2.5	26.03	8.19	8.20	526.9	337.2	
3.0	26.01	8.18	8.20	526.8	337.2	
3.5	26.01	8.18	8.20	526.8	337.1	
4.0	25.98	8.18	8.20	526.8	336.9	
4.5	25.86	8.16	8.16	527.0	337.2	
5.0	25.77	7.84	8.14	527.2	337.4	
5.5	25.66	7.74	8.11	527.5	337.4	
6.0	25.60	7.57	8.07	527.9	337.8	
6.5	25.52	7.15	8.01	529.3	338.6	
7.0	25.14	5.36	7.72	538.3	344.6	
7.5	24.73	1.56	7.54	556.6	351.1	

Table 22. Lake LeAnn physical water quality parameter data collected at deep basin south #3 (July 12, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	26.42	8.33	8.22	547.1	350.7	4.5
0.5	26.38	8.32	8.21	549.0	345.5	
1.0	26.28	8.32	8.21	532.0	342.9	
1.5	26.19	8.32	8.21	534.5	340.0	
2.0	26.13	8.32	8.21	531.7	343.5	
2.5	25.91	8.13	8.17	537.8	342.3	
3.0	25.90	8.01	8.17	531.9	343.2	

Table 23. Lake LeAnn physical water quality parameter data collected at deep basin south #4 (July 12, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	26.20	8.34	8.23	523.8	335.2	3.25
0.5	26.20	8.32	8.23	523.8	335.2	
1.0	26.21	8.32	8.23	523.8	335.2	
1.5	26.21	8.32	8.23	524.0	335.3	
2.0	26.16	8.32	8.23	523.9	335.3	
2.5	26.14	8.32	8.23	524.0	335.3	
3.0	26.12	8.32	8.22	524.1	335.5	
3.5	26.07	8.31	8.22	524.1	335.5	
4.0	26.04	8.27	8.21	524.2	335.4	
4.5	26.00	8.20	8.21	524.3	335.6	
5.0	25.90	8.16	8.20	524.5	335.6	
5.5	25.55	7.91	8.14	524.9	336.0	
6.0	20.13	3.01	7.62	541.9	346.9	
6.5	16.36	1.55	7.60	552.7	412.4	
7.0	14.17	0.68	7.60	549.7	352.9	
7.5	13.40	0.52	7.60	553.3	353.7	
8.0	12.44	0.17	7.60	556.1	355.9	
8.5	11.78	0.09	7.60	560.0	359.2	
9.0	11.58	0.05	7.58	563.5	361.1	
9.5	11.27	0.03	7.54	568.4	364.0	
10.0	11.21	0.03	7.54	568.8	364.1	
10.5	10.91	0.02	7.52	573.5	366.8	
11.0	10.77	0.02	7.48	575.6	368.4	
11.5	10.67	0.02	7.44	578.7	370.3	

Table 24. Lake LeAnn physical water quality parameter data collected at deep basin south #5 (July 12, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	26.14	8.31	8.24	524.3	335.5	4.08
0.5	26.17	8.31	8.25	524.0	335.4	
1.0	26.15	8.30	8.24	524.3	335.4	
1.5	26.14	8.30	8.25	524.3	335.5	
2.0	26.14	8.29	8.25	524.2	335.8	
2.5	26.13	8.29	8.24	524.9	336.0	
3.0	26.08	8.29	8.24	524.8	335.9	
3.5	26.08	8.28	8.24	525.0	335.9	
4.0	26.08	8.28	8.24	524.9	336.0	
4.5	26.08	8.26	8.24	524.8	335.9	
5.0	26.08	8.25	8.24	524.9	336.0	
5.5	26.08	8.24	8.24	524.9	335.9	
6.0	24.00	5.01	7.81	530.1	339.3	
6.5	21.61	1.68	7.61	536.3	343.2	
7.0	18.36	0.83	7.59	549.9	352.5	
7.5	15.99	0.43	7.59	565.3	358.3	
8.0	13.71	0.20	7.54	567.8	361.9	
8.5	12.50	0.11	7.50	577.5	369.8	
9.0	11.72	0.07	7.48	584.4	374.1	
9.5	11.43	0.05	7.45	605.1	393.87	

Table 25. Lake LeAnn physical water quality parameter data collected at deep basin north #1 (September 15, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	22.54	9.04	8.44	477.3	305.4	2.0
0.5	22.46	9.21	8.49	477.0	305.1	
1.0	22.53	9.26	8.50	476.9	305.2	
1.5	22.52	9.33	8.51	476.9	305.0	
2.0	22.5	9.39	8.51	477.1	304.9	
2.5	22.37	9.32	8.50	477.0	305.7	
3.0	22.20	9.25	8.50	477.5	305.1	
3.5	22.07	9.29	8.50	477.2	305.4	
4.0	22.01	9.27	8.49	477.8	305.7	
4.5	21.07	9.20	8.46	478.3	306.1	
5.0	21.02	9.04	8.40	478.7	306.4	
5.5	20.50	8.62	8.37	479.1	306.6	
6.0	20.01	8.48	8.37	478.9	306.6	

Table 26. Lake LeAnn physical water quality parameter data collected at deep basin north #2 (September 15, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	23.97	10.90	8.62	475.0	303.9	1.8
0.5	25.23	11.04	8.69	474.1	303.4	
1.0	23.11	11.26	8.70	474.1	303.3	
1.5	23.02	11.30	8.68	474.5	303.8	
2.0	22.48	10.80	8.52	476.1	304.8	
2.5	22.37	10.01	8.46	476.5	305.2	
3.0	22.34	9.18	8.40	477.2	305.2	
3.5	22.27	8.52	8.35	477.7	305.8	
4.0	22.26	7.96	8.32	477.6	305.8	
4.5	22.01	7.57	8.24	479.4	306.8	
5.0	21.81	5.83	8.08	482.7	309.1	

Table 27. Lake LeAnn physical water quality parameter data collected at deep basin north #3 (September 15, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	24.04	10.92	8.78	470.0	301.0	1.6
0.5	23.40	11.78	8.79	468.7	300.1	
1.0	23.04	12.08	8.80	468.1	299.5	
1.5	22.70	11.85	8.71	470.4	301.4	
2.0	22.52	11.03	8.65	471.3	301.6	
2.5	22.37	10.26	8.52	474.4	303.2	

Table 28. Lake LeAnn physical water quality parameter data collected at deep basin north #4 (September 15, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	23.38	11.10	8.69	483.2	309.2	1.66
0.5	23.11	12.25	8.74	482.8	309.1	
1.0	22.68	12.20	8.68	484.0	309.9	
1.5	22.42	11.48	8.57	483.1	309.1	
2.0	22.39	10.96	8.55	482.9	309.1	
2.5	21.12	9.18	8.37	490.7	313.8	
3.0	20.70	6.45	8.14	495.8	317.3	

Table 29. Lake LeAnn physical water quality parameter data collected at deep basin north #5 (September 15, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	23.56	9.94	8.69	473.6	303.1	1.7
0.5	23.47	11.63	8.74	473.0	302.5	
1.0	23.30	11.98	8.75	472.3	302.3	
1.5	22.81	12.07	8.72	473.4	303.0	
2.0	22.77	11.65	8.69	474.0	303.3	
2.5	22.69	11.25	8.65	474.4	303.7	
3.0	21.90	11.12	8.65	474.4	303.8	

Table 30. Lake LeAnn physical water quality parameter data collected at deep basin north Outflow (September 15, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	23.80	9.98	8.69	473.5	303.0	N/A

Table 31. Lake LeAnn physical water quality parameter data collected at deep basin south #1 (September 15, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	22.46	9.11	8.40	517.3	331.0	5.5
0.5	22.44	9.13	8.42	516.9	330.9	
1.0	22.45	9.15	8.42	517.0	330.8	
1.5	22.45	9.15	8.42	517.0	330.8	
2.0	22.45	9.14	8.43	516.9	330.9	
2.5	22.44	9.15	8.43	517.1	330.9	
3.0	22.43	9.15	8.43	517.0	330.9	
3.5	22.41	9.16	8.42	517.1	330.9	
4.0	22.38	9.15	8.41	516.9	330.8	
4.5	22.37	9.09	8.41	516.8	330.9	
5.0	22.37	9.07	8.40	517.1	330.8	
5.5	22.37	9.06	8.40	516.9	331.2	

Table 32. Lake LeAnn physical water quality parameter data collected at deep basin south #2 (September 15, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	22.88	9.13	8.38	532.1	340.7	5.6
0.5	22.41	9.19	8.39	531.6	340.1	
1.0	22.37	9.23	8.41	531.7	339.8	
1.5	22.33	9.26	8.39	532.3	341.1	
2.0	22.30	9.21	8.37	533.4	341.3	
2.5	22.25	9.13	8.36	533.2	341.1	
3.0	22.21	9.10	8.37	532.6	340.9	
3.5	22.16	9.06	8.36	533.2	341.2	
4.0	22.15	9.03	8.36	533.3	341.3	
4.5	22.15	8.99	8.35	533.1	341.1	
5.0	22.12	8.96	8.35	533.8	341.6	
5.5	22.10	8.93	8.34	534.7	342.3	
6.0	21.09	8.91	8.30	536.7	343.5	
6.5	20.88	8.81	8.28	538.3	344.4	

Table 33. Lake LeAnn physical water quality parameter data collected at deep basin south #3 (September 15, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	22.47	9.17	8.32	529.3	338.7	5.8
0.5	22.52	9.06	8.33	528.9	338.5	
1.0	22.42	9.04	8.34	528.7	338.4	
1.5	22.38	9.01	8.34	528.5	338.4	
2.0	22.35	9.01	8.35	529.1	338.5	
2.5	22.34	9.01	8.34	529.3	338.7	
3.0	22.32	9.00	8.34	529.0	338.7	

Table 34. Lake LeAnn physical water quality parameter data collected at deep basin south #4 (September 15, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	23.21	8.61	8.36	530.1	339.5	5.8
0.5	22.73	8.97	8.36	529.6	339.1	
1.0	22.45	9.05	8.36	529.8	339.0	
1.5	22.31	9.05	8.36	529.9	339.1	
2.0	22.27	9.05	8.36	529.8	339.0	
2.5	22.27	9.05	8.37	529.7	339.0	
3.0	22.22	9.05	8.36	530.0	339.2	
3.5	22.19	9.05	8.36	530.6	339.5	
4.0	22.17	9.05	8.35	531.0	339.8	
4.5	22.15	9.04	8.35	531.1	339.9	
5.0	22.12	9.03	8.34	531.4	340.2	
5.5	22.10	8.97	8.32	531.5	340.3	
6.0	22.07	8.78	8.30	531.9	340.5	
6.5	22.05	8.58	8.29	532.0	340.5	
7.0	21.99	8.44	8.28	532.9	341.1	
7.5	21.39	7.55	8.11	537.3	344.5	
8.0	17.71	4.32	7.62	571.1	366.3	
8.5	14.86	2.92	7.40	583.1	372.5	
9.0	13.01	1.70	7.35	589.3	377.8	
9.5	12.50	0.81	7.26	604.5	386.6	
10.0	11.89	0.43	7.25	607.2	388.9	
10.5	11.45	0.18	7.23	614.3	393.5	
11.0	11.21	0.13	7.20	623.4	398.8	
11.5	11.03	0.08	7.15	641.0	410.6	
12.0	10.92	0.07	7.09	652.2	417.5	

Table 35. Lake LeAnn physical water quality parameter data collected at deep basin south #5 (September 15, 2022).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Secchi Depth (ft)
0	23.59	8.78	8.34	531.1	339.9	6.2
0.5	22.84	8.92	8.36	530.0	338.8	
1.0	22.51	9.03	8.37	528.8	338.6	
1.5	22.41	9.08	8.38	528.7	338.4	
2.0	22.35	9.08	8.38	528.6	338.3	
2.5	22.32	9.08	8.38	528.8	338.3	
3.0	22.29	9.08	8.37	528.6	338.2	
3.5	22.26	9.07	8.36	528.7	338.4	
4.0	22.24	9.02	8.36	529.8	338.4	
4.5	22.21	8.94	8.36	529.8	338.5	
5.0	22.18	8.90	8.35	529.1	338.6	
5.5	22.14	8.81	8.33	529.4	338.8	
6.0	22.04	8.70	8.30	530.8	339.6	
6.5	21.91	8.39	8.19	533.4	341.3	
7.0	21.85	7.54	8.13	534.3	342.3	
7.5	21.01	6.01	7.88	545.1	348.6	
8.0	17.84	2.41	7.29	608.1	388.5	
8.5	15.83	1.53	7.14	634.1	404.2	
9.0	13.90	0.90	7.09	654.0	418.5	
9.5	13.26	0.57	7.03	674.9	431.7	

3.2 Lake LeAnn 2022 Deep Basin Chemical Water Quality Data Tables:

Table 36. Lake LeAnn chemical water quality parameter data collected at deep basin north #1 (March 21, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3 (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	0.64	0.19	0.052	0.14	<0.10	<10	0.015	<0.010	
3.5	1.00	0.20	0.048	0.16	<0.10	<10	0.025	<0.010	
7.0	0.77	0.21	0.060	0.15	<0.10	<10	0.021	<0.010	

Table 37. Lake LeAnn chemical water quality parameter data collected at deep basin south #4 (March 21, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3 (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	0.77	0.26	0.084	0.18	<0.10	<10	0.015	<0.010	
5	0.98	0.27	0.090	0.18	<0.10	<10	0.018	<0.010	
9.5	0.91	0.27	0.11	0.16	<0.10	<10	0.017	<0.010	

Table 38. Lake LeAnn chemical water quality parameter data collected at deep basin north #1 (May 10, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3 (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	0.69	<0.10	0.039	<0.10	<0.10	<10	0.016	<0.010	0
3.5	1.10	0.17	0.043	0.13	<0.10	<10	0.016	<0.010	
6.5	0.96	0.19	0.054	0.19	<0.10	12	0.032	<0.010	

Table 39. Lake LeAnn chemical water quality parameter data collected at deep basin north #2 (May 10, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3 (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	0.66	<0.10	0.028	<0.10	<0.10	<10	0.023	<0.010	0
2.0	0.99	<0.10	0.040	<0.10	<0.10	<10	0.030	<0.010	
4.0	0.84	<0.10	0.043	<0.10	<0.10	10	0.029	<0.010	

Table 40. Lake LeAnn chemical water quality parameter data collected at deep basin north #3 (May 10, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH3 (mg/L)	NO3- (mg/L)	NO2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	--	--	--	--	--	--	--	--	--
1.0	1.60	<0.10	0.068	<0.10	<0.10	<10	0.045	<0.010	3.47
2.5	--	--	--	--	--	--	--	--	--

Table 41. Lake LeAnn chemical water quality parameter data collected at deep basin north #4 (May 10, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH3-N (mg/L)	NO3-N (mg/L)	NO2-N (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	--	--	--	--	--	--	--	--	--
1.5	1.00	<0.10	0.033	<0.10	<0.10	<10	0.027	<0.010	0
3.0	--	--	--	--	--	--	--	--	--

Table 42. Lake LeAnn chemical water quality parameter data collected at deep basin north #5 (May 10, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3-N (mg/L)	NO_3-N (mg/L)	NO_2-N (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	--	--	--	--	--	--	--	--	--
1.5	0.88	<0.10	0.029	<0.10	<0.10	<10	0.029	<0.010	0
3.0	--	--	--	--	--	--	--	--	--

Table 43. Lake LeAnn chemical water quality parameter data collected at north lake outlet (May 10, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3-N (mg/L)	NO_3-N (mg/L)	NO_2-N (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	0.51	<0.10	0.034	<0.10	<0.10	<10	0.024	<0.010	N/A

Table 44. Lake LeAnn chemical water quality parameter data collected at deep basin south #1 (May 10, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3 (mg/L)	NO_3-N (mg/L)	NO_2-N (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	<0.50	<0.10	0.016	<0.10	<0.10	<10	0.016	<0.010	2.94
3.0	0.50	0.15	0.110	<0.10	0.036	<10	0.014	<0.010	
6.0	0.76	0.16	0.050	0.11	<0.10	10	0.020	<0.010	

Table 45. Lake LeAnn chemical water quality parameter data collected at deep basin south #2 (May 10, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3 (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	<0.50	0.12	0.010	0.11	<0.10	<10	0.022	<0.010	1.60
3.0	<0.50	0.10	<0.010	0.10	<0.10	<10	0.011	<0.010	
6.5	<0.50	0.14	0.021	0.12	<0.10	28	0.015	<0.010	

Table 46. Lake LeAnn chemical water quality parameter data collected at deep basin south #3 (May 10, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3 (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	<0.50	<0.10	0.012	<0.10	<0.10	<10	0.015	<0.010	3.6
1.5	<0.50	<0.10	0.013	<0.10	<0.10	<10	0.017	<0.010	
3.0	<0.50	<0.10	0.026	<0.10	<0.10	14	0.014	<0.010	

Table 47. Lake LeAnn chemical water quality parameter data collected at deep basin south #4 (May 10, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3 (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	0.60	<0.10	0.019	<0.10	<0.10	12	0.012	<0.010	0
6.0	0.74	0.81	0.013	0.80	<0.10	12	0.013	<0.010	
11.5	1.20	0.34	0.210	0.12	<0.10	18	0.036	<0.010	

Table 48. Lake LeAnn chemical water quality parameter data collected at deep basin south #5 (May 10, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3 (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	0.88	0.13	0.011	0.12	<0.10	10	0.016	<0.010	0
4.5	0.92	0.16	0.058	0.10	<0.10	10	0.015	<0.010	
9.0	0.94	1.20	0.098	0.42	0.66	12	0.013	<0.010	

Table 49. Lake LeAnn chemical water quality parameter data collected at deep basin north #1 (July 12, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3 (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	<0.50	<0.10	0.012	<0.10	<0.10	32	0.029	<0.010	6.14
3.0	<0.50	<0.10	0.042	<0.10	<0.10	18	0.033	<0.010	
6.5	0.65	<0.10	0.063	<0.10	<0.10	12	0.037	<0.010	

Table 50. Lake LeAnn chemical water quality parameter data collected at deep basin north #2 (July 12, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3 (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	<0.50	<0.10	<0.010	<0.10	<0.10	<10	0.029	<0.010	1.07
2.0	0.67	<0.10	0.022	<0.10	<0.10	<10	0.034	<0.010	
4.5	0.59	<0.10	0.016	<0.10	<0.10	<10	0.032	<0.010	

Table 51. Lake LeAnn chemical water quality parameter data collected at deep basin north #3 (July 12, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3 (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	--	--	--	--	--	--	--	--	--
1.0	1.4	<0.10	0.064	<0.10	<0.10	16	0.031	<0.010	0.53
2.5	--	--	--	--	--	--	--	--	--

Table 52. Lake LeAnn chemical water quality parameter data collected at deep basin north #4 (July 12, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3- (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	--	--	--	--	--	--	--	--	--
1.5	0.66	<0.10	0.014	<0.10	<0.10	<10	0.020	<0.010	1.07
3.0	--	--	--	--	--	--	--	--	--

Table 53. Lake LeAnn chemical water quality parameter data collected at deep basin north #5 (May 10, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3- (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	--	--	--	--	--	--	--	--	--
1.5	0.54	<0.10	0.015	<0.10	<0.10	<10	0.027	0.018	0.27
3.0	--	--	--	--	--	--	--	--	--

Table 54. Lake LeAnn chemical water quality parameter data collected at north lake outlet (May 10, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3- (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	<0.50	<0.10	<0.010	<0.10	<0.10	<10	0.030	<0.010	NA

Table 55. Lake LeAnn chemical water quality parameter data collected at deep basin south #1 (July 12, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3 (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	<0.50	<0.10	0.092	<0.10	<0.10	<10	0.018	<0.010	2.94
3.0	0.51	<0.10	0.036	<0.10	<0.10	<10	0.020	<0.010	
6.5	0.50	<0.10	0.040	<0.10	<0.10	<10	0.020	<0.010	

Table 56. Lake LeAnn chemical water quality parameter data collected at deep basin south #2 (July 12, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3 (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	0.74	<0.10	0.029	<0.10	<0.10	<10	0.015	<0.010	0.27
3.5	0.82	<0.10	0.074	<0.10	<0.10	<10	0.018	<0.010	
7.5	0.98	0.22	0.220	<0.10	<0.10	10	0.022	<0.010	

Table 57. Lake LeAnn chemical water quality parameter data collected at deep basin south #3 (July 12, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3 (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	--	--	--	--	--	--	--	--	--
1.5	0.90	<0.10	0.057	<0.10	<0.10	<10	0.018	<0.010	0.80
3.0	--	--	--	--	--	--	--	--	--

Table 58. Lake LeAnn chemical water quality parameter data collected at deep basin south #4 (July 12, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3 (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	0.72	<0.10	0.036	<0.10	<0.10	<10	0.016	<0.010	1.34
5.5	0.84	0.29	0.29	<0.10	<0.10	10	0.023	<0.010	
11.5	2.60	<0.10	0.032	<0.10	<0.10	<10	0.050	0.011	

Table 59. Lake LeAnn chemical water quality parameter data collected at deep basin south #5 (July 12, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3 (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	0.92	0.11	0.11	<0.10	<0.10	<10	0.020	<0.010	0.27
4.5	0.96	0.19	0.19	<0.10	<0.10	<10	0.019	<0.010	
9.5	2.30	1.90	1.90	<0.10	<0.10	<10	0.048	<0.10	

Table 60. Lake LeAnn chemical water quality parameter data collected at deep basin north #1 (September 15, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3 (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	0.65	0.24	0.018	0.22	<0.10	<10	0.053	<0.010	2.49
3.0	1.50	<0.10	0.026	<0.10	<0.10	<10	0.067	<0.010	
6.0	1.20	<0.10	0.020	<0.10	<0.10	<10	0.064	<0.010	

Table 61. Lake LeAnn chemical water quality parameter data collected at deep basin north #2 (September 15, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3 (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	1.10	<0.10	0.014	<0.10	<0.10	<10	0.059	0.011	18.9
2.5	1.30	<0.10	0.028	<0.10	<0.10	10	0.064	<0.010	
4.5	1.40	<0.10	0.031	<0.10	<0.10	16	0.059	0.027	

Table 62. Lake LeAnn chemical water quality parameter data collected at deep basin north #3 (September 15, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3 (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	--	--	--	--	--	--	--	--	--
1.0	1.40	<0.10	0.026	<0.10	<0.10	10	0.056	0.018	13.9
2.0	--	--	--	--	--	--	--	--	--

Table 63. Lake LeAnn chemical water quality parameter data collected at deep basin north #4 (September 15, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3- (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	--	--	--	--	--	--	--	--	--
1.5	1.60	<0.10	0.033	<0.10	<0.10	<10	0.065	0.014	16.0
3.0	--	--	--	--	--	--	--	--	--

Table 64. Lake LeAnn chemical water quality parameter data collected at deep basin north #5 (September 15, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3 (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	--	--	--	--	--	--	--	--	--
1.0	1.20	<0.10	0.028	<0.10	<0.10	<10	0.061	<0.010	19.6
2.0	--	--	--	--	--	--	--	--	--

Table 65. Lake LeAnn chemical water quality parameter data collected at north lake outlet (September 15, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3 (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	0.96	<0.10	0.012	<0.10	<0.10	<10	0.049	0.039	NA

Table 66. Lake LeAnn chemical water quality parameter data collected at deep basin south #1 (September 15, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3 (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	0.62	<0.10	0.022	<0.10	<0.10	<10	0.018	<0.010	4.27
3.0	0.77	<0.10	0.020	<0.10	<0.10	<10	0.019	<0.010	
6.0	0.75	<0.10	0.020	<0.10	<0.10	<10	0.019	<0.010	

Table 67. Lake LeAnn chemical water quality parameter data collected at deep basin south #2 (September 15, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3 (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	0.68	<0.10	0.068	<0.10	<0.10	16	0.015	<0.010	2.14
3.5	0.88	<0.10	0.046	<0.10	<0.10	<10	0.019	<0.010	
6.5	0.74	<0.10	0.047	<0.10	<0.10	14	0.017	<0.010	

Table 68. Lake LeAnn chemical water quality parameter data collected at deep basin south #3 (September 15, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3 (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	--	--	--	--	--	--	--	--	--
1.5	1.20	<0.10	0.047	<0.10	<0.10	<10	0.026	<0.010	0
3.0	--	--	--	--	--	--	--	--	--

Table 69. Lake LeAnn chemical water quality parameter data collected at deep basin south #4 (September 15, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3 (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	0.60	<0.10	0.025	<0.10	<0.10	<10	0.014	0.011	0
5.5	0.78	<0.10	0.043	<0.10	<0.10	<10	0.016	<0.010	
11.5	5.30	4.50	4.50	<0.10	<0.10	<10	0.048	0.019	

Table 70. Lake LeAnn chemical water quality parameter data collected at deep basin south #5 (September 15, 2022).

Depth (m)	TKN (mg/L)	TIN (mg/L)	NH_3 (mg/L)	NO_3- (mg/L)	NO_2- (mg/L)	TSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chl-a (µg/L)
0	0.63	<0.10	0.027	<0.10	<0.10	<10	<0.010	<0.010	2.14
2.5	0.77	0.69	0.69	<0.10	<0.10	<10	0.016	<0.010	
5.5	1.40	<0.10	0.076	<0.10	<0.10	<10	0.025	<0.010	

Table 71. Sediment particle size and composition data (September 15, 2022).

Sample Site	% OM	Total Gravel (%)	Total Sand (%)	Total Fines (%)
S1	11	9.0	82.0	9.0
S2	28	0	66.9	33.1
S3	33	0	83.4	16.6
S4	1.6	0.7	88.4	10.9
S5	1.4	0	92.4	7.6
S6	0.58	0	99.5	0.5
S7	0.93	0	99.4	0.4
S8	2.8	46.7	51.3	2.0
S9	21	0	82.4	17.6
S10	1.3	25.6	68.7	5.7
S11	22	0	65.7	34.3
S12	1.4	33.8	65.1	1.1
S13	1.6	28.7	69.3	2.0

3.3 Lake LeAnn 2022 Drain Physical & Chemical Water Quality Data Tables:

RLS collected water quality samples from Lake LeAnn in 2022 and has characterized the lake as eutrophic. Previous analyses demonstrated that the CSA's around the lake contribute nutrient and sediment loads to the lake which lead to water quality degradation over time. Such degradation has currently resulted in the occurrence of internal loading within the lake. RLS has identified impaired CSA sites and the data and results to date are presented here.

Water quality is highly variable among the CSA's and this variability is due to land use practices and climatic events. Climatic factors (i.e. spring runoff, heavy rainfall) may alter water quality in the short term; whereas, anthropogenic (man-induced) factors (i.e. shoreline development, lawn fertilizer use) alter water quality over longer time periods. Since many lakes have a fairly long hydraulic residence time, the water may remain in the lake for years and is therefore sensitive to nutrient loading and pollutants.

CSA Water Quality Parameters Measured:

Water quality parameters such as dissolved oxygen, water temperature, pH, conductivity, total dissolved solids, total suspended solids, total phosphorus, ortho-phosphorus, total inorganic nitrogen (specifically ammonia, nitrate, and nitrite), and total Kjeldahl nitrogen were measured at each of the CSA areas under flowing conditions. Samples consisted of preserved grab bottles which were placed on ice and transported to the NELAC-certified laboratory for analysis. The data for the CSA's are discussed below and are presented in Table 72 with descriptive statistics. Samples and water quality measurements were collected on July 12, 2022 and September 16, 2022. Measurements were taken with a calibrated Eureka Manta II® multi-parameter probe. A discussion of each parameter and how they are collected and measured follows. During both 2022 sampling dates, sites 3, 5, 4a, 4b were not flowing and thus could not be sampled.

Table 72. Summary statistics for CSA's sampled by RLS in 2022.

Water Quality Parameter	CSA #1A	CSA #1B	CSA #2A	CSA #2B
Water temp (°C)	22.5±5.1	15.6±5.0	15.9±4.0	15.2±3.1
pH (S.U.)	7.8±0.1	7.6±0.0	8.0±0.1	7.8±0.1
Dissolved oxygen (mg/L)	9.4±0.4	9.0±0.8	9.1±0.9	9.4±0.4
Conductivity (mS/cm)	649±28	784±2.1	681±8.5	710±3.5
Total dissolved solids (mg/L)	415±18	503±2.1	436±4.9	455±2.1
Total Kjeldahl nitrogen (mg/L)	0.6±0.1	0.5±0.0	0.5±0.0	0.5±0.0
Total inorganic nitrogen (mg/L)	0.100±0.0	1.0±0.1	0.880±0.5	0.895±0.7
Ammonia nitrogen (mg/L)	0.022±0.0	0.020±0.0	0.018±0.0	0.070±0.7
Nitrate nitrogen (mg/L)	0.100±0.0	0.980±0.2	0.870±0.5	0.785±0.6
Nitrite nitrogen (mg/L)	0.100±0.0	0.100±0.0	0.100±0.0	0.100±0.0
Total phosphorus (mg/L)	0.010±0.0	0.010±0.0	0.012±0.0	0.019±0.0
Ortho-Phosphorus (mg/L)	0.010±0.0	0.010±0.0	0.010±0.0	0.011±0.0
Total suspended solids (mg/L)	10±0.0	10.0±0.0	13±4.2	11±1.4
Flow rate (cfs)	0.8±0.1	0.6±0.2	0.8±0.7	0.6±0.4

3.4 Lake LeAnn 2022 Phytoplankton Community:

Algal Community Composition Data:

The algal genera were determined from a 500-ml composite water sample collected over the 9 deep basins of Lake LeAnn on September 15, 2022 Sub-samples were collected from the 500-ml sample and placed in a Sedgewick Rafter counting chamber for analysis under a Zeiss® compound bright field microscope. Tables 73-74 below shows a breakdown by algal group of what was present in the algal samples collected on the sampling date. Figures 6-7 graphically demonstrate the relative abundance by algal category over time.

Table 73. Counts (# cells per 1 mL sub-sample) for each genera of algae found at each sampling location (n=4) in the north lake basin of Lake LeAnn (September 15, 2022).

Taxa Present	Type	N1	N2	N3	N4
Akinestrodesmus sp.	G	3	9	2	1
Chlorella sp.	G	13	6	2	0
Closterium sp.	G	4	2	1	1
Cosmarium sp.	G	3	2	0	1
Haematococcus sp.	G	6	4	2	0
Mougeotia sp.	G	2	7	1	3
Pediastrum sp.	G	1	0	0	1
Rhizoclonium sp.	G	9	7	6	5
Scenedesmus sp.	G	2	7	4	6
Staurastrum sp.	G	2	1	0	0
Ulothrix sp.	G	1	1	1	0
Microcystis sp.	BG	1,000	550	310	1,610
Dolichospermum sp.	BG	55	80	2	37
Oscillatoria sp.	BG	2	0	4	7
Cymbella sp.	D	5	2	7	3
Fragillaria sp.	D	11	8	6	4
Navicula sp.	D	5	2	0	8
Rhoicosphenia sp.	D	12	8	5	0
Synedra sp.	D	16	27	8	1

Note: G = green algae (Chlorophyta); BG = blue-green algae (Cyanophyta); D = diatoms (Bacillariophyta).

Table 74. Counts (# cells per 1 mL sub-sample) for each genera of algae found at each sampling location (n=5) in the south lake basin of Lake LeAnn (September 15, 2022).

Taxa Present	Type	S1	S2	S3	S4	S5
Chlorella sp.	G	5	9	2	1	3
Closterium sp.	G	1	0	0	0	2
Cosmarium sp.	G	3	5	9	2	1
Haematococcus sp.	G	13	10	5	7	4
Mougeotia sp.	G	9	2	0	1	0
Pediastrum sp.	G	1	1	0	0	0
Rhizoclonium sp.	G	11	5	4	1	0
Scenedesmus sp.	G	6	2	4	1	0
Ulothrix sp.	G	2	0	0	1	3
Microcystis sp.	BG	55	65	40	21	29
Dolichospermum sp.	BG	24	22	1	15	10
Oscillatoria sp.	BG	2	0	0	0	0
Cymbella sp.	D	4	9	5	1	0
Fragillaria sp.	D	10	7	2	5	0
Navicula sp.	D	3	13	19	7	5
Rhoicosphenia sp.	D	8	11	4	6	18
Synedra sp.	D	2	1	8	1	0

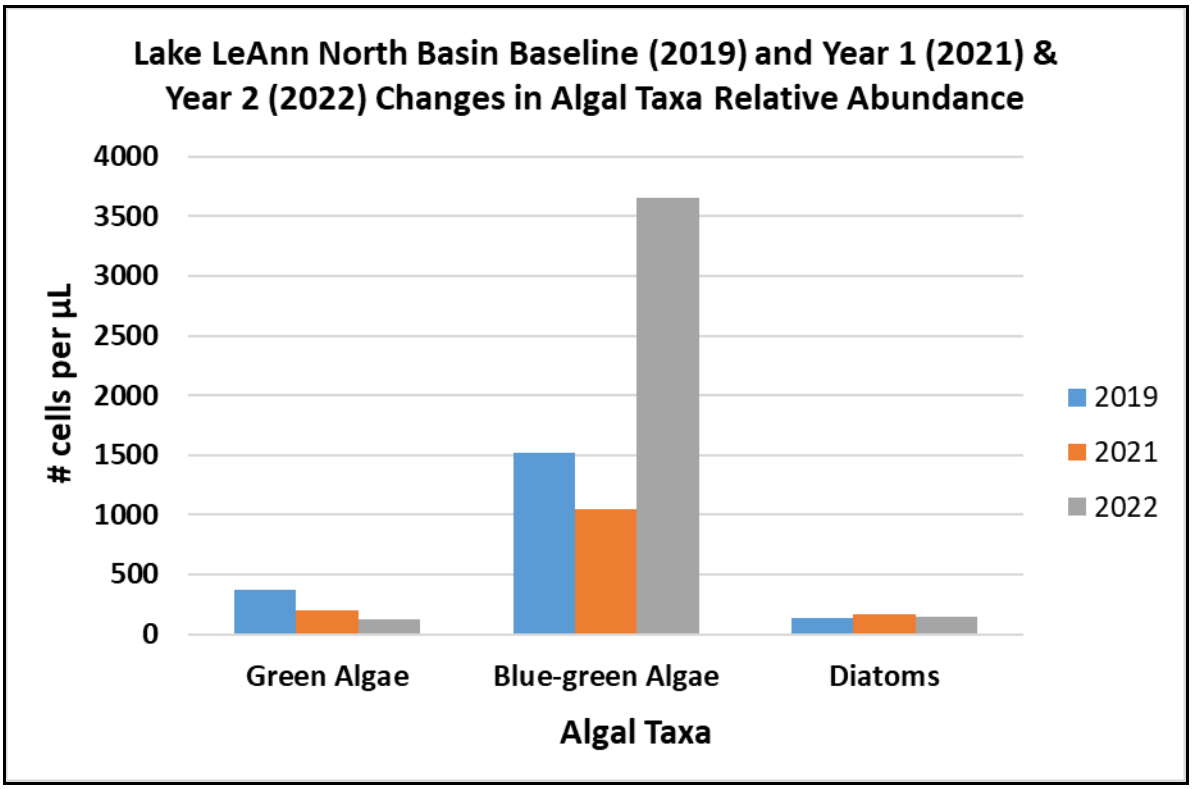

Figure 6. Algal relative abundance by taxa in the north lake basin (2019-2022).

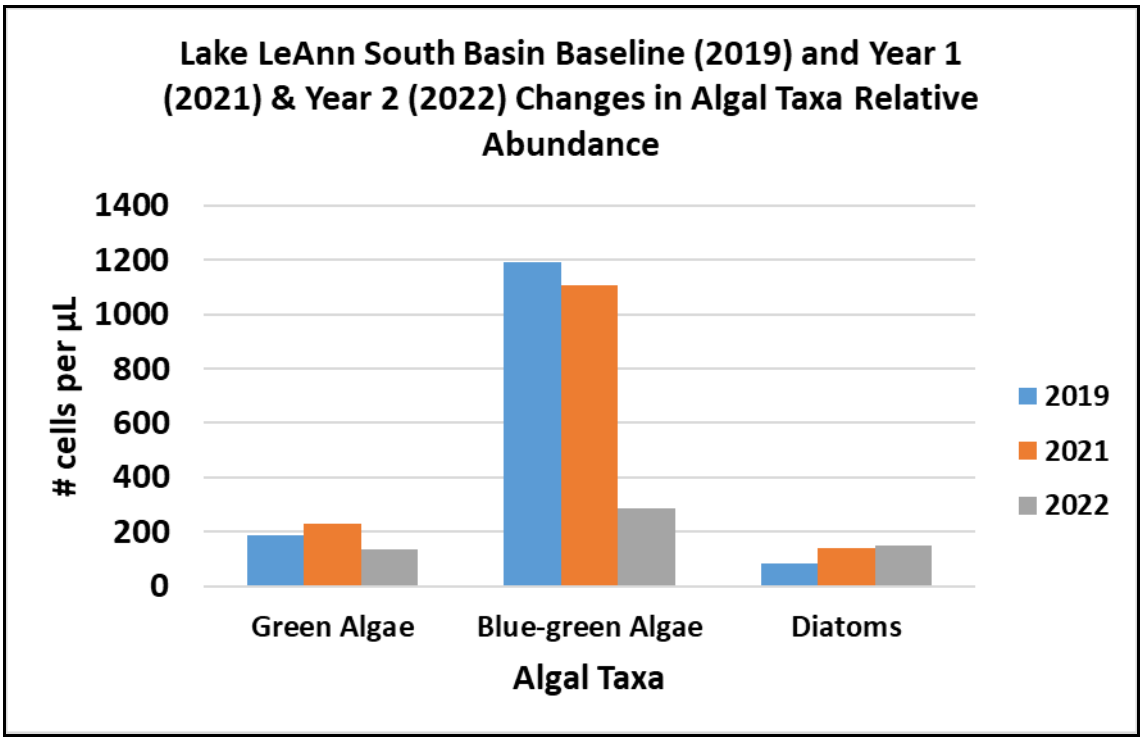

Figure 7. Algal relative abundance by taxa in the south lake basin (2019-2022).

3.5 Lake LeAnn 2022 Zooplankton Community:

A zooplankton tow was conducted over the deep basin of Lake LeAnn on May 10, 2022 and September 15, 2022 using a plankton tow net (Figure 8). The net was lowered into the hypolimnion and carefully pulled through the water column at an approximate rate of ~4 feet per second and up to the surface to yield a full 125-ml sample. The plankton net was then rinsed into the collection bottle where an Alka Seltzer® tablet was then placed along with 70% ethyl alcohol solution. The sample was then quantified for zooplankton community composition using a Ward counting wheel under a Zeiss® dissection microscope (Tables 75-78).

Table 75. Zooplankton taxa and count data from the north basin of Lake LeAnn (May 10, 2022).

Zooplankton Taxa	N1	N2	N3	N4
Cladocerans				
Daphnia parvula	11	14	6	4
Daphnia spp.	9	18	2	7
Bosmina longirostris	2	5	1	2
Bosmina sp.	3	1	0	2
Copepods/Cyclopods				
Diaptomus copepodites	1	2	4	1
Mesocyclops sp.	6	8	9	5
Nauplius sp.	2	1	1	0
Rotifers				
Brachionus sp.	3	7	4	2
Keratella sp.	6	1	5	9

Table 76. Zooplankton taxa and count data from the north basin of Lake LeAnn (September 15, 2022).

Zooplankton Taxa	N1	N2	N3	N4
Cladocerans				
Daphnia parvula	17	23	9	7
D. retrocurva	6	2	0	4
Bosmina longirostris	3	0	0	1
Bosmina sp.	8	2	6	3
Copepods/Cyclopods				
Mesocyclops edax	11	9	15	7
Nauplius sp.	3	5	1	0
Rotifers				
Keratella sp.	3	4	7	7

Table 77. Zooplankton taxa and count data from the south basin of Lake LeAnn (May 10, 2022).

Zooplankton Taxa	S1	S2	S3	S4	S5
Cladocerans					
Daphnia parvula	12	5	19	13	7
Daphnia sp.	15	6	2	11	4
Bosmina longirostris	2	1	1	3	2
Copepods/Cyclopods					
Diaptomus sp.	3	6	1	1	0
Nauplius sp.	6	4	2	1	2
Rotifers					
Keratella sp.	9	2	4	0	0
Brachionus sp.	5	3	1	0	1

Table 78. Zooplankton taxa and count data from the south basin of Lake LeAnn (September 15, 2022).

Zooplankton Taxa	S1	S2	S3	S4	S5
Cladocerans					
Daphnia parvula	13	9	21	8	5
D. retrocurva	10	11	5	9	9
Daphnia sp.	2	6	16	4	3
Copepods/Cyclopods					
Diaptomus sp.	1	1	3	1	4
Mesocyclops sp.	2	9	2	0	1
Nauplius sp.	3	5	1	0	0
Rotifers					
Keratella sp.	2	1	0	3	2

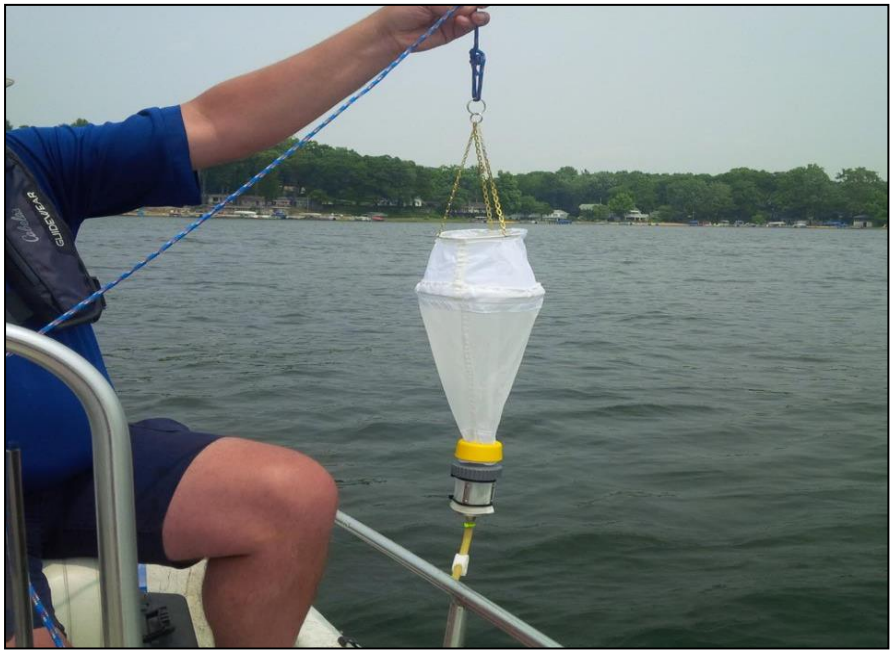

Figure 8. A zooplankton sampling net. ©RLS

3.6 Lake LeAnn Aquatic Vegetation Biovolume Data (September 15-16, 2022)

A whole-lake scan of the aquatic vegetation in Lake LeAnn was conducted on September 15-16, 2022 with a WAAS-enabled Lowrance HDS 9 GPS with variable frequency transducer. This data included 11,739 data points in the north basin and 16,872 data points in the south basin. Points were then uploaded into a cloud software program to reveal maps that displayed depth contours, sediment hardness, and aquatic vegetation biovolume (Figures 9-10). On these maps, the color blue refers to areas that lack vegetation. The color green refers to low-lying vegetation. The colors red/orange refer to tall-growing vegetation. There are many areas around the littoral (shallow) zone of the lake that contain low-growing plants like Chara
. In addition, any emergent canopies or lily pads will show as red color on the map. For this reason, the scans are conducted in conjunction with a whole lake GPS survey to account for individual species identification of all aquatic plants in the lake. Tables 79 and 80 show the biovolume categories by plant cover during the September 15, 2022 scan and survey.

The Point-Intercept Survey method is used to assess the presence and percent cumulative cover of submersed, floating-leaved, and emergent aquatic vegetation within and around the littoral zones of inland lakes.

With this survey method, sampling locations are geo-referenced (via GPS waypoints) and assessed throughout the entire lake to determine the species of aquatic macrophytes present and density of each macrophyte which are recorded onto a data sheet.

Each separate plant species found in each sampling location is recorded along with an estimate of each plant density. Each macrophyte species corresponds to an assigned number. There are designated density codes for the aquatic vegetation surveys, where a = found (occupying < 2% of the surface area of the lake), b = sparse (occupying 2-20% of the surface area of the lake), c = common, (occupying 21-60% of the surface area of the lake), and d = dense (occupying > 60% of the surface area of the lake).

The survey of the north basin of Lake LeAnn consisted of 120 sampling locations around the littoral zone and the survey of the south basin consisted of 140 sampling locations and was conducted in spring during May 10, 2022 with follow-up post treatment surveys later in the season to confirm treatment efficacy. Data were placed in a table showing the relative abundance of each aquatic plant species found and a resultant calculation showing the frequency of each plant, and cumulative cover.

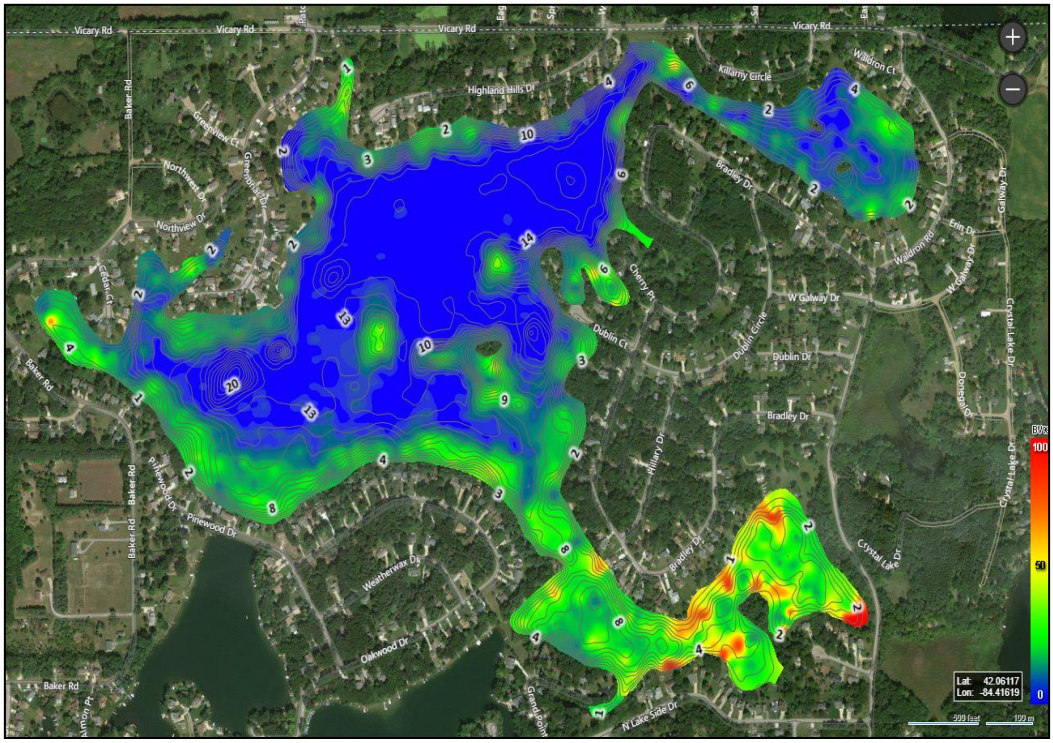

Figure 9. Aquatic plant biovolume of all aquatic plants in north Lake LeAnn, Hillsdale County, Michigan (September 15-16, 2022). Note: Red color denotes high-growing aquatic plants, green color denoted low-growing aquatic plants, and blue color represents a lack of aquatic vegetation.

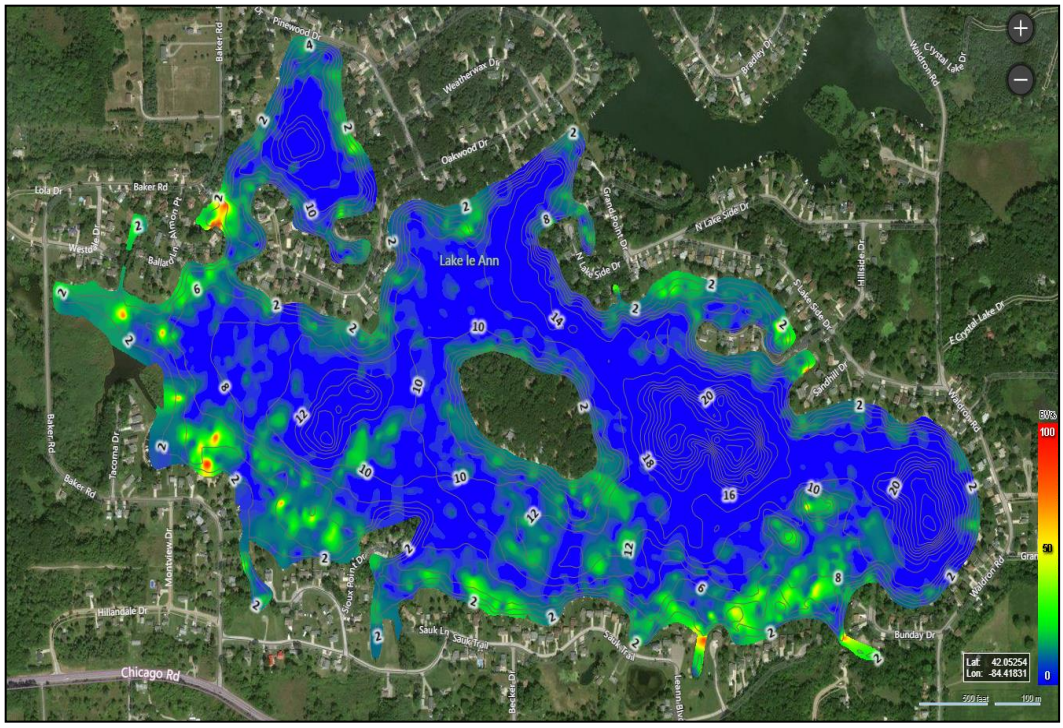

Figure 10. Aquatic plant biovolume of all aquatic plants in south Lake LeAnn, Hillsdale County, Michigan (September 15-16, 2022). Note: Red color denotes high-growing aquatic plants, green color denoted low-growing aquatic plants, and blue color represents a lack of aquatic vegetation.

Table 79. Lake LeAnn north basin aquatic vegetation biovolume by category percent over of each category (relative cover on September 15-16, 2022).

Biovolume Cover Category	% Relative Cover of Bottom by Category
<5%	56.6
5-20%	23.6
20-40%	12.6
40-60%	5.4
60-80%	0.7
>80%	1.1

Table 80. Lake LeAnn south basin aquatic vegetation biovolume by category percent over of each category (relative cover on September 15-16, 2022).

Biovolume Cover Category	% Relative Cover of Bottom by Category
<5%	71.1
5-20%	22.1
20-40%	4.7
40-60%	1.3
60-80%	0.3
>80%	0.5

During the May 10, 2022 survey, the north basin of Lake LeAnn contained 5 native submersed, 2 floating-leaved, and 2 emergent aquatic plant species, for a total of 9 native aquatic macrophyte species (Table 81). This represents a loss of 4 species relative to 2021 and may be attributed to the increased canopy of milfoil that required treatment in 2021 and germination of low-growing natives has been slow. During the May 10, 2022 survey, the south basin of Lake LeAnn contained 4 native submersed, 2 floating-leaved, and 1 emergent aquatic plant species, for a total of 7 native aquatic macrophyte species (Table 82). This represents a loss of 4 native species similar to the north basin. The milfoil canopy was present in 2021 and again in 2022 in the south basin. The emergent macrophytes were found along the shoreline of the lake. Additionally, the majority of the floating-leaved macrophyte species were found near the shoreline and wetland areas.

The dominant native aquatic plants in the north basin of the lake included the Chara (77.5% of the sampling sites), and White Waterlily (6.7% of the sampling sites). The dominant native aquatic plants in the south basin of the lake included the Chara (37.1% of the sampling sites), and emergent cattails (5.7% of the sampling sites).

The relative abundance of rooted aquatic plants (relative to non-rooted plants) in the lake suggests that the sediments are the primary source of nutrients (relative to the water column), since these plants obtain most of their nutrition from the sediments. The emergent plants, such as (Cattails) are critical for shoreline stabilization as well as for wildlife and fish spawning habitat.

RLS discourages the treatment of any native submersed aquatic plants as the lake needs those species in the absence of invasive cover by milfoil and Curly-leaf Pondweed. All invasives should be treated however, as continued growth leads to spread and further loss of native submersed aquatic plant species. Figures 11-13 below display the treatment areas in 2022 where targeted treatments of invasive species were needed to reduce milfoil, Curly-leaf Pondweed, and Starry Stonewort.

Figure 11. North Lake LeAnn May 2022 treatment map.

Figure 12. South Lake LeAnn May, 2022 treatment map.

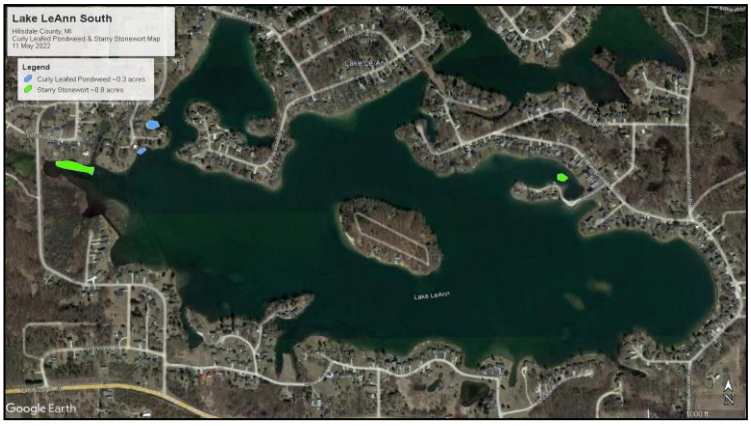

Figure 13. South Lake LeAnn May, 2022 treatment map.

Table 81. Lake LeAnn north basin native aquatic plants (May 10, 2022).

Aquatic Plant Common Name	Aquatic Plant Latin Name	A level	B level	C level	D level	# Sites Found (% of total)
Muskgrass	*Chara vulgaris*	78	15	0	0	77.5
Flat-stem Pondweed	*Potamogeton zosteriformis*	1	0	0	0	0.8
Large-leaf Pondweed	*Potamogeton amplifolius*	1	0	0	0	0.8
Coontail	*Ceratophyllum demersum*	6	0	0	0	5.0
Elodea	*Elodea canadensis*	2	1	0	0	2.5
White Waterlily	*Nymphaea odorata*	8	0	0	0	6.7
Yellow Waterlily	*Nuphar variegata*	4	0	0	0	3.3
Cattails	*Typha latifolia*	4	1	0	0	4.2
Iris sp.	*Iris* sp.	1	0	0	0	0.8

Table 82. Lake LeAnn south basin native aquatic plants (May 10, 2022).

Aquatic Plant Common Name	Aquatic Plant Latin Name	A level	B level	C level	D level	# Sites Found (% of total)
Muskgrass	*Chara vulgaris*	39	13	0	0	37.1
Flat-stem Pondweed	*Potamogeton zosteriformis*	1	0	0	0	0.7
Large-leaf Pondweed	*Potamogeton amplifolius*	1	0	0	0	0.7
Northern Watermilfoil	*Myriophyllum sibiricum*	0	1	0	0	0.7
White Waterlily	*Nymphaea odorata*	1	0	0	0	0.7
Yellow Waterlily	*Nuphar variegata*	4	2	0	0	4.3
Cattails	*Typha latifolia*	3	5	0	0	5.7

3.7 Lake LeAnn Bottom Hardness Scan and Substrate Data:

A bottom sediment hardness scan was conducted of the entire lake bottom on September 15-16, 2022. The bottom hardness maps show (Figures 14-15) that most of the lake bottom consists of fairly consolidated sediment throughout the lake with a few areas with soft organic bottom. This is not surprising given the amount of sandy loams in the region which contribute to lake geology. Tables 83-84 below show the categories of relative bottom hardness with 0.0-0.1 referring to the softest and least consolidated bottom and >0.4 referring to the hardest, most consolidated bottom for the two lake basins. This scale does not mean that any of the lake contains a truly "hard" bottom but rather a bottom that is more cohesive and not flocculent. Table 85 displays the sediment organic matter and particle size data.

Table 83. Lake LeAnn north basin relative hardness of the lake bottom by category or hardness and percent cover of each category (relative cover).

Lake Bottom Relative Hardness Category	# GPS Points in Each Category (Total =7,986)	% Relative Cover of Bottom by Category
0.0-0.1	15	0.2
0.1-0.2	429	5.4
0.2-0.3	4910	61.5
0.3-0.4	2612	32.7
>0.4	20	0.2

Table 84. Lake LeAnn south basin relative hardness of the lake bottom by category or hardness and percent cover of each category (relative cover).

Lake Bottom Relative Hardness Category	# GPS Points in Each Category (Total =11,647)	% Relative Cover of Bottom by Category
0.0-0.1	6	0.1
0.1-0.2	712	6.1
0.2-0.3	7358	63.2
0.3-0.4	3552	30.5
>0.4	19	0.1

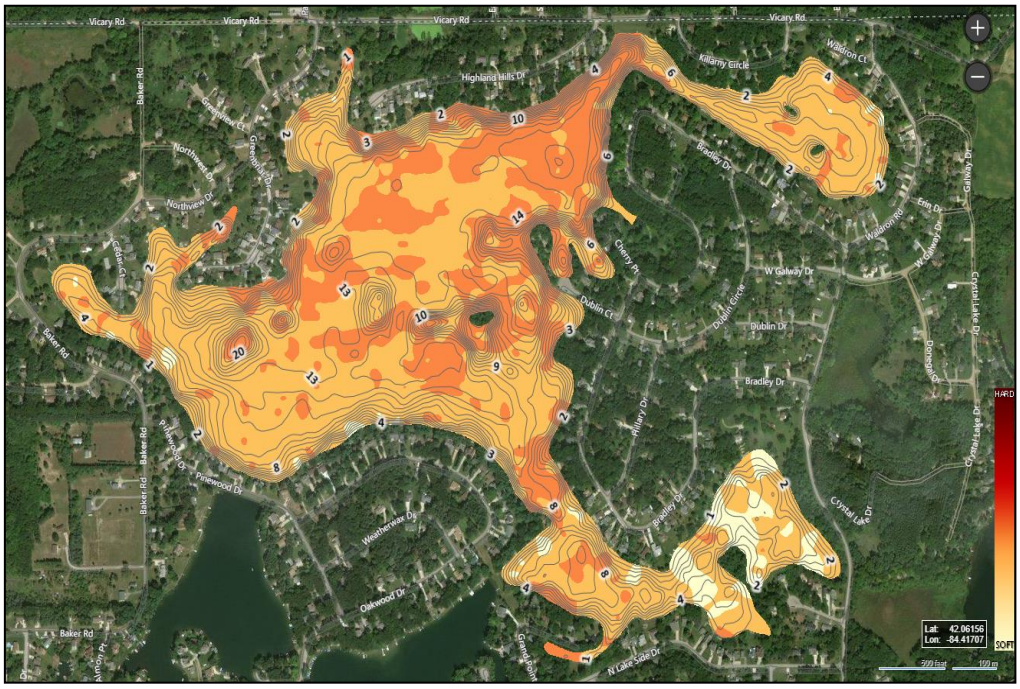

Figure 14. Lake LeAnn north basin sediment relative hardness map (September 15, 2022).

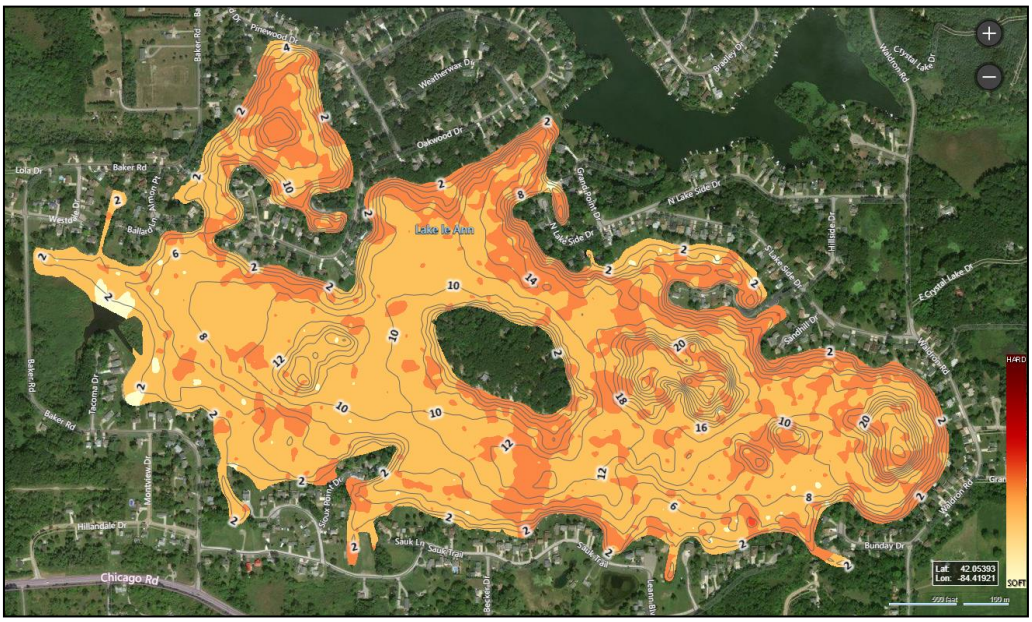

Figure 15. Lake LeAnn south basin sediment relative hardness map (September 15, 2022)

Table 85. Lake LeAnn sediment organic matter and particle size data collected at n= 13 locations (September 15, 2022). NOTE: There was no gravel components in the data set.

Site	%OM	Total Gravel Fractional Components (%)	Total Sand Fractional Components (%)	Total Fines Fractional Components (%)
N1	11.0	9.0	82.0	9.0
N2	28.0	0	66.9	33.1
N3	33.0	0	83.4	16.6
N4	1.6	0.7	88.4	10.9
N5	1.4	0	92.4	7.6
N6	0.6	0	99.5	0.5
S7	0.9	0	99.4	0.4
S8	2.8	46.7	51.3	2.0
S9	21.0	0	82.4	17.6
S10	1.3	25.6	68.7	5.7
S11	22.0	0	65.7	34.3
S12	1.4	33.8	65.1	1.1
S13	1.6	28.7	69.3	2.0

3.8 Lake LeAnn Destratification Ice Sampling Data:

A through the ice sampling over the deepest basins of Lake LeAnn was conducted on March 10, 2022. The data shown in Tables 1-2 of this report present low nutrients and nearly uniform water temperatures from top to bottom with elevated dissolved oxygen concentrations. RLS will collect through-the-ice sampling in 2023 over the deepest basins as long as safe ice conditions are present. As a requirement of the LFA permit, a profile with all physical data as well as chemical data would be collected as is displayed in Tables 1-2. The ice conditions on the sampling date and air temperature and weather conditions will be recorded. If ice is not safe, then no samples will be collected. Ice conditions were not safe for sampling in 2019.

4.0 LAKE LEANN 2019-2022 CONCLUSIONS AND RECOMMENDATIONS FOR 2023

The implementation of the LFA technology and concomitant use of bioaugmentation (beneficial bacteria and enzymes) in Lake LeAnn occurred in 2021 and 2022. This was to begin initiation of the primary goals addressed in the earlier sections above. Specifically, the lake needs more native aquatic vegetation, less invasive aquatic plant species, less cyanobacteria, and less nutrients. The nutrient concentrations in the lake are indicative of eutrophic waters with elevated phosphorus, nitrogen, and chlorophyll-a. Additional impairments include low dissolved oxygen with depth in non-aerated locations, and reduced water clarity through low secchi transparency readings. The nutrients have multiple sources which include drains entering the lake, septic systems, and other land uses. The Sections below (I-VI) display the 2019 mean baseline data set and the post-LFA mean data sets (2021-2022). The following sub-sections below summarize an analysis of all collected data from 2019 and 2021-2022 with comparisons. The Mirror Lake Outlet data was added post 2019 by EGLE and thus 2021-2022 data has been collected at the outlet. In addition, RLS collected through the ice sampling in 2022 as conditions were previously unsafe. Comparisons on this data set will be made based on successful future sampling events with safe ice. All data collected has been analyzed and are summarized below with descriptive statistic tables that include means and standard deviations.

Management recommendations for 2023 are last and mentioned in Section VII below.

Statistical Summary of Baseline (2019) and Year 1 (2021) and Year 2 (2022) Lake LeAnn LFA Data

I. Lake Basins:

The tables below (86-92) display the means and standard deviations for both lake basins in 2019 (baseline) and 2021-2022 (Year 1 and Year 2 of LFA operation). This analysis allowed for a seasonal comparison of baseline to post-LFA conditions for all water quality parameters. Based on this complete and comprehensive data analysis, the following conclusions can be made:

North Basin:

- The TIN declined over time, except for in September of 2022.
- The NH_3 declined over time.
- The chlorophyll-a increased over time.
- The specific conductivity increased over time.
- The TP increased in April, decreased in July, and increased in September. The highest reported concentration was in September of 2022 with a concentration of 0.067 mg/L.
- The Secchi transparency increased in 2021 but declined in 2022.

South Basin:

- The DO increased over time.
- The chlorophyll-a increased over time.
- The total phosphorus declined in July and September but was higher in April.
- The total suspended solids declined in April and July but increased in September
- The TIN increased in September.

It is apparent that possible activities conducted by the drain commissioner (to lower levels due to substantial rainfall) in late summer may have allowed for nutrient-enriched water to pass through the south basin and increase TP and TIN which was noted in the north basin. This is unfortunate, but when mitigation continues in 2023, further reductions in nutrients are expected in the absence of such dam activity. This should also result in reduced algal blooms. Blue-green algae are increasing globally due to atmospheric enrichment of CO_2 which then is utilized by cyanobacteria for accelerated growth. This is happening more in nutrient-rich lakes such as Lake LeAnn. If the LFA is to achieve continued lake improvement, then all residents should assist the LLPOA with nutrient reductions by annually cleaning and inspecting all septic systems and drain fields, avoiding the use of all lawn fertilizers, and supporting the LLPOA efforts to reduce nutrients coming into the lake from the CSA drains.

Table 86. Descriptive statistics of all water quality parameters in the North Basin of Lake LeAnn for LFA parameters collected in April/May of 2019, 2021, and 2022.

Water Quality Parameter	2019 Baseline April/May Means ± SD	2021 Year 1 April/May Means ± SD	2022 Year 2 April/May Means ± SD
Water temp (°C)	12.9±0.9	13.2±0.6	15.3±0.9
pH (S.U.)	8.3±0.1	8.5±0.1	8.1±0.1
Dissolved oxygen (mg/L)	10.1±0.6	11.6±0.9	9.9±0.4
Conductivity (mS/cm)	509±3.6	502±9.0	557±176
Secchi transparency (ft)	8.4±1.6	10.2±2.4	4.7±0.9
Chlorophyll-a (µg/L)	0.134±0.3	0.606±0.4	0.700±1.6
Total Kjeldahl nitrogen (mg/L)	0.6±0.1	0.5±0.1	1.0±0.3
Total inorganic nitrogen (mg/L)	0.240±0.0	0.027±0.0	0.118±0.0
Ammonia nitrogen (mg/L)	0.073±0.0	0.027±0.0	0.042±0.0
Nitrate nitrogen (mg/L)	0.166±0.0	0.100±0.0	0.113±0.0
Nitrite nitrogen (mg/L)	0.100±0.0	0.100±0.0	0.100±0.0
Total phosphorus (mg/L)	0.025±0.0	0.016±0.0	0.027±0.0
Ortho-phosphorus (mg/L)	0.010±0.0	0.010±0.0	0.010±0.0
Total suspended solids (mg/L)	25±12	10.0±0.0	10.2±2.0

Table 87. Descriptive statistics of all water quality parameters in the North Basin of Lake LeAnn for LFA parameters collected in July of 2019, 2021, and 2022.

Water Quality Parameter	2019 Baseline July Means ± SD	2021 Year 1 July Means ± SD	2022 Year 2 July Means ± SD
Water temp (°C)	21.2±2.6	25.5±0.4	25.9±0.3
pH (S.U.)	8.5±0.1	8.5±0.2	8.0±0.3
Dissolved oxygen (mg/L)	7.3±2.1	9.4±1.2	7.7±1.2
Conductivity (mS/cm)	584±75	425±86	720±134
Secchi transparency (ft)	6.1±0.1	6.2±0.6	3.5±1.1
Chlorophyll-a (µg/L)	0.340±0.7	3.8±2.5	1.8±2.4
Total Kjeldahl nitrogen (mg/L)	1.2±0.9	0.5±0.0	0.7±0.3
Total inorganic nitrogen (mg/L)	0.172±0.4	0.012±0.0	0.100±0.0
Ammonia nitrogen (mg/L)	0.172±0.4	0.012±0.0	0.029±0.0
Nitrate nitrogen (mg/L)	0.100±0.0	0.100±0.0	0.100±0.0
Nitrite nitrogen (mg/L)	0.100±0.0	0.100±0.0	0.100±0.0
Total phosphorus (mg/L)	0.047±0.0	0.034±0.0	0.030±0.0
Ortho-phosphorus (mg/L)	0.026±0.0	0.010±0.0	0.011±0.0
Total suspended solids (mg/L)	10.5±1.4	10.0±0.0	14.2±7.3

Table 88. Descriptive statistics of all water quality parameters in the North Basin of Lake LeAnn for LFA parameters collected in September of 2019, 2021, and 2022.

Water Quality Parameter	2019 Baseline Sept Means ± SD	2021 Year 1 Sept Means ± SD	2022 Year 2 Sept Means ± SD
Water temp (°C)	22.6±1.2	23.7±0.8	22.5±1.0
pH (S.U.)	8.4±0.2	8.6±0.1	8.5±0.2
Dissolved oxygen (mg/L)	8.2±2.2	9.0±1.1	10.1±1.5
Conductivity (mS/cm)	472±13	480±1.8	477±5.2
Secchi transparency (ft)	3.3±0.1	3.5±0.5	1.8±0.2
Chlorophyll-a (µg/L)	0.0±0.0	2.8±2.0	14.2±6.9
Total Kjeldahl nitrogen (mg/L)	1.0±0.3	1.0±0.5	1.3±0.3
Total inorganic nitrogen (mg/L)	0.057±0.1	0.100±0.0	0.116±0.0
Ammonia nitrogen (mg/L)	0.057±0.1	0.036±0.0	0.025±0.0
Nitrate nitrogen (mg/L)	0.100±0.0	0.100±0.0	0.113±0.0
Nitrite nitrogen (mg/L)	0.100±0.0	0.100±0.0	0.100±0.0
Total phosphorus (mg/L)	0.037±0.0	0.047±0.0	0.061±0.0
Ortho-phosphorus (mg/L)	0.010±0.0	0.013±0.0	0.013±0.0
Total suspended solids (mg/L)	10.6±1.9	21.0±10.0	10.7±2.0

Table 89. Descriptive statistics of all water quality parameters in the South Basin of Lake LeAnn for LFA parameters collected in April/May of 2019, 2021, and 2022.

Water Quality Parameter	2019 Baseline April/May Means ± SD	2021 Year 1 April/May Means ± SD	2022 Year 2 April/May Means ± SD
Water temp (°C)	12.7±1.1	12.6±1.1	14.1±1.9
pH (S.U.)	8.4±0.1	8.4±0.1	8.3±0.1
Dissolved oxygen (mg/L)	10.3±0.7	10.3±0.7	10.5±1.6
Conductivity (mS/cm)	544±5.3	541±4.6	711±150
Secchi transparency (ft)	6.0±0.9	7.5±0.5	3.8±0.5
Chlorophyll-a (µg/L)	1.8±2.5	0.8±0.8	1.6±1.7
Total Kjeldahl nitrogen (mg/L)	0.5±0.0	0.5±0.1	0.7±0.2
Total inorganic nitrogen (mg/L)	0.223±0.1	0.104±0.1	0.254±0.3
Ammonia nitrogen (mg/L)	0.035±0.0	0.104±0.1	0.045±0.1
Nitrate nitrogen (mg/L)	0.191±0.1	0.100±0.0	0.173±0.2
Nitrite nitrogen (mg/L)	0.100±0.0	0.100±0.0	0.133±0.1
Total phosphorus (mg/L)	0.018±0.0	0.015±0.0	0.017±0.0
Ortho-phosphorus (mg/L)	0.010±0.0	0.010±0.0	0.010±0.0
Total suspended solids (mg/L)	16.1±11.0	10.0±0.0	12.4±4.9

Table 90. Descriptive statistics of all water quality parameters in the South Basin of Lake LeAnn for LFA parameters collected in July of 2019, 2021, and 2022.

Water Quality Parameter	2019 Baseline July Means ± SD	2021 Year 1 July Means ± SD	2022 Year 2 July Means ± SD
Water temp (°C)	23.9±4.8	22.4±5.0	23.1±5.5
pH (S.U.)	8.5±0.1	8.1±0.4	8.0±0.3
Dissolved oxygen (mg/L)	6.7±3.5	6.8±4.2	6.2±3.3
Conductivity (mS/cm)	494±49	536±25	552±45
Secchi transparency (ft)	8.7±1.0	2.8±0.2	4.2±0.6
Chlorophyll-a (µg/L)	0.5±0.6	2.5±2.3	1.1±1.1
Total Kjeldahl nitrogen (mg/L)	1.1±1.2	1.0±0.7	1.0±0.7
Total inorganic nitrogen (mg/L)	0.253±0.8	0.456±0.8	0.270±0.5
Ammonia nitrogen (mg/L)	0.253±0.8	0.456±0.8	0.239±0.5
Nitrate nitrogen (mg/L)	0.100±0.0	0.100±0.0	0.100±0.0
Nitrite nitrogen (mg/L)	0.100±0.0	0.100±0.0	0.100±0.0
Total phosphorus (mg/L)	0.039±0.1	0.042±0.0	0.024±0.0
Ortho-phosphorus (mg/L)	0.012±0.0	0.010±0.0	0.010±0.0
Total suspended solids (mg/L)	13.7±11.0	10.0±0.0	10.0±0.0

Table 91. Descriptive statistics of all water quality parameters in the South Basin of Lake LeAnn for LFA parameters collected in September of 2019, 2021, and 2022.

Water Quality Parameter	2019 Baseline Sept Means ± SD	2021 Year 1 Sept Means ± SD	2022 Year 2 Sept Means ± SD
Water temp (°C)	21.2±2.6	21.9±3.4	20.8±3.4
pH (S.U.)	8.4±0.1	8.3±0.5	8.2±0.4
Dissolved oxygen (mg/L)	7.1±2.5	7.7±3.1	7.6±3.0
Conductivity (mS/cm)	570±74	526±42	544±37
Secchi transparency (ft)	5.5±2.2	3.0±0.2	5.8±0.3
Chlorophyll-a (µg/L)	0.0±0.0	6.2±7.8	1.7±1.8
Total Kjeldahl nitrogen (mg/L)	1.1±1.0	1.9±2.2	1.2±1.3
Total inorganic nitrogen (mg/L)	0.397±1.0	0.800±1.6	0.484±1.2
Ammonia nitrogen (mg/L)	0.397±1.0	0.700±1.6	0.433±1.2
Nitrate nitrogen (mg/L)	0.100±0.0	0.100±0.0	0.100±0.0
Nitrite nitrogen (mg/L)	0.100±0.0	0.100±0.0	0.100±0.0
Total phosphorus (mg/L)	0.023±0.0	0.024±0.0	0.020±0.0
Ortho-phosphorus (mg/L)	0.012±0.0	0.010±0.0	0.011±0.0
Total suspended solids (mg/L)	10.0±0.0	60.0±136	10.8±1.9

Table 92. Descriptive statistics of all water quality parameters in the Outlet of Lake LeAnn to Mirror Lake for LFA baseline parameters collected in April/May, July, and September of 2021-2022.

Water Quality Parameter	2021 Means ± SD	2022 Means ± SD
Water temp (°C)	22.1±6.7	22.5±4.5
pH (S.U.)	8.6±0.1	8.3±0.3
Dissolved oxygen (mg/L)	10.4±0.2	9.0±1.0
Conductivity (mS/cm)	483±16	601±191
Total Kjeldahl nitrogen (mg/L)	0.7±0.3	0.7±0.3
Total inorganic nitrogen (mg/L)	0.045±0.0	0.100±0.0
Ammonia nitrogen (mg/L)	0.047±0.0	0.019±0.0
Nitrate nitrogen (mg/L)	0.100±0.0	0.100±0.0
Nitrite nitrogen (mg/L)	0.100±0.0	0.100±0.0
Total phosphorus (mg/L)	0.031±0.0	0.034±0.0
Ortho-phosphorus (mg/L)	0.010±0.0	0.020±0.0
Total suspended solids (mg/L)	14.0±6.9	10.0±0.0

II. Drains/CSA's

In 2019, CSA's 1A (S1), 2A (S2), S3, and N4 were sampled as they were flowing. In 2021, CSA's 1A, 2A, 1B, and 2B were sampled as they were flowing. In 2022, CSA's 1A, 2A, 1B, and 2B were also sampled as they were flowing. With three data sets for two of the sites (CSA 1A and CSA 2A), RLS developed trend graphs to demonstrate the changes in key parameters such as total phosphorus (TP) and total inorganic nitrogen (TIN).

CSA 1A has demonstrated a strong decrease in TP and TIN with time (Figures 16-17). CSA 2A has demonstrated a decline in TP but an increase in TIN (Figures 18-19). In 2022, the mean TIN concentrations were also high in 1B and 2B with very high nitrate (NO_3) concentrations. Continued mitigation of these CSA drains is recommended.

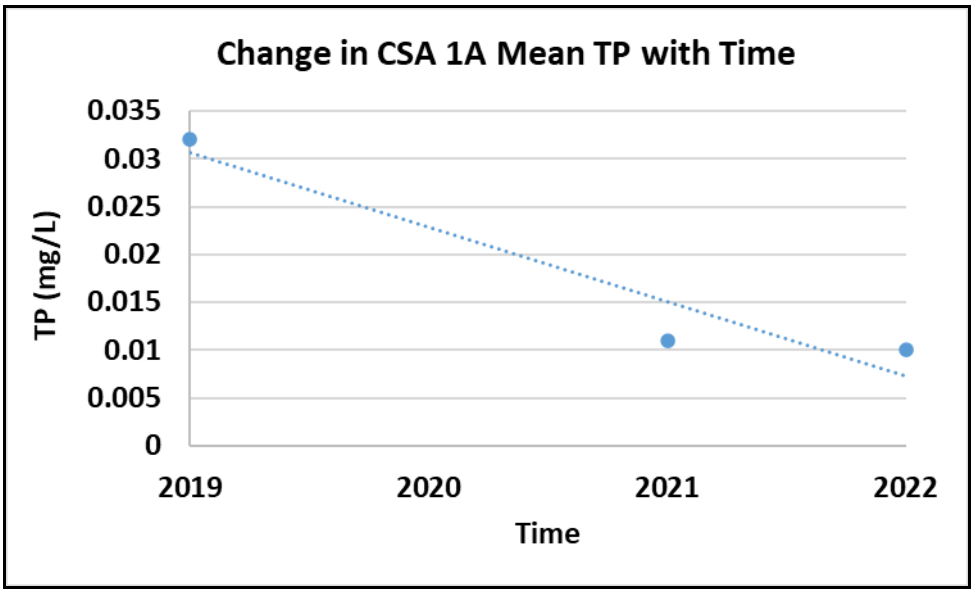

Figure 16. Change in CSA 1A mean TP with time (2019-2022).

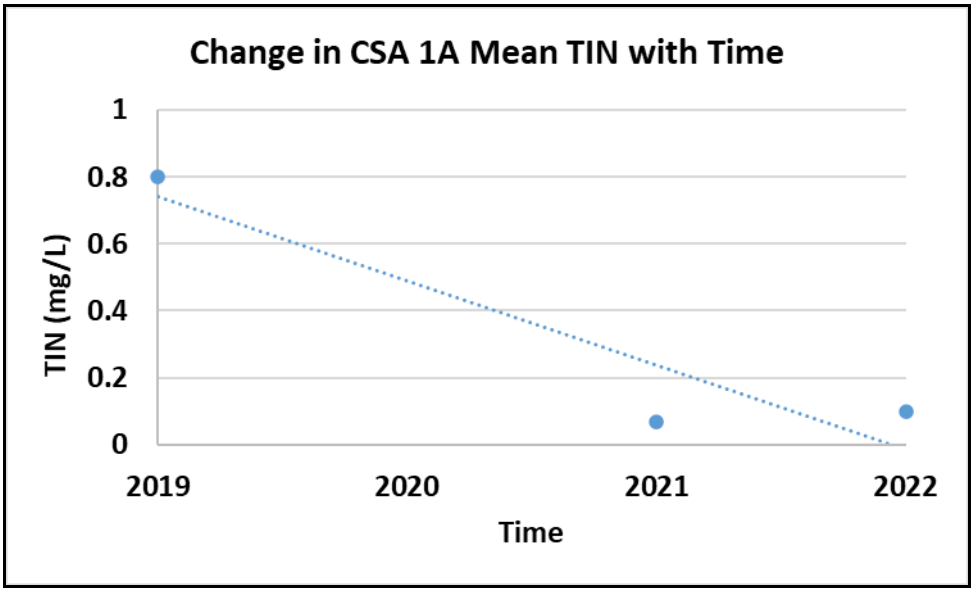

Figure 17. Change in CSA 1A mean TIN with time (2019-2022).

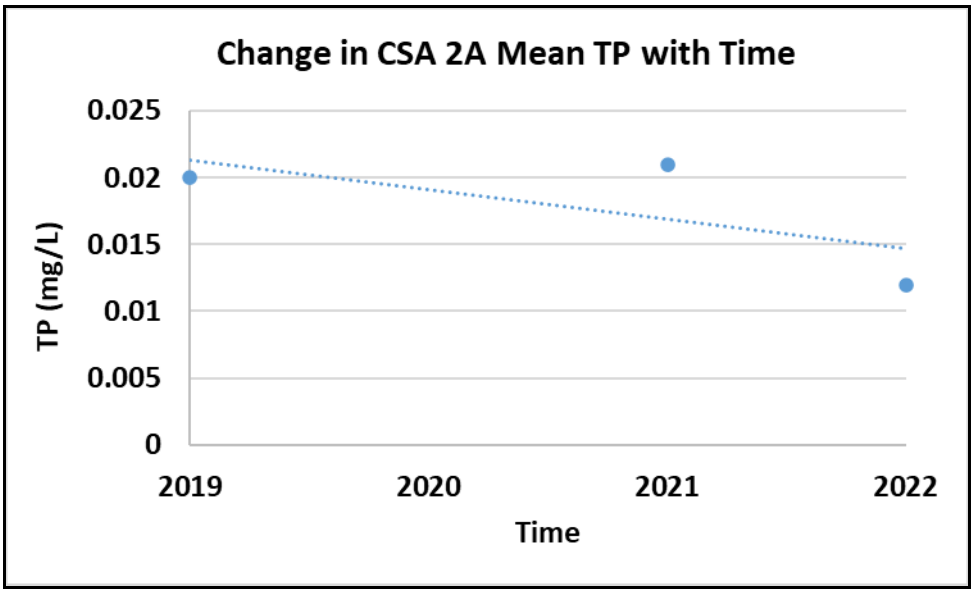

Figure 18. Change in CSA 2A mean TP with time (2019-2022).

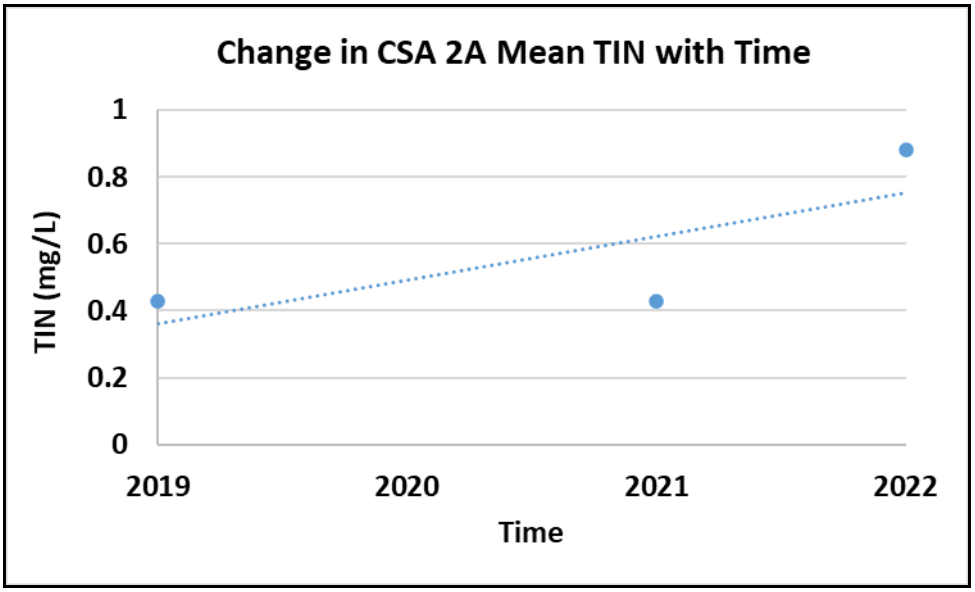

Figure 19. Change in CSA 2A mean TIN with time (2019-2022).

III. Aquatic Vegetation Biovolume

There have been modest reductions in the highest biovolume cover categories (60-80% and >80%) with time in both basins (Tables 93-94). This could be attributed to intensive efforts to reduce canopy invasives such as Eurasian watermilfoil and Curly-leaf Pondweed. It is most beneficial to aim for a goal of increased low-growing cover that allows light to reach the bottom to encourage germination of favorable native aquatic plants.

Table 93. Lake LeAnn north basin aquatic vegetation biovolume by category percent cover of each category (relative cover 2019, 2021-2022).

Biovolume Cover Category	2019 % Relative Cover of Bottom by Category	2021 % Relative Cover by Category	2022 % Relative Cover by Category
<5%	59.7	32.1	56.6
5-20%	15.7	29.1	23.6
20-40%	9.9	19.8	12.6
40-60%	5.5	12.0	5.4
60-80%	3.4	2.0	0.7
>80%	5.7	4.3	1.1

Table 94. Lake LeAnn south basin aquatic vegetation biovolume by category percent cover of each category (relative cover 2019, 2021-2022).

Biovolume Cover Category	2019 % Relative Cover of Bottom by Category	2021 % Relative Cover by Category	2022 % Relative Cover by Category
<5%	58.0	70.3	71.1
5-20%	22.3	22.7	22.1
20-40%	12.3	5.0	4.7
40-60%	3.2	1.0	1.3
60-80%	1.8	0.3	0.3
>80%	2.4	0.6	0.5

IV. Sediment Relative Hardness & Particle Size:

The relative hardness of sediments in the north basin has slightly increased over time and the softest bottom category has decreased slightly over time for both basins (Tables 95-96). This is a favorable outcome. The intermediate categories have remained relatively similar over the years.

Table 95. Lake LeAnn north basin relative hardness of the lake bottom by category or hardness and percent cover of each category (relative cover).

Lake Bottom Relative Hardness Category	2019 Relative Cover %	2021 Relative Cover %	2022 Relative Cover %
0.0-0.1	0.7	0.3	0.2
0.1-0.2	18.4	6.5	5.4
0.2-0.3	48.4	63.6	61.5
0.3-0.4	32.5	29.4	32.7
>0.4	0.01	0.1	0.2

Table 96. Lake LeAnn south basin relative hardness of the lake bottom by category or hardness and percent cover of each category (relative cover).

Lake Bottom Relative Hardness Category	2019 Relative Cover %	2021 Relative Cover %	2022 Relative Cover %
0.0-0.1	0.5	0.0	0.1
0.1-0.2	18.2	8.7	6.1
0.2-0.3	49.9	64.9	63.2
0.3-0.4	31.3	26.4	30.5
>0.4	0.1	0.0	0.1

There has been a significant reduction in sediment % organic matter and % fines for both north and south basins. This is likely due to LFA given the differences.

Table 97. North Basin particle size data (2019, 2021-2022).

Year	% OM	% Gravel	% Sand	% Fines
2019	34±9.3	0.0±0.0	55.6±8.7	44.4±8.7
2021	7.9±15.4	3.5±5.4	74.8±20.6	21.8±22.3
2022	12.6±14.5	1.6±3.6	85.4±11.1	13.0±11.2

Table 98. South Basin particle size data (2019, 2021-2022).

Year	% OM	% Gravel	% Sand	% Fines
2019	22.6±7.9	0.0±0.0	53.7±8.8	46.3±8.8
2021	6.5±9.3	7.5±10.2	74.3±19.4	16.8±20.6
2022	7.3±9.7	19.3±19.2	71.7±15.2	9.0±12.6

V. Phytoplankton:

In the north basin, the green algae declined with time. Given the increase in zooplankton, this could be attributed to increased grazing pressure. The blue-green algae decreased in the north basin in 2021 but increased in 2022. RLS was informed of a discharge of water from the south basin to the north basin from the drain commission. This increased the nutrient levels in September, 2022 which would also have resulted in more algae that was measured. Diatoms, the most favorable algae, increased in 2021 but decreased slightly in 2022.

In the south basin, green algae increased in 2021 but decreased in 2022. The blue-green algae significantly decreased in 2021 and 2022. The diatoms have increased in 2021 and 2022, which is also favorable.

In addition to the phytoplankton data and the chlorophyll-a data referenced above, RLS also began measuring total chlorophyll with a calibrated in situ Turner Designs® fluorimeter. This method is EPA approved and is used to determine concentrations of chlorophyll-a at the surface, since most blue-green algae have gas vacuoles and are buoyant on the lake surface. RLS has found that even with proper sampling methods for chlorophyll-a laboratory methods, in situ numbers can be much higher.
This is because the laboratory chlorophyll-a method measures the pigment in a composite sample.

If the majority of the algae is at the surface and the samples are homogenized, then there is a higher chance that chlorophyll-a will remain undetected or low. The in situ data in Tables 99-100 clearly show a decline in chlorophyll-a over time since LFA began.

Table 99. Lake LeAnn North Basin in situ chlorophyll-a concentrations (2021-2022).

Sampling Location	July 19, 2021	May 10, 2022	July 12, 2022	September 15, 2022
North #1	28	3	12	6
North #2	20	3	12	9
North #3	25	2	17	9
North #4	20	NA	5	7
North #5	20	3	10	9
MEAN	**22.6**	**2.8**	**11.2**	**8**

Table 100. Lake LeAnn South Basin in situ chlorophyll-a concentrations (2021-2022).

Sampling Location	19 July 2021	10 May 2022	12 July 2022	15 September 2022
South #1	38	2	7	6
South #2	35	4	8	8
South #3	38	4	6	5
South #4	33	5	8	5
South #5	35	4	6	7
MEAN	**35.8**	**3.8**	**7.0**	**6.2**

V1. Zooplankton:

The total number of zooplankton present has overall increased since LFA began with an increase in the total number of different taxa as well (Table 101). RLS noted a reduction in the green algae in the north basin in 2022 which may be attributed to increased grazing pressures. Zooplankton prefer diatoms and small green algae over blue-green algae, so if the favorable taxa are present amongst blue-green algae, they will likely be selected by the zooplankton as the best food sources.

Table 101. Lake LeAnn total zooplankton counts and number of different taxa 2019, 2021-2022.

Year	North Basin Total South	North Basin Total # Taxa	South Basin Total Count	South Basin Total # Taxa
2019	136	8	162	7
2021	150	8	116	8
2022	327	11	326	9

VII. Management Recommendations for 2023:

Continued whole-lake surveys and targeted control of the invasive Eurasian Watermilfoil, Curly-leaf Pondweed, and Starry Stonewort are needed to allow for germination and colonization of native aquatic plant species to improve biodiversity in Lake LeAnn. The Eurasian Watermilfoil in particular was showing strong signs of herbicide resistance and thus the new systemic herbicide ProcellaCOR® was used in 2022 given its evaluated efficacy and longer-lasting control. RLS was present to oversee the herbicide applications with very little milfoil remaining at the end of 2022. Care must be taken to avoid removal of too much aquatic vegetation as this can exacerbate blue-green algal blooms by allowing for less competition from plants for nutrients.

The current BioBlast® bioaugmentation methodology is uncertain. RLS is cautious about the inability of this solution to effectively reduce blue-green algal blooms and thus another bioaugmentation control agent may be necessary. This is being discussed with the LLPOA for consideration.

As previously stated, RLS encourages the LLPOA to work with its residents to follow lakeshore best management practices (BMP's) such as proper annual inspection and pumping of septic systems and drain fields, protection of lakeshore emergent vegetation, preventing usage of lawn fertilizers and watering with lake water instead, and public education and outreach. If nutrient loads to the lake are not reduced, the efficacy of the LFA system will be reduced. Additionally, if the 2023 data do not show additional improvements, especially reductions in chlorophyll-a and increases in Secchi transparency, then the LLPOA may have to consider application of a nutrient inactivation method such as Phoslock® to reduce these blooms. Such a solution, however, is not sustainable as it will have to be applied many times through the years. Lastly, consideration should be given to avoiding the use of large wake boats on the lake. The lake is too irregular and shallow and sediment resuspension will continue to occur. This creates less clear water and also drives nutrients locked in the sediments into the water column that are then utilized by algae for increased growth.

APPENDIX A

LAKE LEANN 2022 FIELD DATA SHEETS

APPENDIX B

LAKE LEANN 2022 LABORATORY REPORTS