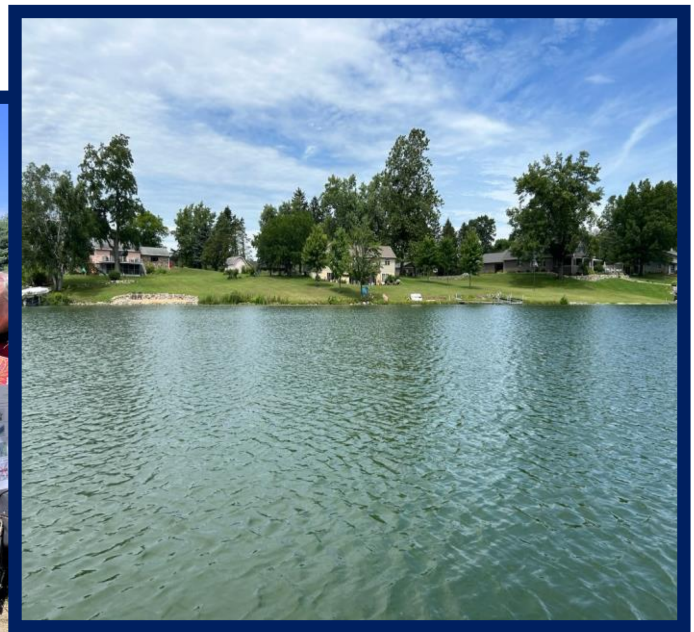
Lake LeAnn 2024 LFA
Evaluation Data, Conclusions to Date, and 2025 Management Recommendations
Hillsdale County, Michigan



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1.0 2024 EXECUTIVE SUMMARY

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 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, 2024 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 2024 evaluation, 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. In 2024, there was one sizeable herbicide treatment to address both the EWM and CLP. 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. Cyanobacteria blooms have been prevalent in the lakes and thus in situ measurements of chlorophyll-a have been conducted to measure the changes in this algae with time. Previous treatments for blue-green algal blooms have included chelated copper, Phycomycin, and peroxide-based products.

It may take years 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 have applied for permits through EGLE to place biochar filters in the key problematic drains, but they will not allow these filters in the drains that they have classified as wetlands, despite numerous data that show these drains are contributing nutrients to the lakes. Modifications to the bottom-placed char filters are currently being explored for 2025.

RLS and the LLPOA are working diligently with Lake LeAnn property owners to reduce nutrient 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. This is especially true for the north basin. Currently, only two locations in the south basin (#4 and #5) have dissolved oxygen depletion. The northern region of the north basin is experiencing nearshore internal loading from lawn fertilizers and septic leachate. RLS recommends that all of those properties cease the use of fertilizers or consider using special products designed to keep the nutrients locked in the root zones and not prone to runoff. Literature on those recommended products are being distributed by the LLPOA for dissemination to the public.

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. In 2024, only CSA #1A, #1B, #2A, and #2B were flowing during sampling events with #4A flowing only in the spring. The efficacy of the LFA system will be reduced if such loads are not also reduced over time. Currently, due to low runoff conditions and some mitigation to these drains, the TP and TIN has declined in all of these four drains, which is favorable.

The LFA system has reduced some soft lake bottom, but this will change each year, dependent upon the quantity of vegetation that grows and decays and contributes soft organic deposits to the lake bottom.

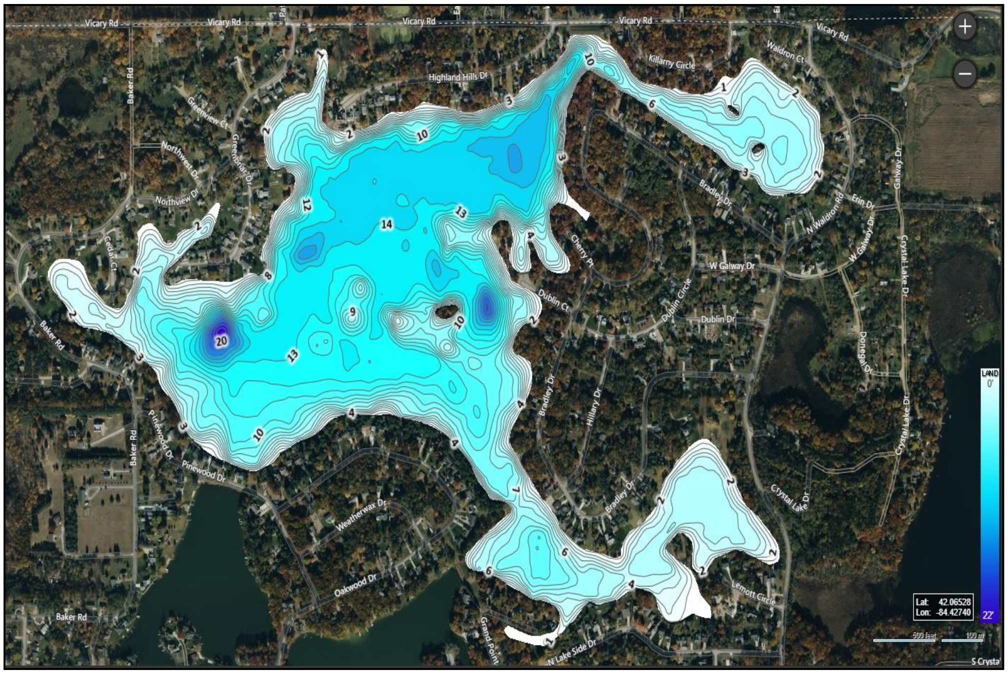

Figure 1. Lake LeAnn (north basin) depth contour map (RLS, 2024).

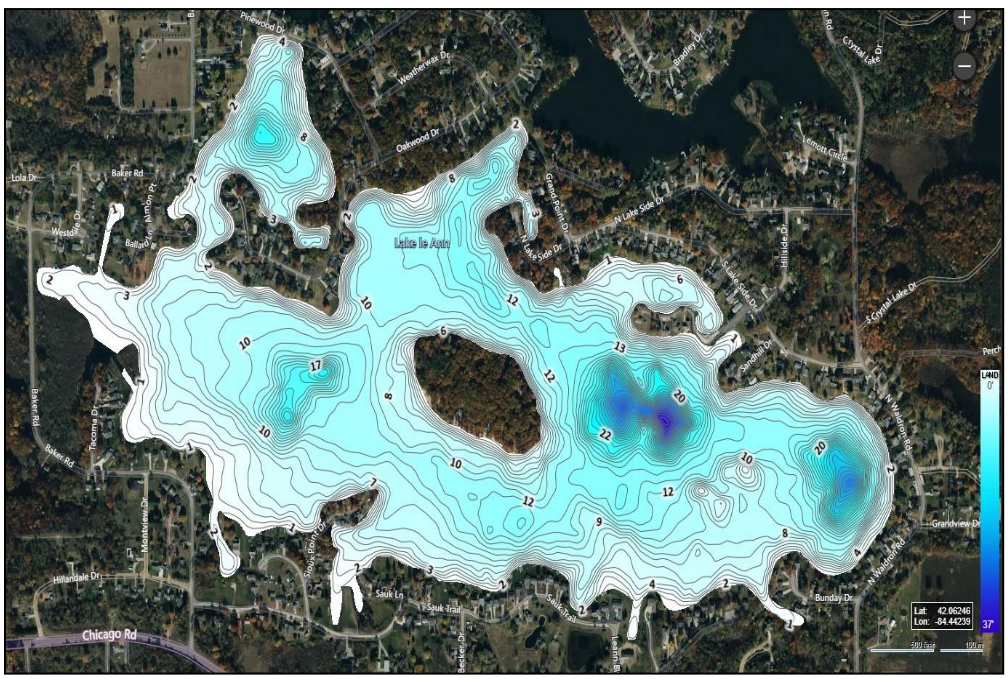

Figure 2. Lake LeAnn (south basin) depth contour map (RLS, 2024).

1.1 Summary of Lake LeAnn Aeration Operations:

This report provides data for the determination of aeration efficacy 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 2022-2024. 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. The in situ method was used in 2023-2024 to measure the changes in the surface blooms.

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 2024 SAMPLING METHODS & PARAMETERS

Restorative Lake Sciences sampled 10 locations in 2024 (5 in the south basin and 5 in the north basin) as well as the drains entering both basins. The sampling scope in 2024 was reduced with physical parameters such as depth, water temperature, dissolved oxygen, pH, conductivity, and Secchi transparency that were collected at 0.5-meter increments and throughout the water column profile. Chemical water quality parameters such as total phosphorus, total inorganic nitrogen, and in situ chlorophyll-a measured in all N=10 locations of the north and south basins. A bottom hardness scan and biovolume scan was conducted for both basins.

Additionally, all CSA's were evaluated for flow and sampled for all physical parameters including flow as well as total phosphorus, ortho-phosphorus, total inorganic nitrogen, total Kjeldahl nitrogen, and total suspended solids.

The basin samples and the CSA samples were collected on May 7, 2024, July 2, 2024, and September 9, 2024. All sampling location maps for the lake basins and drains are shown below in Figures 3-4.

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. 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.

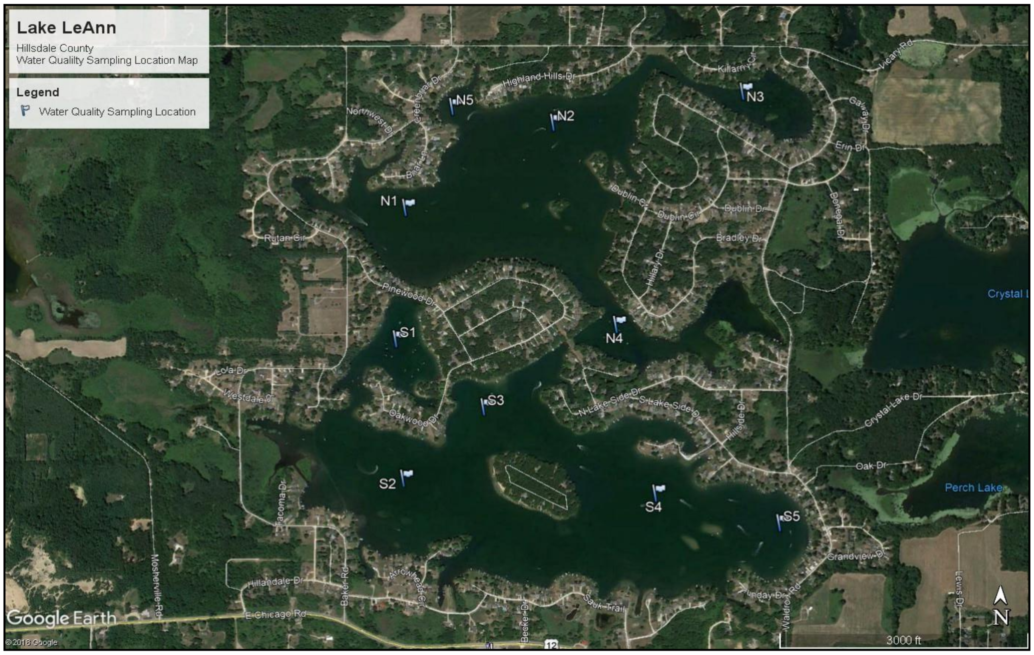

Figure 3. 2021-2024 water quality sampling locations on Lake LeAnn.

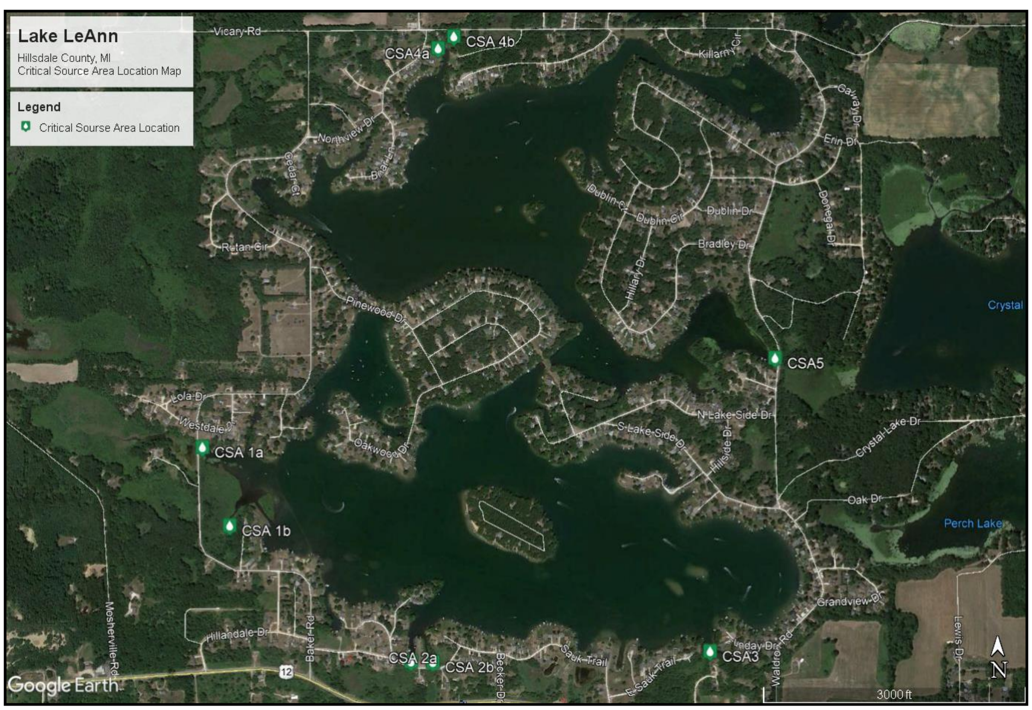

Figure 4. 2019-2024 drain sampling locations on Lake LeAnn.

3.0 LAKE LEANN 2024 WATER QUALITY SAMPLING RESULTS

All 2024 deep basin physical water quality data is shown in Tables 1-6. 2024 chemical water quality data is shown in Tables 7-12. 2024 CSA drain physical and chemical water quality data is shown below in Tables 13-15. 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 2024 Deep Basin Chemical Water Quality Data Tables:

Table 1. Lake LeAnn north basin May 7, 2024 physical water quality data.

Site	Depth (m)	Temp °C	DO (mg/L)	pH (S.U.)	Cond (mS/cm)
1 North	0	18.1	9.9	8.9	511
	0.5	18.1	10.3	8.9	511
	1	18.1	10.3	8.9	511
	1.5	18.1	10.4	8.9	511
	2	18.1	10.5	9	511
	2.5	18.1	10.5	9	511
	3	18.1	10.6	9	511
	3.5	18.1	10.6	9	511
	4	18.1	10.5	9	511
	4.5	18	10.5	9	511
	5	18	10.4	9	510
	5.5	18	10.4	9	510
	6	18	10.3	9	510
	6.5	17.9	10.1	8.9	510
2 North	0	18.1	10	8.9	512
	0.5	18.1	10	8.9	513
	1	18.1	10	8.9	513
	1.5	18.1	10	8.9	512
	2	18	10	8.9	512
	2.5	18	10.0	8.9	512
	3	18	10.0	8.9	512
	3.5	18	9.9	8.9	512
	4	18	9.9	8.9	512
	4.5	18	9.9	8.9	512
3 North	0	19.3	11.3	9.2	469

	0.5	**19.3**	**11.6**	**9.2**	**469**
	1	**19**	**11.9**	**9.2**	**465**
	1.5	**18.8**	**11.9**	**9.2**	**465**
	2	**18.6**	**11.9**	**9.2**	**466**
4 North	**0**	**18.9**	**11.4**	**9.1**	**493**
	0.5	**18.9**	**12.2**	**9.2**	**492**
	1	**18.6**	**12.5**	**9.2**	**489**
	1.5	**18.2**	**13**	**9.2**	**484**
	2	**18**	**13.4**	**9.2**	**488**
	2.5	**17.9**	**13.4**	**9.1**	**491**
	3	**17.3**	**13.1**	**8.7**	**520**
5 North	**0**	**18.5**	**10.8**	**9**	**509**
	0.5	**18.4**	**11.2**	**9**	**509**
	1	**18.4**	**11.3**	**9**	**509**
	1.5	**18.2**	**11.4**	**9**	**508**
	2	**18.2**	**11.5**	**9**	**507**
	2.5	**18.2**	**11.7**	**9.1**	**511**
	3	**18**	**12**	**9**	**510**
	MEAN	**18.2**	**11.0**	**9.0**	**503**
	STD DEV	**0.4**	**1.0**	**0.1**	**15**

Table 2. Lake LeAnn south basin May 7, 2024 physical water quality data.

Site	Depth (m)	Temp °C	DO (mg/L)	pH (S.U.)	Cond (mS/cm)	TDS (mg/L)
1 South	**0**	**18.6**	**9.0**	**8.8**	**546.7**	**349.8**
	0.5	**18.6**	**9.0**	**8.9**	**546.7**	**349.8**
	1	**18.6**	**9.0**	**8.9**	**546.6**	**349.8**
	1.5	**18.6**	**9.0**	**8.9**	**546.6**	**349.8**
	2	**18.6**	**9.0**	**8.9**	**546.6**	**349.8**
	2.5	**18.6**	**9.0**	**8.9**	**546.7**	**349.9**
	3	**18.6**	**9.0**	**8.9**	**546.6**	**349.8**
	3.5	**18.6**	**9.0**	**8.9**	**546.5**	**349.8**
	4	**18.6**	**9.0**	**8.9**	**546.6**	**349.8**
	4.5	**18.6**	**9.0**	**8.9**	**546.6**	**349.8**
	5	**18.5**	**9.1**	**8.9**	**546.5**	**349.8**

	5.5	**18.5**	**9.1**	**8.9**	**546.5**	**349.8**
	6	**17.7**	**8.2**	**8.9**	**556.8**	**356.5**
2 South	**0**	**18.1**	**9.2**	**8.8**	**553.4**	**354**
	0.5	**18.1**	**9.3**	**8.9**	**553.2**	**354**
	1	**18.1**	**9.4**	**8.9**	**553.4**	**354.1**
	1.5	**18.1**	**9.4**	**8.9**	**553.2**	**354.1**
	2	**18.1**	**9.4**	**8.9**	**553.4**	**354.2**
	2.5	**18.1**	**9.4**	**8.9**	**553.4**	**354.1**
	3	**18.1**	**9.4**	**8.9**	**553.3**	**354**
	3.5	**18.1**	**9.4**	**8.9**	**553.8**	**354.1**
	4	**18.0**	**9.4**	**8.9**	**553.2**	**354.1**
	4.5	**18.0**	**9.4**	**8.9**	**553.3**	**354**
	5	**18.0**	**9.4**	**8.9**	**553.3**	**354**
	5.5	**18.0**	**9.4**	**8.9**	**553.2**	**354.1**
	6	**18.1**	**9.4**	**8.9**	**553.3**	**354.1**
	6.5	**18.0**	**9.4**	**8.9**	**553.2**	**354**
	7	**17.9**	**9.4**	**8.9**	**553.3**	**354.1**
3 South	**0**	**18.2**	**9.4**	**8.9**	**553.8**	**354.3**
	0.5	**18.2**	**9.5**	**8.9**	**553.7**	**354.3**
	1	**18.2**	**9.6**	**8.9**	**553.5**	**354.3**
	1.5	**18.2**	**9.6**	**8.9**	**553.6**	**354.3**
	2	**18.2**	**9.6**	**8.9**	**553.6**	**354.3**
	2.5	**18.2**	**9.6**	**8.9**	**553.5**	**354.2**
	3	**18.2**	**9.6**	**8.9**	**553.5**	**354.1**
4 South	**0**	**18.2**	**9.3**	**8.9**	**552.8**	**353.8**
	0.5	**18.2**	**9.3**	**8.9**	**553**	**353.8**
	1	**18.2**	**9.3**	**8.9**	**553**	**353.8**
	1.5	**18.2**	**9.3**	**8.9**	**553**	**353.9**
	2	**18.2**	**9.3**	**8.9**	**552.9**	**353.9**
	2.5	**18.2**	**9.3**	**8.9**	**552.8**	**353.9**
	3	**18.2**	**9.3**	**8.9**	**553**	**353.9**
	3.5	**18.2**	**9.3**	**8.9**	**553**	**353.9**
	4	**18.2**	**9.3**	**8.9**	**553**	**353.9**
	4.5	**18.2**	**9.3**	**8.9**	**552.9**	**353.8**
	5	**18.1**	**9.3**	**8.9**	**552.9**	**353.9**
	5.5	**17.9**	**9.4**	**8.9**	**554.2**	**354.7**
	6	**17.2**	**9.5**	**8.8**	**556.3**	**356**
	6.5	**16.2**	**9.5**	**8.8**	**556.5**	**356.4**
	7	**14.6**	**9.1**	**8.7**	**558.5**	**357**

	7.5	**13.3**	**8.7**	**8.5**	**559.1**	**357.6**
	8	**12.8**	**8.6**	**8.1**	**561.8**	**359.7**
	8.5	**12.2**	**8.5**	**7.6**	**561.3**	**359.2**
	9	**11.8**	**6.8**	**8.4**	**562.7**	**360.5**
	9.5	**11.7**	**5.0**	**8.3**	**563.9**	**361**
	10	**11.6**	**2.9**	**8.3**	**565.2**	**361.6**
	10.5	**11.5**	**2.4**	**8.2**	**566**	**362.2**
	11	**11.5**	**2.0**	**8.2**	**567.9**	**362.8**
	11.5	**11.5**	**0.3**	**8.2**	**566.4**	**362.5**
	12	**11.4**	**0.2**	**8.2**	**568.4**	**363.7**
5 South	**0**	**18.1**	**9.2**	**8.9**	**552.3**	**353.6**
	0.5	**18.0**	**9.2**	**8.9**	**553.1**	**354**
	1	**18.1**	**9.2**	**8.9**	**553.3**	**354.1**
	1.5	**18.1**	**9.2**	**8.9**	**553.4**	**354.1**
	2	**18.1**	**9.2**	**8.9**	**553.3**	**354.1**
	2.5	**18.0**	**9.2**	**8.9**	**553.4**	**354.2**
	3	**18.0**	**9.2**	**8.9**	**553.3**	**354.1**
	3.5	**18.0**	**9.2**	**8.9**	**553.4**	**354.1**
	4	**17.9**	**9.2**	**8.9**	**553.3**	**354.1**
	4.5	**17.9**	**9.2**	**8.9**	**553.1**	**354.1**
	5	**17.8**	**9.2**	**8.9**	**553.6**	**354.4**
	5.5	**17.8**	**9.1**	**8.9**	**553.6**	**354.3**
	6	**15.3**	**9.1**	**8.9**	**558.2**	**358.8**
	6.5	**13.5**	**9.0**	**8.6**	**560.1**	**359.2**
	7	**12.6**	**8.4**	**8.5**	**556.9**	**360.3**
	7.5	**11.8**	**7.9**	**8.5**	**561.8**	**359.7**
	8	**11.5**	**7.1**	**8.3**	**564.4**	**361.3**
	8.5	**11.2**	**6.1**	**8.2**	**566.3**	**362.3**
	9	**11.3**	**4.4**	**8.2**	**567.7**	**364.1**
	MEAN	**16.8**	**8.5**	**8.8**	**555**	**355**
	STD DEV	**2.6**	**2.0**	**0.3**	**6**	**4**

Table 3. Lake LeAnn north basin July 2, 2024 physical water quality data.

Site	Depth (m)	Temp °C	DO (mg/L)	pH (S.U.)	Cond (mS/cm)
1 North	0	25.2	8.9	9	489
	0.5	25.2	8.9	9	488
	1	25.1	8.9	8.9	488
	1.5	25.1	8.8	9	488
	2	25.1	8.8	9	489
	2.5	24.8	8.8	8.9	488
	3	24.8	8.5	8.9	488
	3.5	24.8	8.4	8.9	489
	4	24.8	8.1	8.9	489
	4.5	24.8	8	8.9	489
	5	24.7	8	8.8	490
	5.5	24.7	7.8	8.8	491
	6	24.7	7.7	8.7	491
	6.5	24.6	7.5	8.7	492
	7	24.3	6.1	7.6	514
2 North	0	25	8.7	8.9	487
	0.5	25.1	8.6	8.9	487
	1	25.1	8.8	9	487
	1.5	25.1	8.8	9	487
	2	25.1	8.8	9	486
	2.5	25.1	8.8	9	486
	3	24.9	8.6	8.9	486
	3.5	24.8	8.6	8.9	486
	4	24.8	8.4	8.9	486
	4.5	24.7	8.3	8.9	487
3 North	0	25.5	8.5	8.7	483
	0.5	25.5	8.7	8.7	483
	1	25.3	8.7	8.7	482
	1.5	25.3	8.7	8.7	483
	2	25.1	8.8	8.7	482
	2.5	25	8.6	8.7	482
	3	24.6	7.3	8	485
4 North	0	25.3	9.5	8.8	470
	0.5	25.3	10.1	8.8	477

	1	**25.2**	**10.3**	**8.9**	**477**
	1.5	**24.9**	**10.3**	**8.9**	**480**
	2	**24.8**	**10.2**	**9**	**482**
	2.5	**24.4**	**9.9**	**8.8**	**484**
	3	**24.3**	**9.3**	**8.6**	**487**
5 North	**0**	**25.4**	**9**	**9**	**488**
	0.5	**25.4**	**9.1**	**9**	**487**
	1	**25.4**	**9.1**	**9**	**488**
	1.5	**25.4**	**9.2**	**9**	**487**
	2	**25.4**	**9.2**	**9**	**488**
	2.5	**25.3**	**9.1**	**9**	**488**
	MEAN	**25.0**	**8.7**	**8.8**	**486**
	STD DEV	**0.3**	**0.8**	**0.3**	**6**

Table 4. Lake LeAnn south basin July 2, 2024 physical water quality data.

Site	Depth (m)	Temp °C	DO (mg/L)	pH (S.U.)	Cond (mS/cm)	TDS (mg/L)
1 South	0	25.2	8.7	8.7	515.1	329.7
	0.5	25.3	8.7	8.7	515.2	329.6
	1	25.2	8.7	8.7	514.9	329.5
	1.5	25.1	8.8	8.7	514.5	329.2
	2	25.0	8.8	8.7	514.3	329.5
	2.5	24.9	8.8	8.8	513.9	328.8
	3	24.8	8.8	8.7	513.7	328.7
	3.5	24.7	8.8	8.7	513.8	328.8
	4	24.7	8.7	8.7	514.4	329.2
	4.5	24.7	8.6	8.7	515.6	330
	5	24.7	8.5	8.6	516.7	330.7
	5.5	23.7	6.2	7.9	530	339.9
	6	21.9	3.2	7.4	561	359.3
	6.5	20.5	1.2	7.2	592.7	378.8
	7	19.5	0.4	7.0	646.1	413.5
	7.5	19.5	0.2	7	648.7	414.7
2 South	0	24.5	8.6	8.6	528.3	337.6
	0.5	24.5	8.5	8.6	527.2	337.4
	1	24.6	8.5	8.7	526.9	337
	1.5	24.6	8.6	8.7	528	337.8
	2	24.5	8.6	8.6	528.7	338.3
	2.5	24.5	8.5	8.6	528.9	338.5
	3	24.5	8.5	8.6	528.8	338.5
	3.5	24.4	8.5	8.6	529	338.5
	4	24.5	8.5	8.6	528.8	338.5
	4.5	24.4	8.5	8.7	528.9	338.5
	5	24.4	8.5	8.7	529.1	338.6
	5.5	24.4	8.5	8.6	529.5	338.7
	6	24.4	8.3	8.6	529.8	339.1
	6.5	24.2	8.2	8.6	530	339.2
	7	24.2	7.9	8.5	529.7	339
3 South	0	25.0	8.6	8.7	525.9	336.6
	0.5	25.0	8.7	8.7	526.7	336.7
	1	25.0	8.7	8.7	525.9	336.6

	1.5	**24.9**	**8.7**	**8.7**	**526.1**	**336.6**
	2	**24.9**	**8.8**	**8.7**	**525.8**	**336.5**
	2.5	**24.6**	**8.8**	**8.7**	**524.9**	**335.9**
	3	**24.6**	**8.8**	**8.7**	**525**	**335.9**
	3.5	**24.6**	**9.0**	**8.7**	**524.9**	**336**
4 South	**0**	**25.0**	**8.6**	**8.7**	**525.7**	**336.5**
	0.5	**25.0**	**8.7**	**8.7**	**525.7**	**336.4**
	1	**24.9**	**8.7**	**8.7**	**525.7**	**336.4**
	1.5	**24.9**	**8.7**	**8.7**	**525.5**	**336.3**
	2	**24.9**	**8.7**	**8.7**	**525.6**	**336.4**
	2.5	**24.8**	**8.7**	**8.7**	**525.6**	**336.4**
	3	**24.8**	**8.7**	**8.7**	**525.4**	**336.3**
	3.5	**24.8**	**8.7**	**8.7**	**525.5**	**336.3**
	4	**24.7**	**8.7**	**8.7**	**525.6**	**336.4**
	4.5	**24.5**	**8.5**	**8.7**	**525.3**	**336.2**
	5	**24.5**	**8.4**	**8.7**	**525.4**	**336.1**
	5.5	**24.4**	**8.4**	**8.7**	**525.3**	**336.1**
	6	**24.3**	**8.4**	**8.6**	**527.4**	**337.5**
	6.5	**23.1**	**7.3**	**8.1**	**535.8**	**342.8**
	7	**20.8**	**1.4**	**7.8**	**540.7**	**345.5**
	7.5	**20.0**	**0.6**	**7.7**	**542.4**	**347.2**
	8	**19.0**	**0.3**	**7.7**	**550.5**	**352.4**
	8.5	**17.8**	**0.2**	**7.6**	**560**	**358.3**
	9	**16.1**	**0.1**	**7.5**	**574.4**	**368.7**
	9.5	**14.7**	**0.1**	**7.5**	**587.1**	**375.8**
	10	**13.5**	**0.04**	**7.5**	**593**	**379.7**
	10.5	**12.6**	**0.03**	**7.4**	**598.7**	**383**
	11	**12.2**	**0.03**	**7.4**	**603.4**	**386**
	11.5	**12.0**	**0.03**	**7.3**	**608.3**	**389.3**
	12	**11.8**	**0.03**	**7.3**	**615.1**	**393.8**
5 South	**0**	**24.8**	**8.5**	**8.7**	**525.9**	**336.5**
	0.5	**24.9**	**8.5**	**8.7**	**526**	**336.6**
	1	**24.7**	**8.5**	**8.7**	**525.8**	**336.5**
	1.5	**24.7**	**8.5**	**8.7**	**525.8**	**336.5**
	2	**24.7**	**8.5**	**8.7**	**525.6**	**336.4**
	2.5	**24.7**	**8.5**	**8.7**	**525.6**	**336.4**
	3	**24.6**	**8.5**	**8.7**	**525.6**	**336.4**
	3.5	**24.5**	**8.5**	**8.6**	**525.9**	**336.6**
	4	**24.5**	**8.3**	**8.7**	**525.7**	**336.5**

	4.5	**24.4**	**8.22**	**8.7**	**525.7**	**336.4**
	5	**24.4**	**8.19**	**8.7**	**525.8**	**336.5**
	5.5	**24.4**	**8.13**	**8.7**	**525.4**	**336.2**
	6	**24.3**	**8.21**	**8.7**	**525.6**	**336.4**
	6.5	**24.0**	**7.9**	**8.5**	**528.9**	**338.4**
	7	**22.9**	**6.95**	**7.9**	**538.9**	**345**
	7.5	**18.8**	**3.22**	**7.5**	**560.3**	**358.8**
	8	**17.0**	**1.34**	**7.4**	**579.9**	**372**
	8.5	**15.3**	**0.42**	**7.3**	**599.3**	**382.5**
	9	**14.4**	**0.2**	**7.3**	**612.6**	**392.5**
	9.5	**13.4**	**0.1**	**7.1**	**639.4**	**409**
	MEAN	**22.8**	**6.6**	**8.3**	**541**	**346**
	STD DEV	**4.0**	**3.4**	**0.6**	**32**	**21**

Table 5. Lake LeAnn north basin September 9, 2024 physical water quality data.

Site	Depth (m)	Temp °C	DO (mg/L)	pH (S.U.)	Cond (mS/cm)
1 North	0	21.3	9.3	9	480
	0.5	21.3	9.5	9	480
	1	21.3	9.5	9	480
	1.5	21.3	9.5	9	480
	2	21.2	9.5	9	480
	2.5	21.2	9.5	9	480
	3	21.1	9.5	9	480
	3.5	20.9	9.3	8.9	482
	4	20.9	8.9	8.9	482
	4.5	20.9	8.8	8.9	481
	5	20.8	8.8	8.9	483
	5.5	20.8	8.8	8.8	484
	6	20.5	8.5	8.8	484
	6.5	20.5	8.4	8.8	484
	7	20.5	7	8.7	484
2 North	0	21.6	9.8	9.2	478
	0.5	21.6	10	9.2	478
	1	21.5	10.2	9.2	478
	1.5	21.5	10.2	9.2	478
	2	21.4	10.3	9.2	478
	2.5	21.4	10.2	9.1	479
	3	21.3	10.1	9.1	479
	3.5	21.3	10	9.1	479
	4	21.3	10	9.1	479
	4.5	21.2	9.9	9.1	480
3 North	0	21.1	9.5	9.4	469
	0.5	21	10.4	9.4	468
	1	21	11.1	9.4	468
	1.5	20.6	11.4	9.4	467
	2	20.4	11.3	9.4	467
4 North	0	21.3	9.4	9.1	484
	0.5	20.9	10.1	9.2	485
	1	20.8	10.3	9.2	485

	1.5	**20.8**	**10.5**	**9.2**	**485**
	2	**20.7**	**10.7**	**9.2**	**484**
	2.5	**20.3**	**10.8**	**9.2**	**486**
	3	**20**	**10.5**	**9.1**	**487**
5 North	**0**	**21.9**	**9.8**	**9.2**	**479**
	0.5	**21.7**	**10.4**	**9.2**	**478**
	1	**21.5**	**10.7**	**9.2**	**478**
	1.5	**21.3**	**10.6**	**9.2**	**478**
	2	**21.2**	**10.5**	**9.1**	**479**
	2.5	**21.2**	**10.1**	**9.2**	**478**
	3	**21.2**	**10.1**	**9.2**	**478**
	MEAN	**21.1**	**9.9**	**9.1**	**479**
	STD DEV	**0.4**	**0.8**	**0.2**	**5**

Table 6. Lake LeAnn <u>south basin</u> September 9, 2024 physical water quality data.

Site	Depth (m)	Temp °C	DO (mg/L)	pH (S.U.)	Cond (mS/cm)	TDS (mg/L)
1 South	0	22.0	9.1	9	497.6	318.6
	0.5	22.0	9.2	9.0	497.6	318.3
	1	21.9	9.3	9.0	497.4	318.4
	1.5	21.9	9.3	9.1	497.4	318.2
	2	21.8	9.3	9.1	497.4	318.1
	2.5	21.4	9.4	9.1	496.5	317.7
	3	21.3	9.4	9.1	496.3	317.6
	3.5	21.3	9.4	9.1	496.3	317.6
	4	21.2	9.4	9.1	496.8	317.9
	4.5	21.1	9.3	9.1	497.1	318.7
	5	21.0	9.3	9.1	499.7	319.8
	5.5	21.0	9.3	9.0	501	320.4
	6	21.0	9.3	9.0	501.4	321
	6.5	20.9	8.6	8.8	586.3	344.6
2 South	0	21.0	8.9	9.0	513.7	328.7
	0.5	21.0	9.3	9.0	513.6	328.7
	1	21.0	9.3	9.0	513.6	328.7
	1.5	21.0	9.3	9.0	513.6	328.6
	2	21.0	9.3	9.0	513.6	328.6
	2.5	21.0	9.3	9.0	513.6	328.6
	3	21.0	9.3	9.0	513.5	328.6
	3.5	20.9	9.3	9.0	513.6	328.6
	4	21.0	9.3	9.0	513.6	328.7
	4.5	21.0	9.3	9.0	513.6	328.7
	5	21.0	9.2	9.0	513.6	328.7
	5.5	20.9	9.2	9.0	513.4	328.7
	6	20.8	9.2	9.0	513.6	328.8
3 South	0	21.3	9.1	9.0	513.3	328.7
	0.5	21.3	9.1	9.0	513.6	328.7
	1	21.2	9.2	9.0	513.5	328.7
	1.5	21.1	9.2	9.0	513.7	328.8
	2	21.0	9.2	9.0	513.7	328.8
	2.5	20.9	9.1	9.0	513.9	328.9
	3	20.8	8.9	9.0	514	328.9

4 South	**0**	**21.2**	**9.2**	**9.1**	**513.8**	**328.8**
	0.5	**21.2**	**9.2**	**9.0**	**513.7**	**328.7**
	1	**21.2**	**9.1**	**9.0**	**513.8**	**328.7**
	1.5	**21.1**	**9.1**	**9.0**	**513.9**	**328.8**
	2	**21.1**	**9.1**	**9.0**	**513.8**	**328.8**
	2.5	**21.1**	**9.1**	**9.0**	**513.7**	**328.8**
	3	**21.1**	**9.1**	**9.0**	**513.7**	**328.7**
	3.5	**21.1**	**9.1**	**9.0**	**513.9**	**328.8**
	4	**21.1**	**9.1**	**9.0**	**513.8**	**328.9**
	4.5	**21.1**	**9.1**	**9.0**	**513.9**	**328.7**
	5	**21.1**	**9.0**	**9.0**	**513.9**	**328.9**
	5.5	**21.1**	**9.0**	**9.0**	**513.9**	**328.9**
	6	**21.0**	**9.0**	**9.0**	**513.9**	**329**
	6.5	**20.8**	**9.0**	**8.9**	**516**	**330.2**
	7	**20.8**	**8.8**	**8.9**	**516.5**	**330.4**
	7.5	**20.7**	**8.7**	**8.9**	**516.9**	**330.8**
	8	**20.7**	**8.7**	**8.8**	**517.6**	**331.2**
	8.5	**20.6**	**8.5**	**8.8**	**518.8**	**332.2**
	9	**20.5**	**8.5**	**8.7**	**520.8**	**333.3**
	9.5	**20.2**	**8.4**	**8.5**	**523.3**	**334.2**
	10	**14.4**	**4.8**	**7.1**	**645.6**	**412.6**
	10.5	**13.5**	**3.4**	**7.0**	**665**	**425.7**
	11	**13.2**	**2.1**	**7.0**	**675.8**	**431.8**
	11.5	**13.0**	**1.3**	**7.0**	**681.5**	**436.4**
5 South	**0**	**21.3**	**9.3**	**9.0**	**513.8**	**328.7**
	0.5	**21.2**	**9.23**	**9.0**	**513.9**	**328.8**
	1	**21.3**	**9.3**	**9.0**	**513.7**	**328.8**
	1.5	**21.3**	**9.3**	**9.0**	**513.8**	**328.8**
	2	**21.2**	**9.3**	**9.0**	**513.8**	**328.8**
	2.5	**21.2**	**9.3**	**9.0**	**513.8**	**328.8**
	3	**21.2**	**9.3**	**9.0**	**513.7**	**328.8**
	3.5	**21.2**	**9.3**	**9.0**	**513.7**	**328.8**
	4	**21.2**	**9.3**	**9.0**	**513.8**	**328.8**
	4.5	**21.2**	**9.3**	**9.0**	**513.5**	**328.8**
	5	**21.2**	**9.3**	**9.0**	**514**	**328.7**
	5.5	**21.2**	**9.3**	**9.0**	**513.8**	**328.9**
	6	**21.0**	**9.3**	**9.0**	**513.9**	**328.9**
	6.5	**20.8**	**9.3**	**8.9**	**514.9**	**329.2**
	7	**20.7**	**9.1**	**8.9**	**514.3**	**329.3**

	7.5	**20.7**	**8.9**	**8.9**	**516.3**	**330.3**
	8	**20.5**	**8.7**	**8.6**	**522.3**	**334.6**
	8.5	**20.4**	**8.4**	**8.3**	**529.4**	**337.6**
	9	**20.3**	**7.9**	**8.2**	**531.5**	**341.5**
	MEAN	**20.7**	**8.8**	**8.9**	**521**	**333**
	STD DEV	**1.7**	**1.4**	**0.5**	**36**	**23**

3.2 Lake LeAnn 2024 Deep Basin Chemical Water Quality Data Tables:

Table 7. Lake LeAnn north basin May 7, 2024 chemical water quality data.

SITE	Secchi (ft)	Chl-a (μg/L)	SITE	TP (mg/L)	TIN (mg/L)	NH3 (mg/L)	NO3 (mg/L)	NO2 (mg/L)
1 North	9.6	3.0	1 North Top	0.030	0.100	0.027	0.100	0.100
2 North	9.6	3.0	1 North Mid	0.032	0.100	0.032	0.100	0.100
3 North	6.8	3.0	1 North Bot	0.030	0.100	0.030	0.100	0.100
4 North	4.8	4.0	2 North Top	0.028	0.100	0.043	0.100	0.100
5 North	8.4	3.0	2 North Mid	0.030	0.100	0.041	0.100	0.100
MEAN	**7.8**	**3.2**	2 North Bot	0.042	0.100	0.041	0.100	0.100
STD DEV	**2.1**	**0**	3 North Mid	0.056	0.100	0.01	0.100	0.100
			4 North Mid	0.030	0.100	0.01	0.100	0.100
			5 North Mid	0.024	0.100	0.016	0.100	0.100
			MEAN	**0.034**	**0.1**	**0.028**	**0.100**	**0.100**
			STD DEV	**0.0**	**0**	**0.0**	**0**	**0**

Table 8. Lake LeAnn south basin May 7, 2024 chemical water quality data.

SITE	Secchi (ft)	Chl-a (µg/L)	SITE	TP (mg/L)	TIN (mg/L)	NH3 (mg/L)	NO3 (mg/L)	NO2 (mg/L)
1 South	4	3.0	1 South Top	0.024	0.100	0.036	0.100	0.100
2 South	5.7	2.0	1 South Mid	0.028	0.100	0.039	0.100	0.100
3 South	5.0	2.0	1 South Bot	0.054	0.100	0.038	0.100	0.100
4 South	6.2	2.0	2 South Top	0.020	0.100	0.035	0.100	0.100
5 South	5.4	2.0	2 South Mid	0.064	0.100	0.041	0.100	0.100
MEAN	**5.3**	**2.2**	2 South Bot	0.034	0.100	0.037	0.100	0.100
STD DEV	**0.8**	**0**	3 South Mid	0.028	0.100	0.040	0.100	0.100
			4 South Top	0.024	0.100	0.034	0.100	0.100
			4 South Mid	0.022	0.100	0.049	0.100	0.100
			4 South Bot	0.060	0.530	0.53	0.100	0.100
			5 South Top	0.034	0.100	0.042	0.100	0.100
			5 South Mid	0.034	0.100	0.044	0.100	0.100
			5 South Bot	0.032	0.230	0.23	0.100	0.100
			MEAN	**0.035**	**0.143**	**0.092**	**0.100**	**0.100**
			STD DEV	**0.0**	**0**	**0.1**	**0**	**0**

Table 9. Lake LeAnn north basin July 2, 2024 chemical water quality data.

SITE	Secchi (ft)	Chl-a (µg/L)	SITE	TP (mg/L)	TIN (mg/L)	NH3 (mg/L)	NO3 (mg/L)	NO2 (mg/L)
1 North	4.1	5	1 North Top	0.010	0.100	0.010	0.100	0.100
2 North	4.3	6	1 North Mid	0.010	0.100	0.010	0.100	0.100
3 North	4	8	1 North Bot	0.010	0.100	0.011	0.100	0.100
4 North	4.4	5	2 North Top	0.010	0.100	0.010	0.100	0.100
5 North	4.2	5	2 North Mid	0.010	0.100	0.010	0.100	0.100
MEAN	4.2	5.8	2 North Bot	0.010	0.100	0.010	0.100	0.100
STD DEV	0.2	0	3 North Mid	0.010	0.100	0.010	0.100	0.100
			4 North Mid	0.010	0.100	0.010	0.100	0.100
			5 North Mid	0.010	0.100	0.010	0.100	0.100
			MEAN	0.010	0.1	0.010	0.100	0.100
			STD DEV	0.0	0	0.0	0	0

Table 10. Lake LeAnn south basin July 2, 2024 chemical water quality data.

SITE	Secchi (ft)	Chl-a (µg/L)	SITE	TP (mg/L)	TIN (mg/L)	NH3 (mg/L)	NO3 (mg/L)	NO2 (mg/L)
1 South	6.4	4.0	1 South Top	0.010	0.100	0.018	0.100	0.100
2 South	5.3	4.0	1 South Mid	0.010	0.100	0.012	0.100	0.100
3 South	5.9	2.0	1 South Bot	0.010	2.000	2.0	0.100	0.100
4 South	5.5	3.0	2 South Top	0.010	0.100	0.037	0.100	0.100
5 South	5.3	4.0	2 South Mid	0.010	0.100	0.032	0.100	0.100
MEAN	5.7	3.4	2 South Bot	0.022	0.100	0.060	0.100	0.100
STD DEV	0.5	0	3 South Mid	0.010	0.100	0.017	0.100	0.100
			4 South Top	0.010	0.100	0.015	0.100	0.100
			4 South Mid	0.010	0.100	0.018	0.100	0.100
			4 South Bot	0.010	2.600	2.6	0.100	0.100
			5 South Top	0.012	0.100	0.031	0.100	0.100
			5 South Mid	0.012	0.100	0.037	0.100	0.100
			5 South Bot	0.052	1.500	1.5	0.100	0.100
			MEAN	0.014	0.546	0.491	0.100	0.100
			STD DEV	0.0	0	0.9	0	0

Table 11. Lake LeAnn north basin September 9, 2024 chemical water quality data.

SITE	Secchi (ft)	Chl-a (µg/L)	SITE	TP (mg/L)	TIN (mg/L)	NH3 (mg/L)	NO3 (mg/L)	NO2 (mg/L)
1 North	3.7	5	1 North Top	0.030	0.100	0.035	0.100	0.100
2 North	3.9	4	1 North Mid	0.036	0.100	0.060	0.100	0.100
3 North	2.1	10	1 North Bot	0.040	0.100	0.065	0.100	0.100
4 North	3.1	6	2 North Top	0.034	0.100	0.022	0.100	0.100
5 North	3.4	5	2 North Mid	0.042	0.100	0.025	0.100	0.100
MEAN	3.2	6	2 North Bot	0.034	0.100	0.035	0.100	0.100
STD DEV	0.7	0	3 North Mid	0.044	0.100	0.018	0.100	0.100
			4 North Mid	0.036	0.100	0.030	0.100	0.100
			5 North Mid	0.052	0.100	0.028	0.100	0.100
			MEAN	0.039	0.1	0.035	0.100	0.100
			STD DEV	0.0	0	0.0	0	0

Table 12. Lake LeAnn south basin September 9, 2024 chemical water quality data.

SITE	Secchi (ft)	Chl-a (µg/L)	SITE	TP (mg/L)	TIN (mg/L)	NH3 (mg/L)	NO3 (mg/L)	NO2 (mg/L)
1 South	6.5	2.0	1 South Top	0.010	0.100	0.010	0.100	0.100
2 South	6.5	6.0	1 South Mid	0.014	0.100	0.020	0.100	0.100
3 South	4.7	6.0	1 South Bot	0.010	0.100	0.021	0.100	0.100
4 South	5.1	4.0	2 South Top	0.010	0.100	0.022	0.100	0.100
5 South	5	3.0	2 South Mid	0.012	0.100	0.028	0.100	0.100
MEAN	5.6	4.2	2 South Bot	0.010	0.100	0.036	0.100	0.100
STD DEV	0.9	0	3 South Mid	0.010	0.100	0.047	0.100	0.100
			4 South Top	0.010	0.100	0.041	0.100	0.100
			4 South Mid	0.010	0.100	0.049	0.100	0.100
			4 South Bot	0.010	0.210	0.210	0.100	0.100
			5 South Top	0.010	0.100	0.038	0.100	0.100
			5 South Mid	0.010	0.100	0.041	0.100	0.100
			5 South Bot	0.014	0.310	0.310	0.100	0.100
			MEAN	0.011	0.125	0.067	0.100	0.100
			STD DEV	0.0	0	0.1	0	0

3.3 Lake LeAnn 2024 CSA (Drain) Physical & Chemical Water Quality Data Tables:

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. The LLPOA has partnered with the Hillsdale County Conservation District for drain improvements. Additionally, the Hillsdale County Road Commission addressed a road issue at Baker and Northview roads during the spring of 2023 to reduce sediment loads to the lake.

CSA Water Quality Parameters Measured:

Water quality parameters such as dissolved oxygen, water temperature, pH, conductivity, 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 tables 13-15 with descriptive statistics. Samples and water quality measurements were collected on May 8, 2024, July 2, 2024, and September 9, 2024. 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. Any drains not listed below could not be sampled due to a lack of flow.

Table 13. Lake LeAnn Flowing CSA Drain Water Quality Data (May 8, 2024).

CSA	Temp °C	DO (mg/L)	pH (S.U.)	Cond (mS/cm)	TP (mg/L)	SRP (mg/L)	TIN (mg/L)	NH3 (mg/L)	NO3 (mg/L)	NO2 (mg/L)	TKN (mg/L)	TSS (mg/L)	Flow (cfs)
2A	18.5	9.9	8.7	719	0.010	0.010	0.260	0.010	0.260	0.100	1.2	10	0.4
2B	16.6	9.9	8.3	718	0.010	0.010	0.710	0.010	0.710	0.100	1.0	10	6.6
1B	14.5	9.0	8.1	779	0.010	0.010	0.830	0.010	0.830	0.100	0.7	10	0.4
1A	22.8	8.7	8.6	526	0.014	0.010	0.100	0.017	0.100	0.100	1.3	10	0.4
4A	25.0	8.4	8.3	594	0.076	0.010	0.100	0.042	0.100	0.100	1.6	10	0.2
MEAN	**19.5**	**9.2**	**8.4**	**667**	**0.024**	**0.010**	**0.400**	**0.018**	**0.400**	**0.100**	**1.2**	**10**	**1.6**
STD DEV	**4.3**	**0.7**	**0.2**	**104**	**0.0**	**0.0**	**0.3**	**0.0**	**0.3**	**0.0**	**0.3**	**0.0**	**2.8**

Table 14. Lake LeAnn Flowing CSA Drain Water Quality Data (July 2, 2024).

CSA	Temp °C	DO (mg/L)	pH (S.U.)	Cond (mS/cm)	TP (mg/L)	SRP (mg/L)	TIN (mg/L)	NH3 (mg/L)	NO3 (mg/L)	NO2 (mg/L)	TKN (mg/L)	TSS (mg/L)	Flow (cfs)
2A	16.4	9.1	8.1	691	0.010	0.010	0.410	0.036	0.380	0.100	0.6	12	0.4
2B	15.8	9.1	7.8	726	0.010	0.010	0.920	0.033	0.890	0.100	0.5	10	2.1
1B	12.5	8.7	7.3	791	0.010	0.010	0.990	0.017	0.970	0.100	0.5	10	0.2
1A	25.0	8.6	8.1	542	0.012	0.010	0.200	0.035	0.200	0.100	0.8	10	0.1
MEAN	**17.4**	**8.9**	**7.8**	**688**	**0.011**	**0.010**	**0.630**	**0.030**	**0.610**	**0.100**	**0.6**	**10.5**	**0.7**
STD DEV	**5.3**	**0.3**	**0.4**	**105**	**0.0**	**0.0**	**0.4**	**0.0**	**0.4**	**0.0**	**0.1**	**1.0**	**0.9**

Table 15. Lake LeAnn Flowing CSA Drain Water Quality Data (September 9, 2024).

CSA	Temp C	DO (mg/L)	pH (S.U.)	Cond (mS/cm)	TP (mg/L)	SRP (mg/)	TIN (mg/L)	NH3 (mg/L)	NO3 (mg/L)	NO2 (mg/L)	TKN (mg/L)	TSS (mg/L)	Flow (cfs)
2A	16.6	9.7	8.2	658	0.010	0.010	0.280	0.012	0.260	0.100	<0.5	10	0.2
2B	15.4	9.8	8.0	696	0.010	0.010	1.1	0.010	1.1	0.100	<0.5	10	1.4
1B	12.7	9.0	7.6	754	0.010	0.010	0.860	0.010	0.860	0.100	<0.5	10	0.2
1A	21.5	8.8	8.3	547	0.010	0.010	0.100	0.039	0.100	0.100	<0.5	10	0.1
MEAN	**16.6**	**9.3**	**8.0**	**664**	**0.010**	**0.010**	**0.585**	**0.018**	**0.580**	**0.100**	**0.5**	**10**	**0.5**
STD DEV	**3.7**	**0.5**	**0.3**	**87**	**0.0**	**0.0**	**0.5**	**0.0**	**0.5**	**0**	**0.0**	**0.0**	**0.6**

3.4 Lake LeAnn Aquatic Vegetation Biovolume Data (September 9, 2024)

A whole-lake scan of the aquatic vegetation in Lake LeAnn was conducted on September 9, 2024 with a WAAS-enabled Lowrance HDS 9 GPS with variable frequency transducer. This data included 6,711 data points in the north basin and 8,830 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 5-6). 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 16-17 show the biovolume categories by plant cover during the September 9, 2024 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).

In 2024, the September survey of the north basin of Lake LeAnn consisted of 154 sampling locations around the littoral zone and the survey of the south basin consisted of 193 sampling locations. The May survey of the north basin of Lake LeAnn consisted of 120 sampling locations and the south basin had 140 sampling locations. Additional follow-up post treatment surveys were conducted 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.

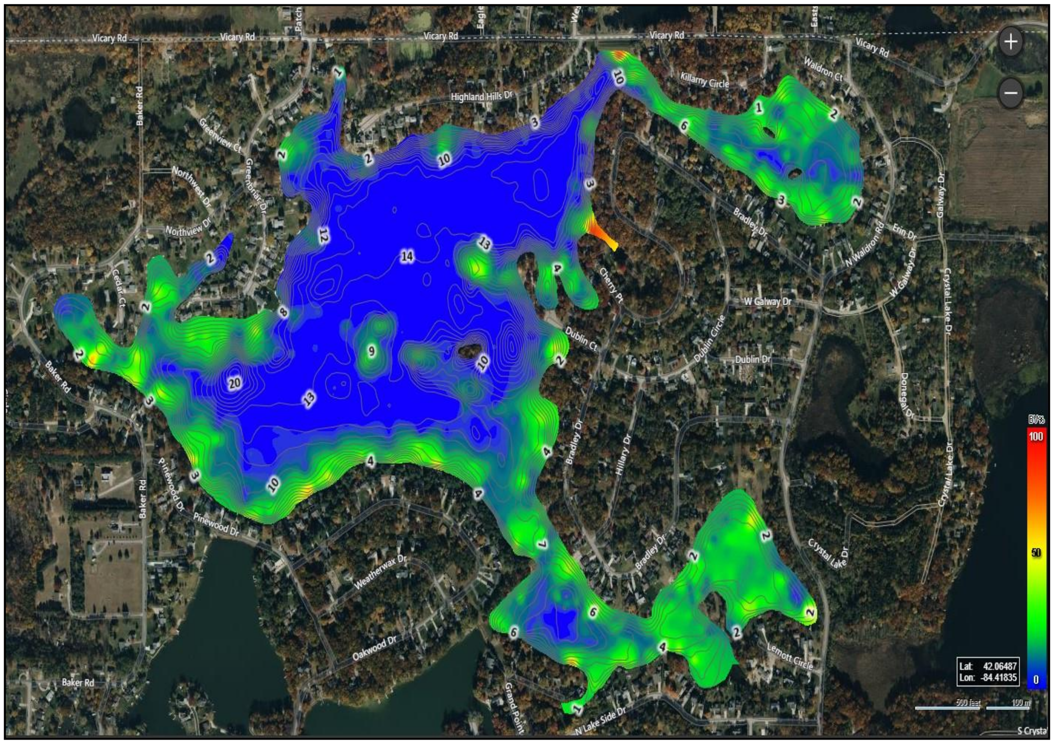

Figure 5. Aquatic plant biovolume of all aquatic plants in north Lake LeAnn, Hillsdale County, Michigan (September 9, 2024). Note: Red color denotes high-growing aquatic plants, green color denoted low-growing aquatic plants, and blue color represents a lack of aquatic vegetation.

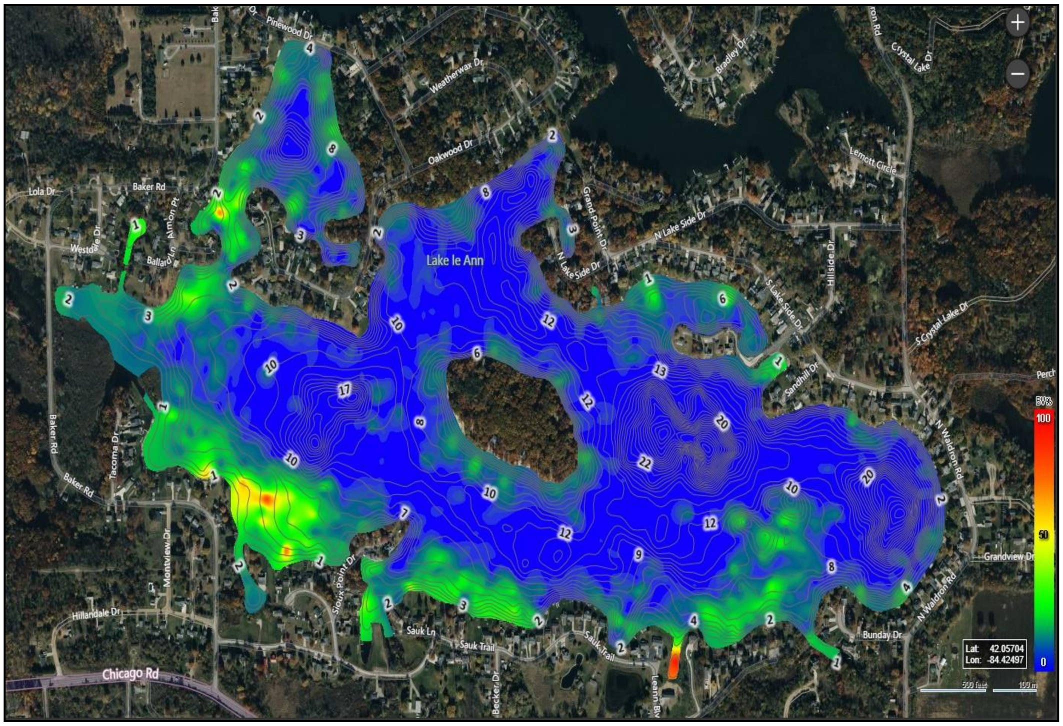

Figure 6. Aquatic plant biovolume of all aquatic plants in south Lake LeAnn, Hillsdale County, Michigan (September 9, 2024). Note: Red color denotes high-growing aquatic plants, green color denoted low-growing aquatic plants, and blue color represents a lack of aquatic vegetation.

Table 16. Lake LeAnn north basin aquatic vegetation biovolume by category percent cover (relative cover on September 9, 2024).

Biovolume Cover Category	% Relative Cover of Bottom by Category
<5%	54.1
5-20%	28.9
20-40%	14.7
40-60%	2.0
60-80%	0.2
>80%	0.1

Table 17. Lake LeAnn south basin aquatic vegetation biovolume by category percent cover (relative cover on September 9, 2024).

Biovolume Cover Category	% Relative Cover of Bottom by Category
<5%	70.1
5-20%	22.7
20-40%	5.9
40-60%	1.0
60-80%	0.2
>80%	0.1

During the May 11, 2024 whole-lake species inventory 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 18). 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 19). The dominant native aquatic plants in the north basin of the lake included Chara (66.4% of the sampling sites), and White Waterlily (5.7% of the sampling sites). The dominant native aquatic plants in the south basin of the lake included Chara (37.1% of the sampling sites), and the native Cattails (5.7% of the sampling sites).

An additional late-season comprehensive inventory of both lakes was conducted on September 9, 2024. The north basin of Lake LeAnn contained 7 native submersed, 2 floating-leaved, and 1 emergent aquatic plant species, for a total of 10 native aquatic macrophyte species (Table 20). The south basin of Lake LeAnn contained 9 native submersed, 2 floating-leaved, and 2 emergent aquatic plant species, for a total of 13 native aquatic macrophyte species (Table 21).

The dominant native aquatic plants in the north basin of the lake included Chara (79.9% of the sampling sites), and Wild Celery (39.0% of the sampling sites). The dominant native aquatic plants in the south basin of the lake included the Chara (89.6% of the sampling sites), and Wild Celery (45.6% of the sampling sites). 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 7-10 below display the treatment areas in 2024 where targeted treatments of invasive species were needed to reduce milfoil and Curly-leaf Pondweed.

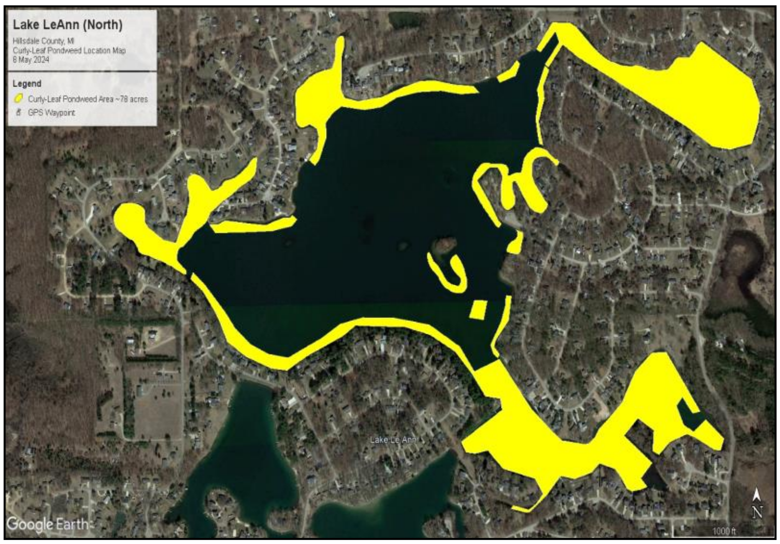

Figure 7. North Lake LeAnn May 2024 CLP treatment map.

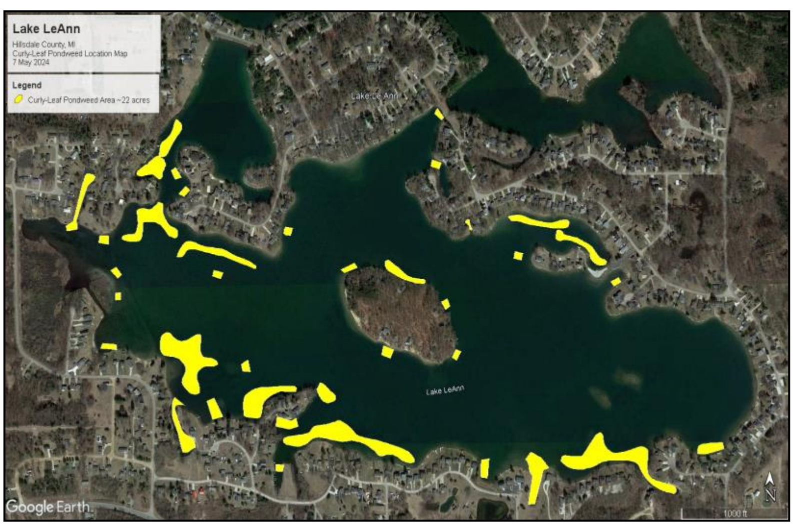

Figure 8. South Lake LeAnn May 2024 CLP treatment map.

Figure 9. North Lake LeAnn May 2024 EWM treatment map.

Figure 10. South Lake LeAnn May 2024 EWM treatment map.

Table 18. Lake LeAnn north basin native aquatic plants (May 11, 2024).

Aquatic Plant Common Name	Aquatic Plant Latin Name	A level	B level	C level	D level	% Sites Found
Muskgrass	*Chara vulgaris*	78	15	0	0	66.4
Flat-stem Pondweed	*Potamogeton zosteriformis*	1	0	0	0	0.7
Large-leaf Pondweed	*Potamogeton amplifolius*	1	0	0	0	0.7
Coontail	*Ceratophyllum demersum*	6	0	0	0	4.3
Common Waterweed	*Elodea canadensis*	2	1	0	0	2.1
White Waterlily	*Nymphaea odorata*	8	0	0	0	5.7
Yellow Waterlily	*Nuphar variegata*	4	0	0	0	2.9
Cattails	*Typha latifolia*	4	0	0	0	2.9
Iris	*Iris* spp.	1	0	0	0	0.7

Table 19. Lake LeAnn south basin native aquatic plants (May 11, 2024).

Aquatic Plant Common Name	Aquatic Plant Latin Name	A level	B level	C level	D level	# Sites Found
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

Table 20. Lake LeAnn north basin native aquatic plants (September 9, 2024).

Aquatic Plant Common Name	Aquatic Plant Latin Name	A level	B level	C level	D level	% Sites Found
Muskgrass	*Chara vulgaris*	70	53	0	0	79.9
Illinois Pondweed	*Potamogeton illinoensis*	40	8	0	0	31.2
Common Waterweed	*Elodea canadensis*	2	0	0	0	1.3
Wild Celery	*Vallisneria americana*	49	11	0	0	39.0
Sago Pondweed	*Stuckenia pectinata*	13	1	0	0	9.1
Large-leaf Pondweed	*Potamogeton amplifolius*	6	0	0	0	3.9
Coontail	*Ceratophyllum demersum*	30	2	0	0	20.8
White Waterlily	*Nymphaea odorata*	18	1	0	0	12.3
Yellow Waterlily	*Nuphar variegata*	2	5	0	0	4.5
Cattails	*Typha latifolia*	1	1	0	0	1.3

Table 21. Lake LeAnn south basin native aquatic plants (September 9, 2024).

Aquatic Plant Common Name	Aquatic Plant Latin Name	A level	B level	C level	D level	# Sites Found
Muskgrass	*Chara vulgaris*	150	20	3	0	89.6
Illinois Pondweed	*Potamogeton illinoensis*	64	10	0	0	38.3
Flat-stem Pondweed	*Potamogeton zosteriformis*	2	0	0	0	1.0
Floating-leaf Pondweed	*Potamogeton natans*	1	0	0	0	0.5
Large-leaf Pondweed	*Potamogeton amplifolius*	1	0	0	0	0.5
Wild Celery	*Vallisneria americana*	82	6	0	0	45.6
Sago Pondweed	*Stuckenia pectinata*	9	0	0	0	4.7
Coontail	*Ceratophyllum demersum*	4	0	0	0	2.1
Common Waterweed	*Elodea canadensis*	2	0	0	0	1.0
White Waterlily	*Nymphaea odorata*	4	1	0	0	2.6
Yellow Waterlily	*Nuphar variegata*	0	1	0	0	0.5
Cattails	*Typha latifolia*	1	0	0	0	0.5
Bulrushes	*Schoenoplectus acutus*	1	0	0	0	0.5

3.5 Lake LeAnn Bottom Hardness Scan and Data:

A bottom sediment hardness scan was conducted of the entire lake bottom on September 9, 2024. The bottom hardness maps show (Figures 11-12) 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 22-23 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 22. Lake LeAnn <u>north basin</u> 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 =6,711)	% Relative Cover of Bottom by Category
0.0-0.1	0	0.0
0.1-0.2	36	0.5
0.2-0.3	4439	66.2
0.3-0.4	2235	33.3
>0.4	1.0	0.0

Table 23. Lake LeAnn <u>south basin</u> 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 =8,830)	% Relative Cover of Bottom by Category
0.0-0.1	1	0.0
0.1-0.2	96	1.1
0.2-0.3	7015	79.4
0.3-0.4	1718	19.5
>0.4	0	0.0

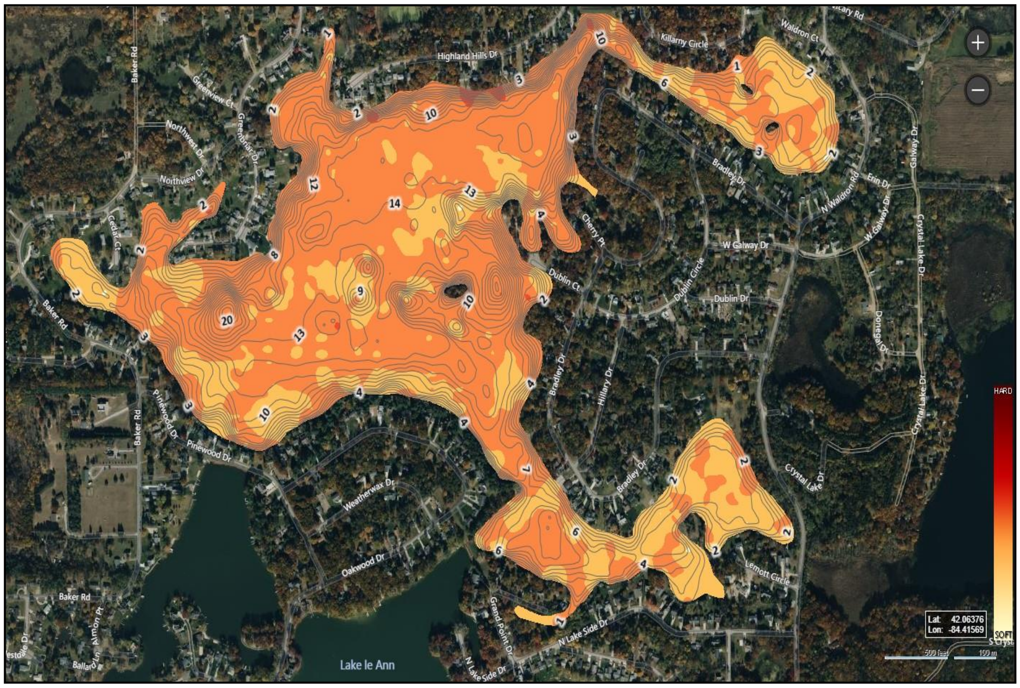

Figure 11. Lake LeAnn <u>north basin</u> sediment relative hardness map (September 9, 2024).

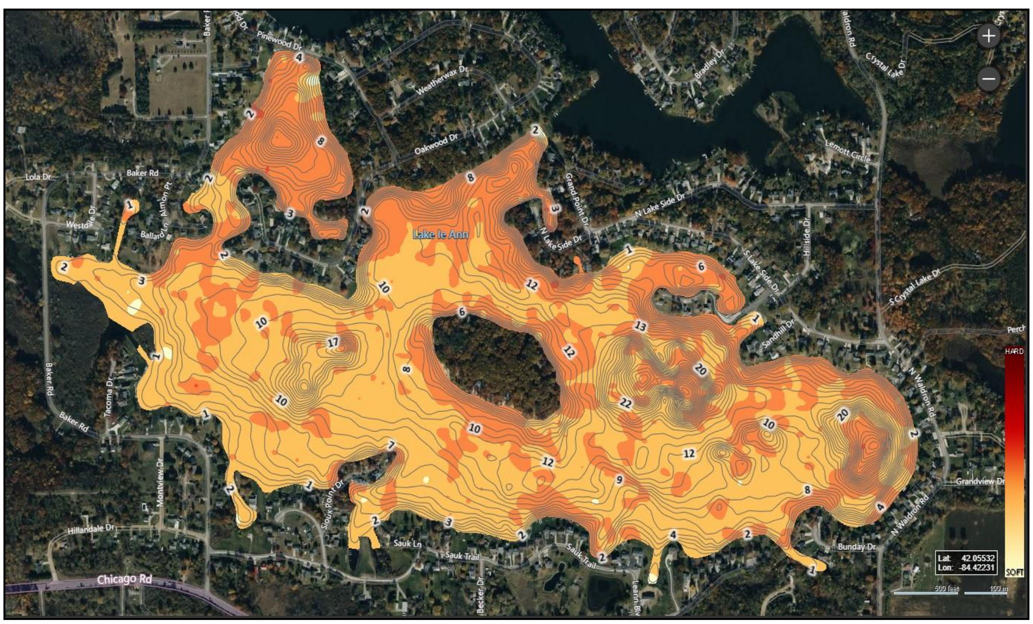

Figure 12. Lake LeAnn <u>south basin</u> sediment relative hardness map (September 9, 2024)

4.0 LAKE LEANN 2019-2024 CONCLUSIONS AND RECOMMENDATIONS FOR 2025

The continued implementation of the LFA technology and concomitant use of bioaugmentation (beneficial bacteria and enzymes) in Lake LeAnn occurred in 2021 and 2023 with reduced efficacy of the bioaugmentation relative to blue-green algae reduction and reductions in nutrients. In 2024, the use of Timberchar® biochar was implemented beginning on June 8, 2024 in both basins to reduce water column nutrients. The use of the biochar in 2025 and beyond should continue to reduce these nutrients and consequential blue-green algal blooms as long as additional actions are taken within the immediate watershed to reduce incoming nutrient loads. This includes lawn fertilization, septic system inputs, and incoming drains. RLS and the LLPOA have worked with Eden Lakes, LLC to apply for necessary permits to implement biochar filters in the drains. EGLE has clarified that it will not permit these filters in the drains that are classified as wetlands. Modifications to bottom-placed filters are thus being considered and will be discussed with EGLE in 2025.

Overall, the lake needs more low-growing, native submersed aquatic vegetation, less invasive aquatic plant species, less cyanobacteria, and less nutrients in order to have clearer water. 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 (2 basins in the South Basin), and reduced water clarity through low secchi transparency readings. The Sections below (I-VI) display the 2019 mean baseline data set and the post-LFA mean data sets (2021-2024). The following sub-sections below summarize an analysis of all collected data from 2019 and 2021-2024 with comparisons. All data collected has been analyzed and are summarized below with descriptive statistic tables that include means and standard deviations.

Management recommendations for 2025 are listed last and mentioned in Section VII below.

Statistical Summary of Baseline (2019) and Year 1 (2021) and Years 2-4 (2022-2024) Lake LeAnn LFA Data

I. Lake Basins:

The tables below (24-29) display the means and standard deviations for both lake basins in 2019 (baseline) and 2021-2024 (Years 1-4 of LFA operation). Figures 13-18 display the trends in key water quality parameters for both basins along with trend lines. 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:

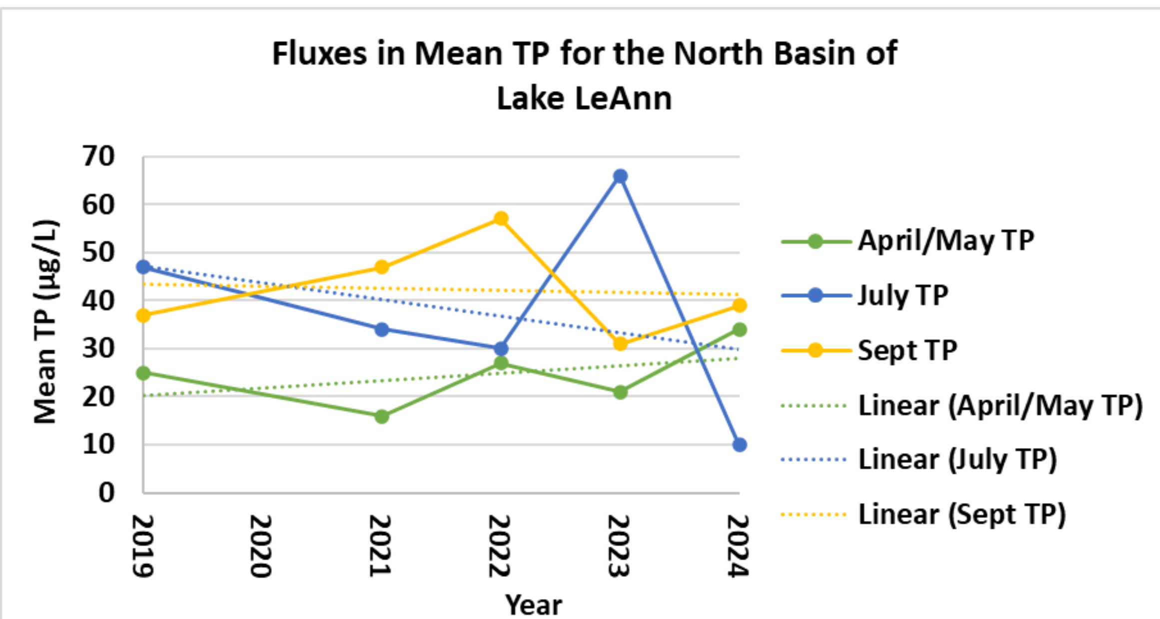

Figure 13. Flux in Mean TP for the north basin of Lake LeAnn (2019-2024).

The mean TP has increased in the spring (April/May) but decreased in July and September which is favorable. Spring concentrations may be increasing due to runoff being higher in the spring months. In 2024, post-biochar, the TP was very low in July. Interestingly, the TP was reduced post-biochar in July and September after implementation on June 8, 2024.

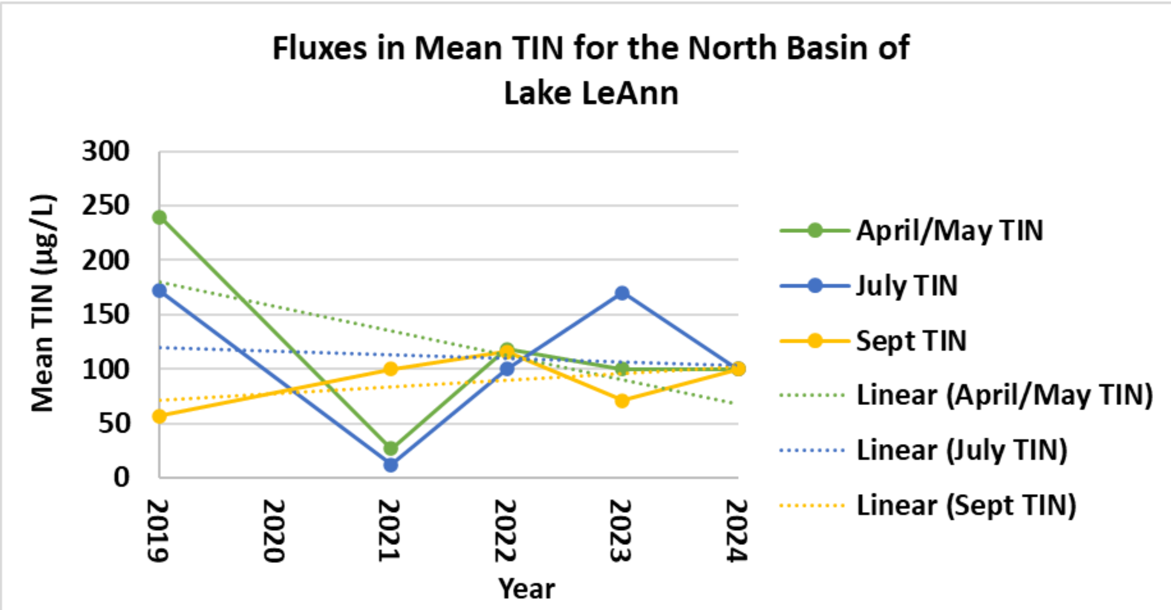

Figure 14. Flux in Mean TIN for the north basin of Lake LeAnn (2019-2024).

The mean TIN has decreased in the spring (April/May) and summer (July) but increased slightly in September. All of the values remain favorable.

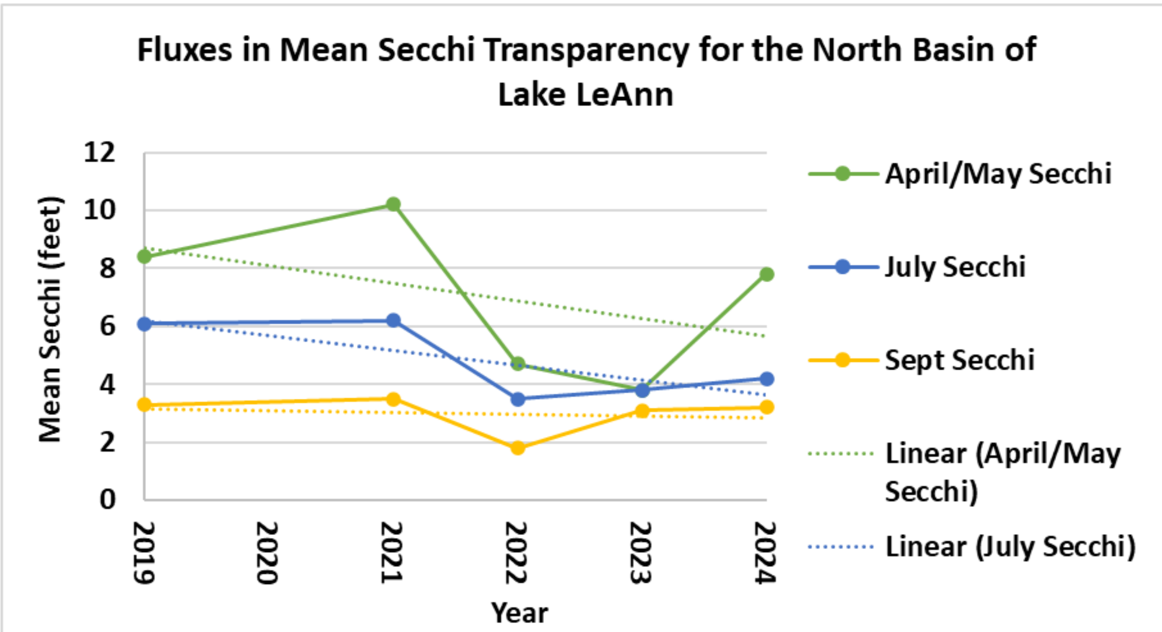

Figure 15. Flux in Mean Secchi Transparency for the north basin of Lake LeAnn (2019-2024).

The mean Secchi transparency has decreased in the spring (April/May) and summer (July) and slightly in September. This is due to the abundance of phytoplankton in the water column since most of the TP concentrations remain well above the eutrophic threshold. A further reduction in TP is needed.

South Basin:

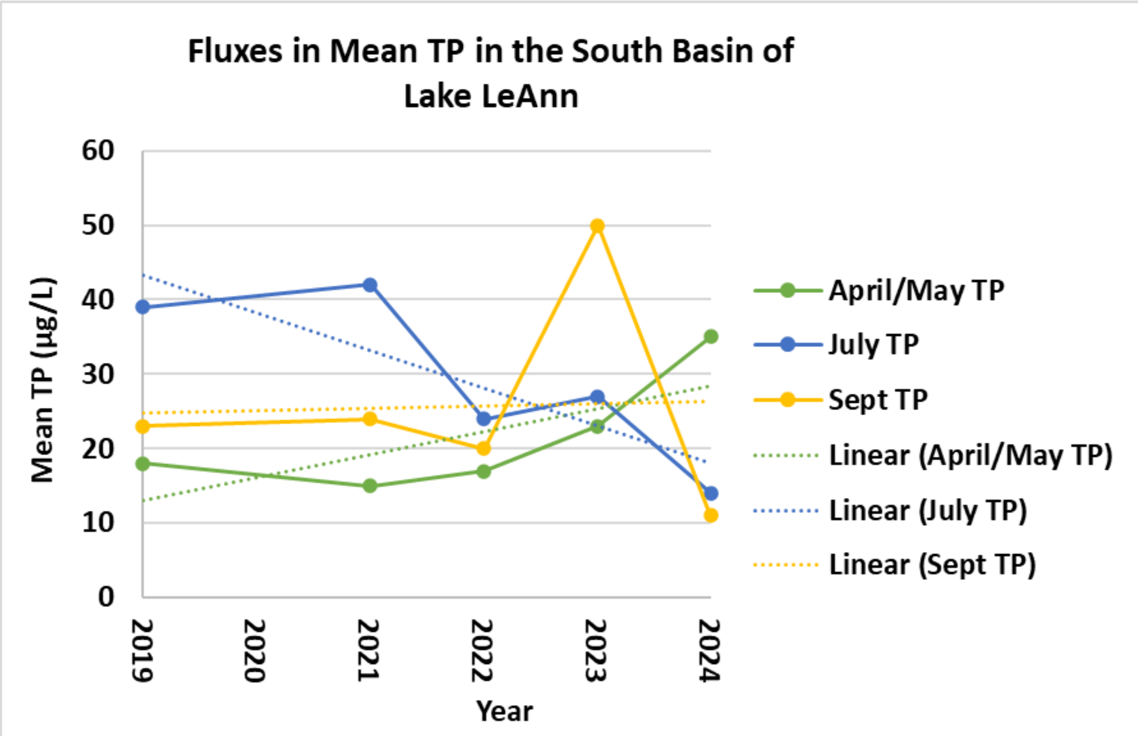

Figure 16. Flux in Mean TP for the south basin of Lake LeAnn (2019-2024).

The mean TP has increased in the spring (April/May) and in September but decreased substantially in July. In 2024, all but the spring TP concentrations were below the eutrophic threshold which means the LFA and biochar combination are effectively reducing the TP to acceptable concentrations.

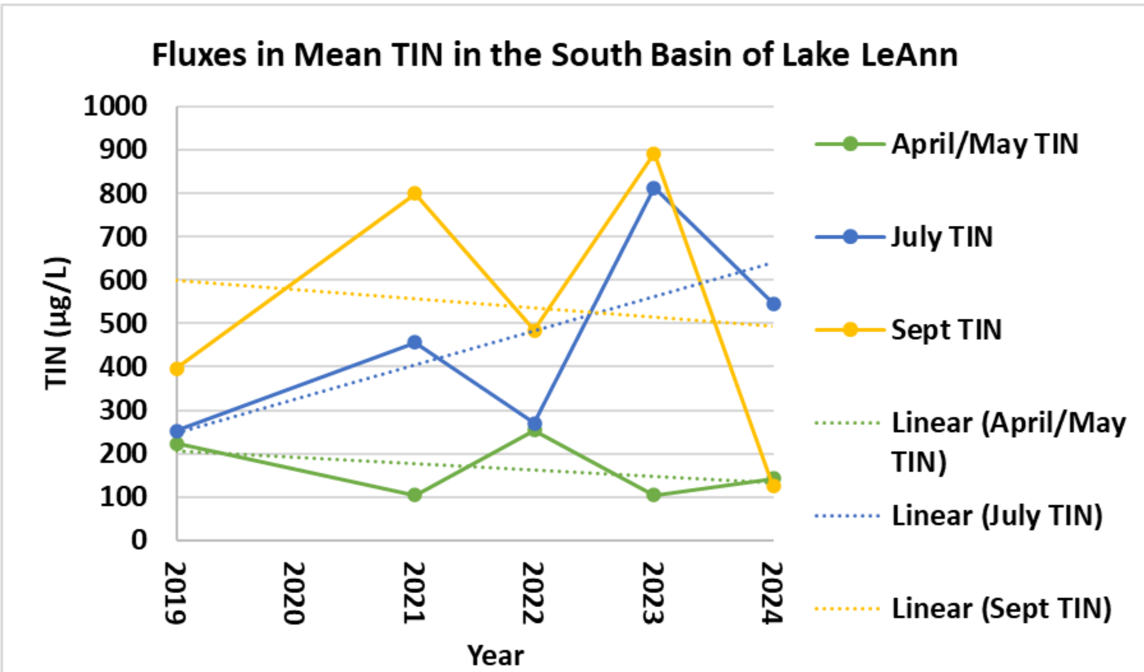

Figure 17. Flux in Mean TIN for the <u>south basin</u> of Lake LeAnn (2019-2024).

The mean TIN in the South Basin of Lake LeAnn decreased in September and April but increased sharply in July. This could be attributed to septic leachate and/or the use of nitrogen-rich lawn fertilizers. This is especially true since biochar readily decreases TIN.

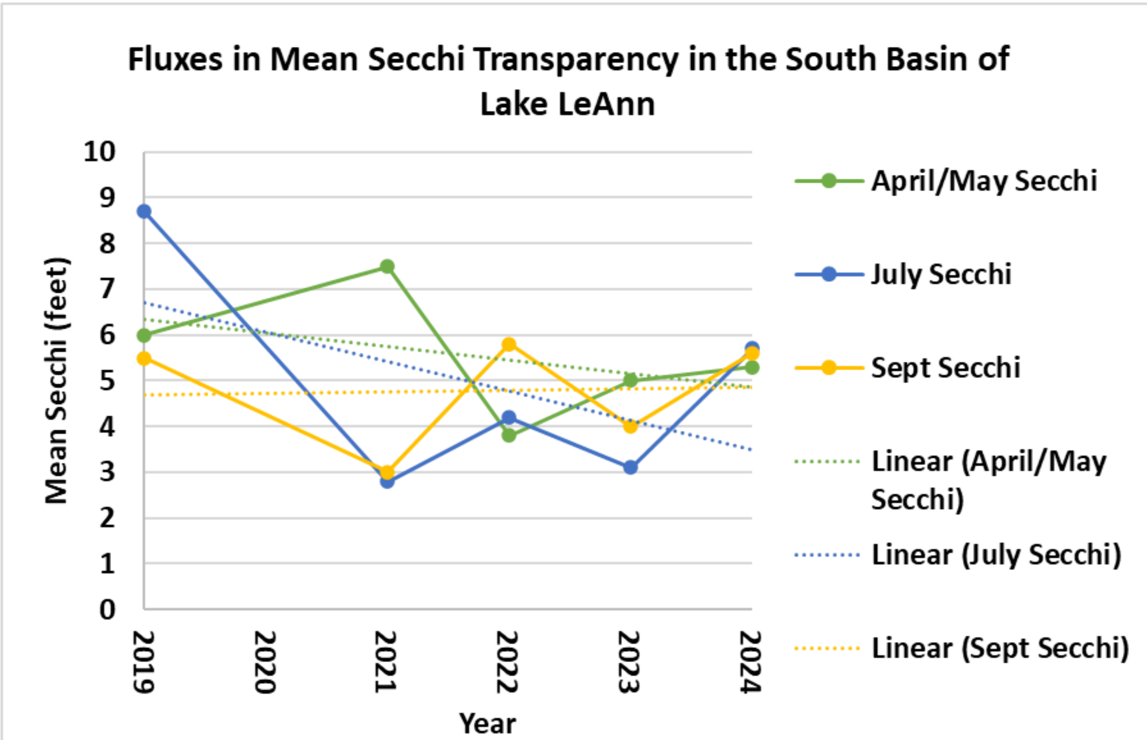

Figure 18. Flux in Mean Secchi Transparency for the south basin of Lake LeAnn (2019-2024).

The Secchi transparency has increased from 2023 to 2024 due to the biochar implementation.

Blue-green algae are increasing globally due to atmospheric enrichment of CO_2 which then is utilized by cyanobacteria for accelerated growth and may have increased in the northern US due to wildfires and atmospheric deposition. If the LFA is to achieve continued local 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 or considering only specific formulas low in nutrients, and supporting the LLPOA efforts to reduce nutrients coming into the lake from the CSA drains.

Table 24. Descriptive statistics of all water quality parameters in the north basin of Lake LeAnn for LFA parameters collected in April/May of 2019, 2021, 2022, 2023, and 2024. NOTE: In situ chlorophyll-a analysis was used in 2023-2024.

Water Quality Parameter	2019 Baseline April/May Means ± SD	2021 Year 1 April/May Means ± SD	2022 Year 2 April/May Means ± SD	2023 Year 3 April/May Means ± SD	2024 Year 4 April/May Means ± SD
Water temp (°C)	12.9±0.9	13.2±0.6	15.3±0.9	11.0±0.6	18.2±0.4
pH (S.U.)	8.3±0.1	8.5±0.1	8.1±0.1	8.6±0.1	9.0±0.1
Dissolved oxygen (mg/L)	10.1±0.6	11.6±0.9	9.9±0.4	11.5±0.7	11.0±0.0
Conductivity (mS/cm)	509±3.6	502±9.0	557±176	1088±364	503±15
Secchi transparency (ft)	8.4±1.6	10.2±2.4	4.7±0.9	3.8±0.6	7.8±2.1
Chlorophyll-a (μg/L)	0.134±0.3	0.606±0.4	0.700±1.6	11.0±0.0	3.2±0.0
Total Kjeldahl nitrogen (mg/L)	0.6±0.1	0.5±0.1	1.0±0.3	NA	NA
Total inorganic nitrogen (mg/L)	0.240±0.0	0.027±0.0	0.118±0.0	0.100±0.0	0.100±0.0
Ammonia nitrogen (mg/L)	0.073±0.0	0.027±0.0	0.042±0.0	0.014±0.0	0.028±0.0
Nitrate nitrogen (mg/L)	0.166±0.0	0.100±0.0	0.113±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	0.100±0.0	0.100±0.0
Total phosphorus (mg/L)	0.025±0.0	0.016±0.0	0.027±0.0	0.021±0.0	0.034±0.0
Ortho-phosphorus (mg/L)	0.010±0.0	0.010±0.0	0.010±0.0	NA	NA
Total suspended solids (mg/L)	25±12	10.0±0.0	10.2±2.0	NA	NA

Table 25. Descriptive statistics of all water quality parameters in the north basin of Lake LeAnn for LFA parameters collected in July of 2019, 2021, 2022, 2023, and 2024. NOTE: In situ chlorophyll-a analysis was used in 2023-2024.

Water Quality Parameter	2019 Baseline July Means ± SD	2021 Year 1 July Means ± SD	2022 Year 2 July Means ± SD	2023 Year 3 July Means ± SD	2024 Year 4 July Means± SD
Water temp (°C)	21.2±2.6	25.5±0.4	25.9±0.3	26.2±1.0	25.0±0.3
pH (S.U.)	8.5±0.1	8.5±0.2	8.0±0.3	8.5±0.1	8.8±0.3
Dissolved oxygen (mg/L)	7.3±2.1	9.4±1.2	7.7±1.2	9.0±1.4	8.7±0.8
Conductivity (mS/cm)	584±75	425±86	720±134	503±17	486±6.0
Secchi transparency (ft)	6.1±0.1	6.2±0.6	3.5±1.1	3.8±0.5	4.2±0.2
Chlorophyll-a (µg/L)	0.340±0.7	3.8±2.5	1.8±2.4	11.4±1.7	5.8±0.0
Total Kjeldahl nitrogen (mg/L)	1.2±0.9	0.5±0.0	0.7±0.3	NA	NA
Total inorganic nitrogen (mg/L)	0.172±0.4	0.012±0.0	0.100±0.0	0.170±0.2	0.100±0.0
Ammonia nitrogen (mg/L)	0.172±0.4	0.012±0.0	0.029±0.0	0.107±0.2	0.010±0.0
Nitrate nitrogen (mg/L)	0.100±0.0	0.100±0.0	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	0.100±0.0	0.100±0.0
Total phosphorus (mg/L)	0.047±0.0	0.034±0.0	0.030±0.0	0.066±0.1	0.010±0.0
Ortho-phosphorus (mg/L)	0.026±0.0	0.010±0.0	0.011±0.0	NA	NA
Total suspended solids (mg/L)	10.5±1.4	10.0±0.0	14.2±7.3	NA	NA

Table 26. Descriptive statistics of all water quality parameters in the north basin of Lake LeAnn for LFA parameters collected in September of 2019, 2021, 2022, 2023, and 2024. NOTE: In situ chlorophyll-a analysis was used in 2023-2024.

Water Quality Parameter	2019 Baseline Sept Means ± SD	2021 Year 1 Sept Means ± SD	2022 Year 2 Sept Means ± SD	2023 Year 3 September Means ± SD	2024 Year 4 September Means ± SD
Water temp (°C)	22.6±1.2	23.7±0.8	22.5±1.0	20.5±0.3	21.1±0.4
pH (S.U.)	8.4±0.2	8.6±0.1	8.5±0.2	8.9±0.0	9.1±0.2
Dissolved oxygen (mg/L)	8.2±2.2	9.0±1.1	10.1±1.5	9.2±0.3	9.9±0.8
Conductivity (mS/cm)	472±13	480±1.8	477±5.2	484±9.0	479±5.0
Secchi transparency (ft)	3.3±0.1	3.5±0.5	1.8±0.2	3.1±0.2	3.2±0.7
Chlorophyll-a (µg/L)	0.0±0.0	2.8±2.0	14.2±6.9	5.4±2.0	6.0±0.0
Total Kjeldahl nitrogen (mg/L)	1.0±0.3	1.0±0.5	1.3±0.3	NA	NA
Total inorganic nitrogen (mg/L)	0.057±0.1	0.100±0.0	0.116±0.0	0.071±0.0	0.100±0.0
Ammonia nitrogen (mg/L)	0.057±0.1	0.036±0.0	0.025±0.0	0.014±0.0	0.035±0.0
Nitrate nitrogen (mg/L)	0.100±0.0	0.100±0.0	0.113±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	0.100±0.0	0.100±0.0
Total phosphorus (mg/L)	0.037±0.0	0.047±0.0	0.057±0.0	0.031±0.0	0.039±0.0
Ortho-phosphorus (mg/L)	0.010±0.0	0.013±0.0	0.013±0.0	NA	NA
Total suspended solids (mg/L)	10.6±1.9	21.0±10.0	10.7±2.0	NA	NA

Table 27. Descriptive statistics of all water quality parameters in the south basin of Lake LeAnn for LFA parameters collected in April/May of 2019, 2021, 2022, 2023, and 2024. NOTE: In situ chlorophyll-a analysis was used in 2023-2024.

Water Quality Parameter	2019 Baseline April/May Means ± SD	2021 Year 1 April/May Means ± SD	2022 Year 2 April/May Means ± SD	2023 Year 3 April/May Means ± SD	2024 Year 4 April/May Means ± SD
Water temp (°C)	12.7±1.1	12.6±1.1	14.1±1.9	11.2±0.8	16.8±2.6
pH (S.U.)	8.4±0.1	8.4±0.1	8.3±0.1	8.5±0.1	8.8±0.3
Dissolved oxygen (mg/L)	10.3±0.7	10.3±0.7	10.5±1.6	11.2±1.2	8.5±2.0
Conductivity (mS/cm)	544±5.3	541±4.6	711±150	957±361	555±6.0
Secchi transparency (ft)	6.0±0.9	7.5±0.5	3.8±0.5	5.0±0.5	5.3±0.8
Chlorophyll-a (µg/L)	1.8±2.5	0.8±0.8	1.6±1.7	3.8±0.8	2.2±0.0
Total Kjeldahl nitrogen (mg/L)	0.5±0.0	0.5±0.1	0.7±0.2	NA	NA
Total inorganic nitrogen (mg/L)	0.223±0.1	0.104±0.1	0.254±0.3	0.104±0.0	0.143±0.0
Ammonia nitrogen (mg/L)	0.035±0.0	0.104±0.1	0.045±0.1	0.026±0.0	0.092±0.1
Nitrate nitrogen (mg/L)	0.191±0.1	0.100±0.0	0.173±0.2	0.101±0.0	0.100±0.0
Nitrite nitrogen (mg/L)	0.100±0.0	0.100±0.0	0.133±0.1	0.100±0.1	0.100±0.0
Total phosphorus (mg/L)	0.018±0.0	0.015±0.0	0.017±0.0	0.023±0.0	0.035±0.0
Ortho-phosphorus (mg/L)	0.010±0.0	0.010±0.0	0.010±0.0	NA	NA
Total suspended solids (mg/L)	16.1±11.0	10.0±0.0	12.4±4.9	NA	NA

Table 28. Descriptive statistics of all water quality parameters in the south basin of Lake LeAnn for LFA parameters collected in July of 2019, 2021, 2022, 2023, 2024. NOTE: In situ chlorophyll-a analysis was used in 2023-2024.

Water Quality Parameter	2019 Baseline July Means ± SD	2021 Year 1 July Means ± SD	2022 Year 2 July Means ± SD	2023 Year 3 July Means ± SD	2024 Year 4 July Means ± SD
Water temp (°C)	23.9±4.8	22.4±5.0	23.1±5.5	22.9±5.4	22.8±4.0
pH (S.U.)	8.5±0.1	8.1±0.4	8.0±0.3	8.2±0.2	8.3±0.6
Dissolved oxygen (mg/L)	6.7±3.5	6.8±4.2	6.2±3.3	6.9±3.3	6.6±3.4
Conductivity (mS/cm)	494±49	536±25	552±45	554±25	541±32
Secchi transparency (ft)	8.7±1.0	2.8±0.2	4.2±0.6	3.1±0.3	5.7±0.5
Chlorophyll-a (µg/L)	0.5±0.6	2.5±2.3	1.1±1.1	5.6±1.8	3.4±0.0
Total Kjeldahl nitrogen (mg/L)	1.1±1.2	1.0±0.7	1.0±0.7	NA	NA
Total inorganic nitrogen (mg/L)	0.253±0.8	0.456±0.8	0.270±0.5	0.813±1.5	0.546±0.0
Ammonia nitrogen (mg/L)	0.253±0.8	0.456±0.8	0.239±0.5	0.808±1.5	0.491±0.9
Nitrate nitrogen (mg/L)	0.100±0.0	0.100±0.0	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	0.100±0.0	0.100±0.0
Total phosphorus (mg/L)	0.039±0.1	0.042±0.0	0.024±0.0	0.027±0.0	0.014±0.0
Ortho-phosphorus (mg/L)	0.012±0.0	0.010±0.0	0.010±0.0	NA	NA
Total suspended solids (mg/L)	13.7±11.0	10.0±0.0	10.0±0.0	NA	NA

Table 29. Descriptive statistics of all water quality parameters in the south basin of Lake LeAnn for LFA parameters collected in September of 2019, 2021, 2022, 2023, and 2024. NOTE: In situ chlorophyll-a analysis was used in 2023-2024.

Water Quality Parameter	2019 Baseline Sept Means ± SD	2021 Year 1 Sept Means ± SD	2022 Year 2 Sept Means ± SD	2023 Year 3 Sept Means ± SD	2024 Year 4 Sept Means ± SD
Water temp (°C)	21.2±2.6	21.9±3.4	20.8±3.4	19.7±3.1	20.7±1.7
pH (S.U.)	8.4±0.1	8.3±0.5	8.2±0.4	8.6±0.4	8.9±0.5
Dissolved oxygen (mg/L)	7.1±2.5	7.7±3.1	7.6±3.0	8.0±3.1	8.8±1.4
Conductivity (mS/cm)	570±74	526±42	544±37	535±45	521±36
Secchi transparency (ft)	5.5±2.2	3.0±0.2	5.8±0.3	4.0±0.2	5.6±0.9
Chlorophyll-a (µg/L)	0.0±0.0	6.2±7.8	1.7±1.8	8.2±1.6	4.2±0.0
Total Kjeldahl nitrogen (mg/L)	1.1±1.0	1.9±2.2	1.2±1.3	NA	NA
Total inorganic nitrogen (mg/L)	0.397±1.0	0.800±1.6	0.484±1.2	0.892±2.2	0.125±0.0
Ammonia nitrogen (mg/L)	0.397±1.0	0.700±1.6	0.433±1.2	0.892±2.2	0.067±0.1
Nitrate nitrogen (mg/L)	0.100±0.0	0.100±0.0	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	0.100±0.0	0.100±0.0
Total phosphorus (mg/L)	0.023±0.0	0.024±0.0	0.020±0.0	0.050±0.1	0.011±0.0
Ortho-phosphorus (mg/L)	0.012±0.0	0.010±0.0	0.011±0.0	NA	NA
Total suspended solids (mg/L)	10.0±0.0	60.0±136	10.8±1.9	NA	NA

II. Drains/CSA's

RLS developed trend graphs to demonstrate the changes in key parameters such as total phosphorus (TP) and total inorganic nitrogen (TIN) for the two most significant contributing drains (Figures 19-22). The mean TP and TIN in both CSA 1A and 2A have declined with time. Continued mitigation of these CSA drains is recommended.

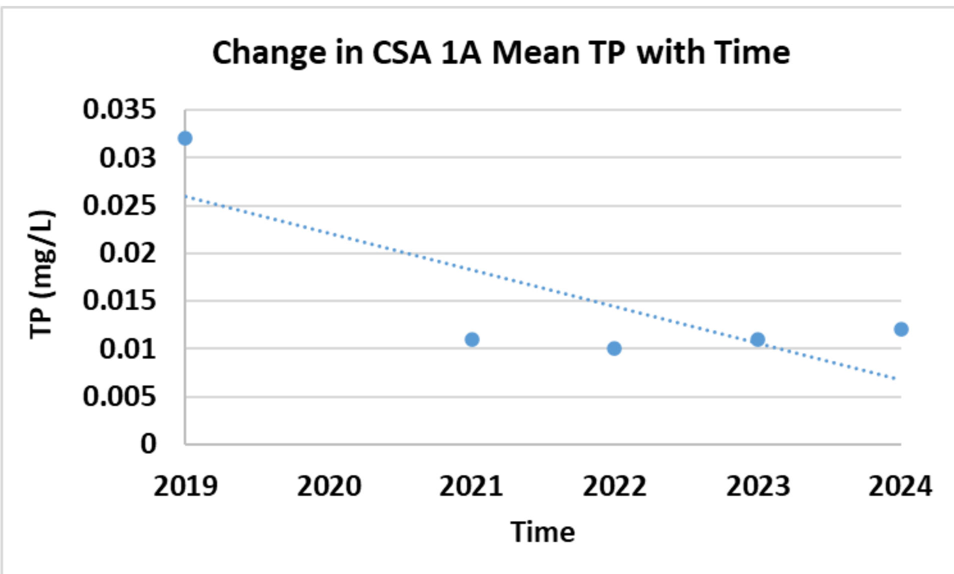

Figure 19. Change in CSA 1A mean TP with time (2019-2024).

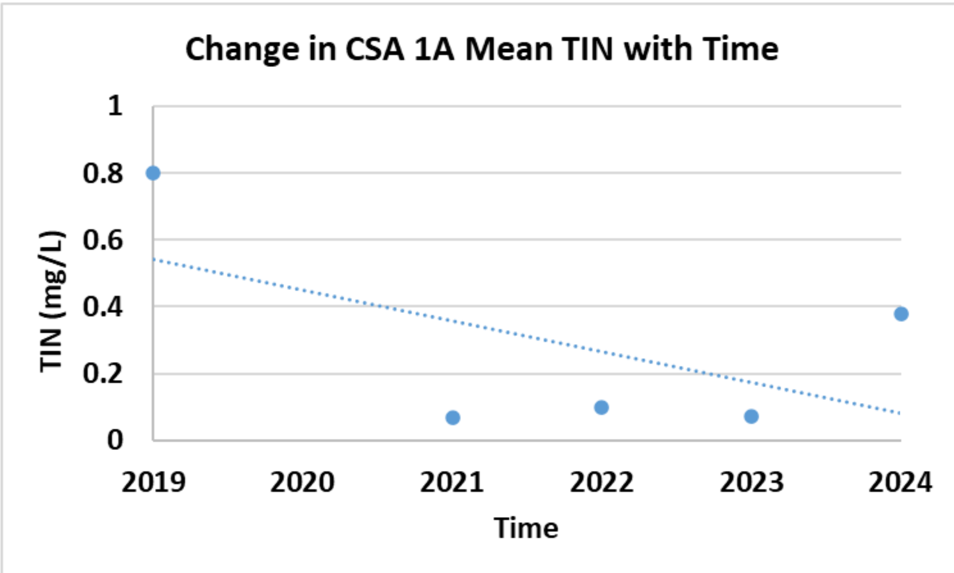

Figure 20. Change in CSA 1A mean TIN with time (2019-2024).

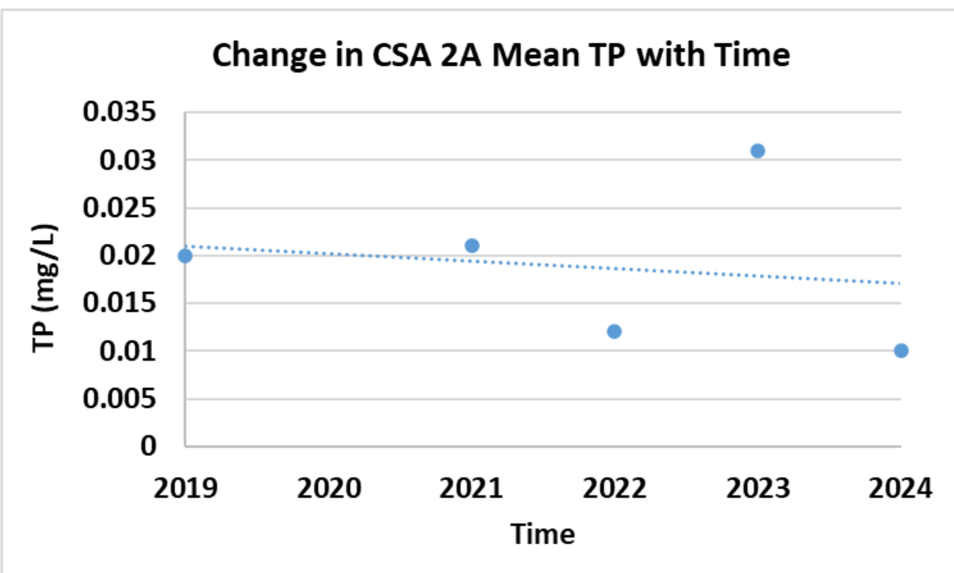

Figure 21. Change in CSA 2A mean TP with time (2019-2024).

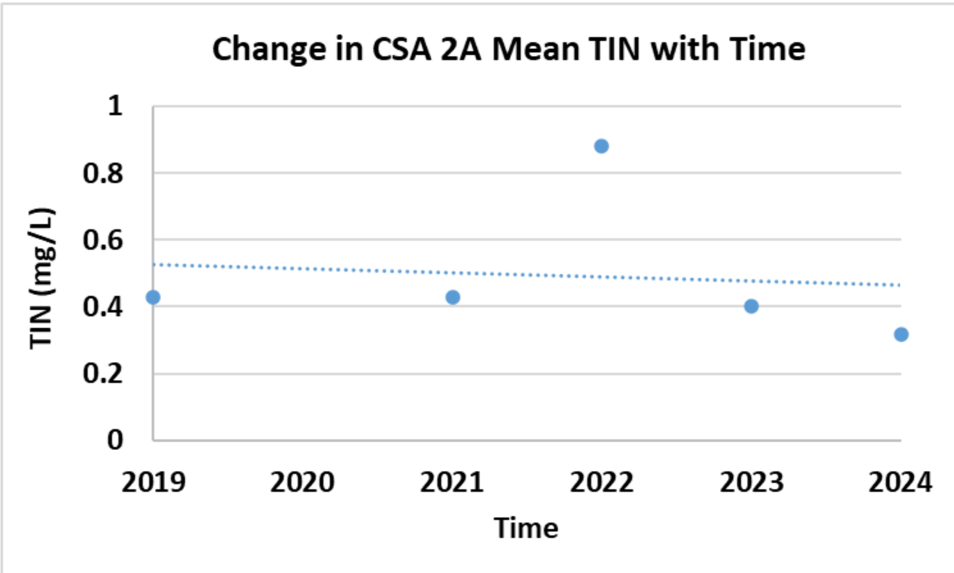

Figure 22. Change in CSA 2A mean TIN with time (2019-2024).

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 30-31). 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. The majority of the biovolume should be in the lowest to moderate categories (≤ 20%) for optimum recreation and fishery habitat.

Table 30. Lake LeAnn north basin aquatic vegetation biovolume by category percent cover of each category (relative cover 2019, 2021-2024).

Biovolume Cover Category	2019 % Relative Cover of Bottom by Category	2021 % Relative Cover by Category	2022 % Relative Cover by Category	2023 % Relative Cover by Category	2024 % Relative Cover by Category
<5%	59.7	32.1	56.6	43.1	54.1
5-20%	15.7	29.1	23.6	28.9	28.9
20-40%	9.9	19.8	12.6	15.0	14.7
40-60%	5.5	12.0	5.4	8.9	2.0
60-80%	3.4	2.0	0.7	1.5	0.2
>80%	5.7	4.3	1.1	1.5	0.1

Table 31. Lake LeAnn south basin aquatic vegetation biovolume by category percent cover of each category (relative cover 2019, 2021-2024).

Biovolume Cover Category	2019 % Relative Cover by Category	2021 % Relative Cover by Category	2022 % Relative Cover by Category	2023 % Relative Cover by Category	2024 % Relative Cover by Category
<5%	58.0	70.3	71.1	76.4	70.1
5-20%	22.3	22.7	22.1	19.4	22.7
20-40%	12.3	5.0	4.7	4.4	5.9
40-60%	3.2	1.0	1.3	1.6	1.0
60-80%	1.8	0.3	0.3	0.1	0.2
>80%	2.4	0.6	0.5	0.1	0.1

IV. Sediment Relative Hardness:

The relative hardness of sediments in the north basin has slightly increased over time and the softest bottom category has decreased slightly (~18%) over time for both basins (Tables 32-33). This is a favorable outcome. The intermediate and most consolidated categories have remained relatively similar over the years.

Table 32. 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 %	2023 Relative Cover %	2024 Relative Cover %
0.0-0.1	0.7	0.3	0.2	0.07	0.0
0.1-0.2	18.4	6.5	5.4	1.70	0.5
0.2-0.3	48.4	63.6	61.5	56.23	66.2
0.3-0.4	32.5	29.4	32.7	41.98	33.3
>0.4	0.01	0.1	0.2	0.02	0.0

Table 33. 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 %	2023 Relative % Cover	2024 Relative % Cover
0.0-0.1	0.5	0.0	0.1	0.01	0.0
0.1-0.2	18.2	8.7	6.1	0.48	1.1
0.2-0.3	49.9	64.9	63.2	51.26	79.4
0.3-0.4	31.3	26.4	30.5	48.25	19.5
>0.4	0.1	0.0	0.1	0.0	0.0

V. Phytoplankton:

RLS has measured total chlorophyll-a 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 33-34 clearly show an overall decline in chlorophyll-a over time since LFA began and especially post-biochar in 2024. Figures 23-24 show the trend in the in situ Chl-a with time in both basins.

Table 34. Lake LeAnn north basin in situ chlorophyll-a concentrations (2021-2024).

Sampling Location	July 19 2021	May 10 2022	July 12 2022	Sept 15 2022	Apr 26 2023	July 25 2023	Sept 19 2023	May 7 2024	July 2 2024	Sept 9 2024
North #1	28	3	12	6	11	13	5	3	5	5
North #2	20	3	12	9	11	9	6	3	6	4
North #3	25	2	17	9	11	13	6	3	8	10
North #4	20	NA	5	7	11	11	7	4	5	6
North #5	20	3	10	9	11	11	3	3	5	5
MEAN	**22.6**	**2.8**	**11.2**	**8**	**11.0**	**11.4**	**5.4**	**3.2**	**5.8**	**6.0**

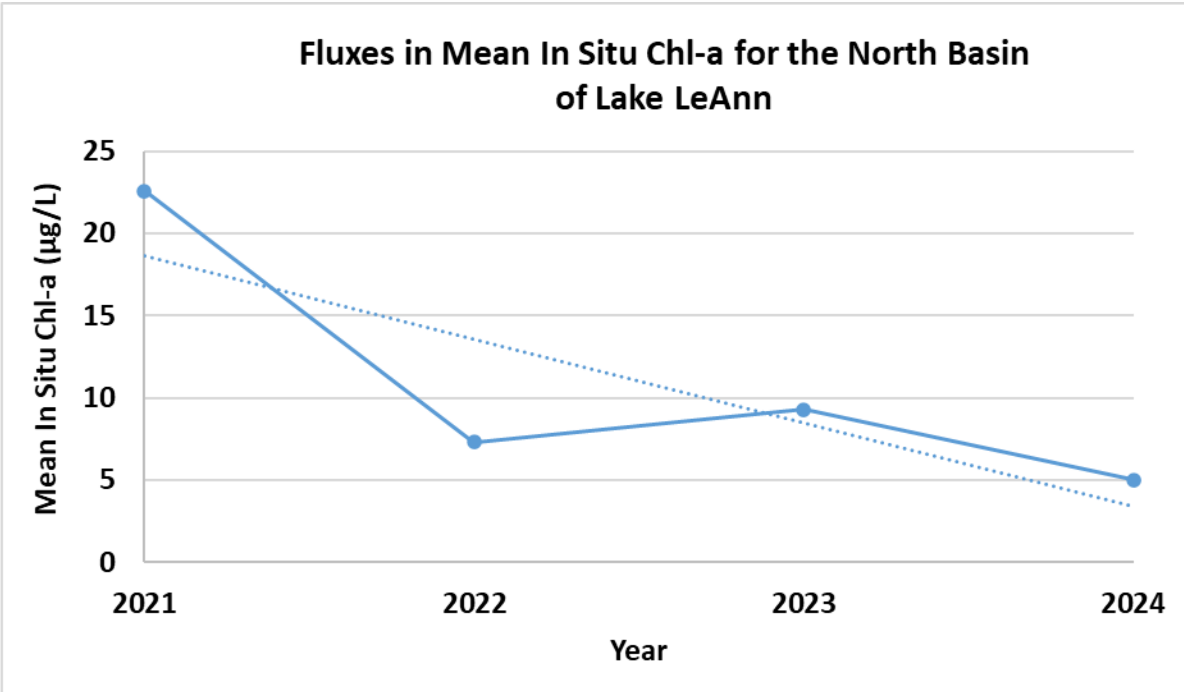

Figure 23. Trend in mean in situ Chl-a in the north basin of Lake LeAnn (2021-2024).

Table 35. Lake LeAnn south basin in situ chlorophyll-a concentrations (2021-2024).

Sampling Location	**July 19 2021**	**May 10 2022**	**July 12 2022**	**Sept 15 2022**	**Apr 26 2023**	**July 25 2023**	**Sept 19 2023**	**May 7 2024**	**July 2 2024**	**Sept 9 2024**
South #1	38	2	7	6	3.0	5.0	10.0	3	4	2
South #2	35	4	8	8	4.0	5.0	10.0	2	4	6
South #3	38	4	6	5	4.0	4.0	7.0	2	2	6
South #4	33	5	8	5	5.0	7.0	7.0	2	3	6
South #5	35	4	6	7	3.0	8.0	7.0	2	4	3
MEAN	**35.8**	**3.8**	**7.0**	**6.2**	**3.8**	**5.8**	**8.2**	**2.2**	**3.4**	**4.6**

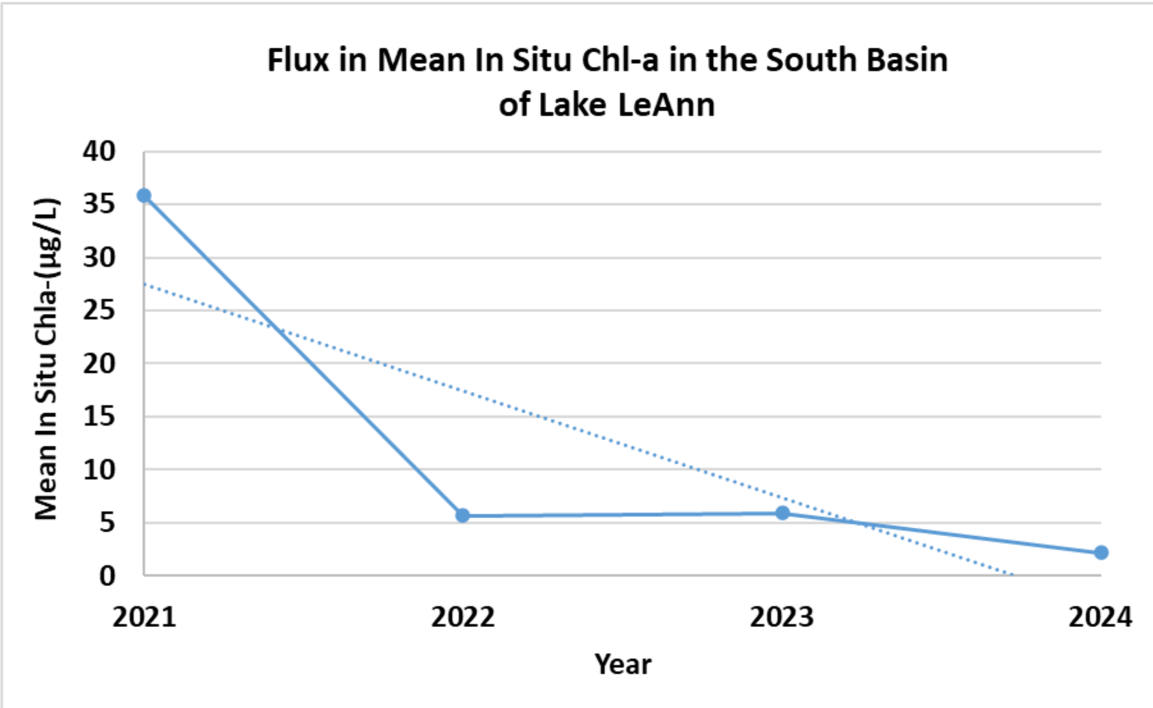

Figure 24. Trend in mean in situ Chl-a in the <u>south basin</u> of Lake LeAnn (2021-2024).

VII. Management Recommendations for 2025:

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. Over the past three years, the new systemic herbicide ProcellaCOR® was used 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 2024. 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. For 2025, RLS recommends leaving some of the Curly-leaf Pondweed to absorb some of the phosphorus and compete with the algae prevalent in the water column. This may be accomplished by treating only selective areas or removing dense areas with mechanical harvesting. This plant naturally dies back by mid-July. Due to the relative scarcity of favorable low-growing submersed aquatic vegetation in Lake LeAnn, there is a need to preserve as much cover as possible.

In past years, BioBlast® bioaugmentation methodology was used to attempt to effectively reduce blue-green algal blooms with little success. In 2024, Timberchar® Biochar was implemented in the lake basins to reduce nutrients associated with these blooms. This biochar has proven to be effective so far in further reducing the nutrients in the lakes. RLS recommends continuation with the biochar program. Due to the elevated blue-green algae blooms in the northern region of the north basin, RLS recommends another method for reducing nearshore phosphorus loading. The use of EutroSorb® or MetaFloc® to reduce these loads is recommended for select area of the north basin. RLS will work with the LLPOA to measure dissolved oxygen ,TP, and TIN in nearshore areas of the north basin to determine possible nearshore internal loading that resulted in the 2024 algal blooms in those regions.

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 lake restoration system will be reduced. 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. RLS will also be surveying the lake for possible carp dominance in 2024 to make possible recommendations for a carp cull that may be needed as these fish can contribute to turbid lake waters.