

LAKE LEMON MONITORING PROGRAM
2024 Results Summary



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Lake Lemon 2024 Water Monitoring Overview

The Lake Lemon Conservancy District (LLCD) began contracting Indiana University in 1998 to monitor water quality of the lake and incoming tributaries. Figure 1 shows the sampling locations for Lake Lemon and the tributaries in 2024. IU has provided full sampling methods to the LLCD. Figure 2 displays precipitation during the sampling season with individual sampling events indicated.

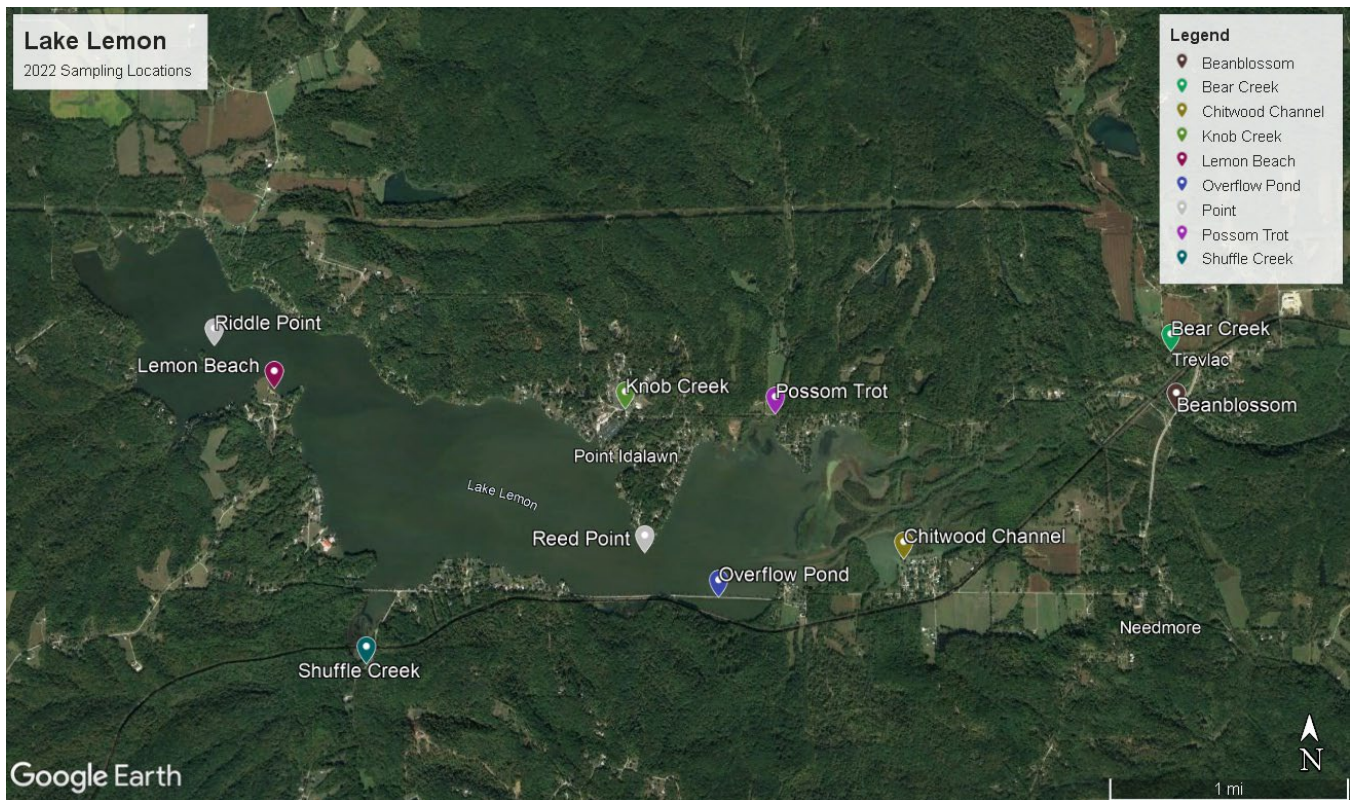


Figure 1 Sampling locations for the Lake Lemon Water Monitoring Program.

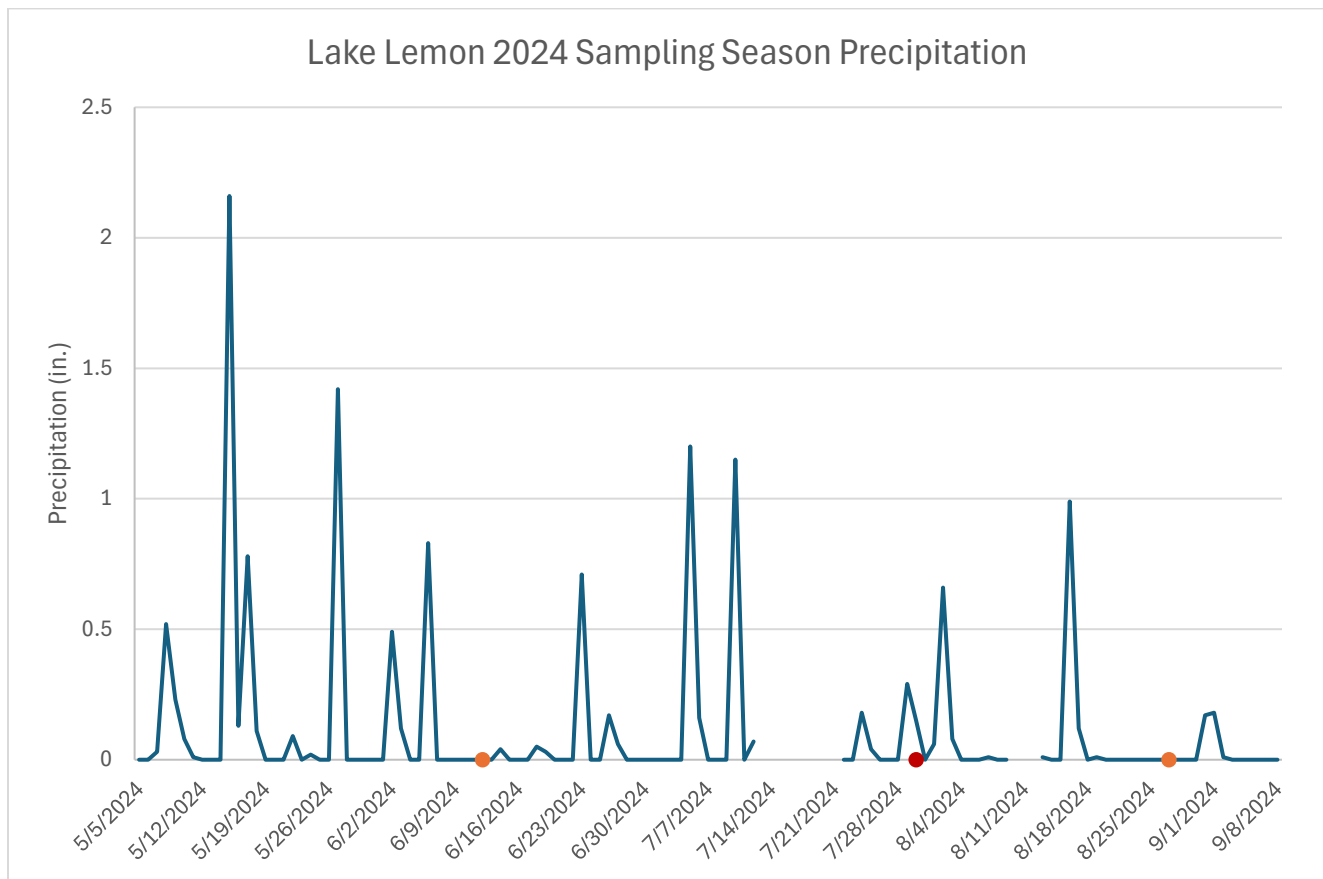


Figure 2 Precipitation amounts during the 2024 sampling season.

Lake Lemon 2024 Summary Results

Temperature and Dissolved Oxygen

IU collected a full profile of temperature and dissolved oxygen from one-meter depth increments through the water column at Riddle and Reed Point in Lake Lemon. The temperature profile illustrates the seasonal variation in water temperature and thermal stratification that occurs as the surface water warms. This year, only the top meter of water remained oxygenated during the August sampling event at Riddle Point (Figure 3). During the August sampling event, the dissolved oxygen dropped after the first meter before dipping into hypoxic levels at 3 meters and greater. The August dissolved oxygen concentrations this year averaged 13.9 mg/L in the epilimnion. This is a significant increase of more than 4.3 mg/L from last year's sample taken mid-August at Riddle Point. Anoxic conditions develop below 4 meters mid-summer as organic matter on the lake bottom creates biochemical oxygen demand (BOD) that breaks down the organic matter consuming available oxygen. Stratification of the surface water reduces mixing of oxygen in the deeper water. The shallow depth of Reed Point and lake turbulence usually keep this area of the lake well mixed and oxygenated, however later this season as was the case last year, we saw anoxic conditions below 2 meters deep for the July sampling event (Figure 4).

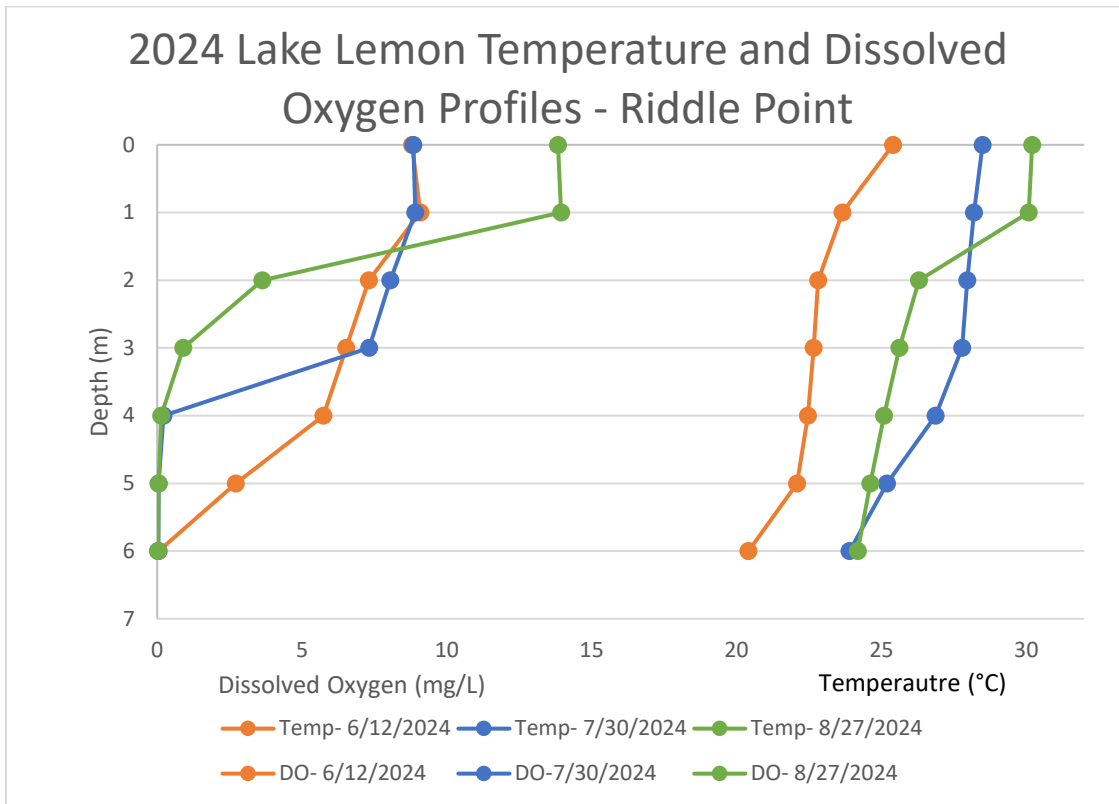


Figure 3 Temperature and dissolved oxygen profiles from all sample dates from Indiana University at Riddle Point in 2024.

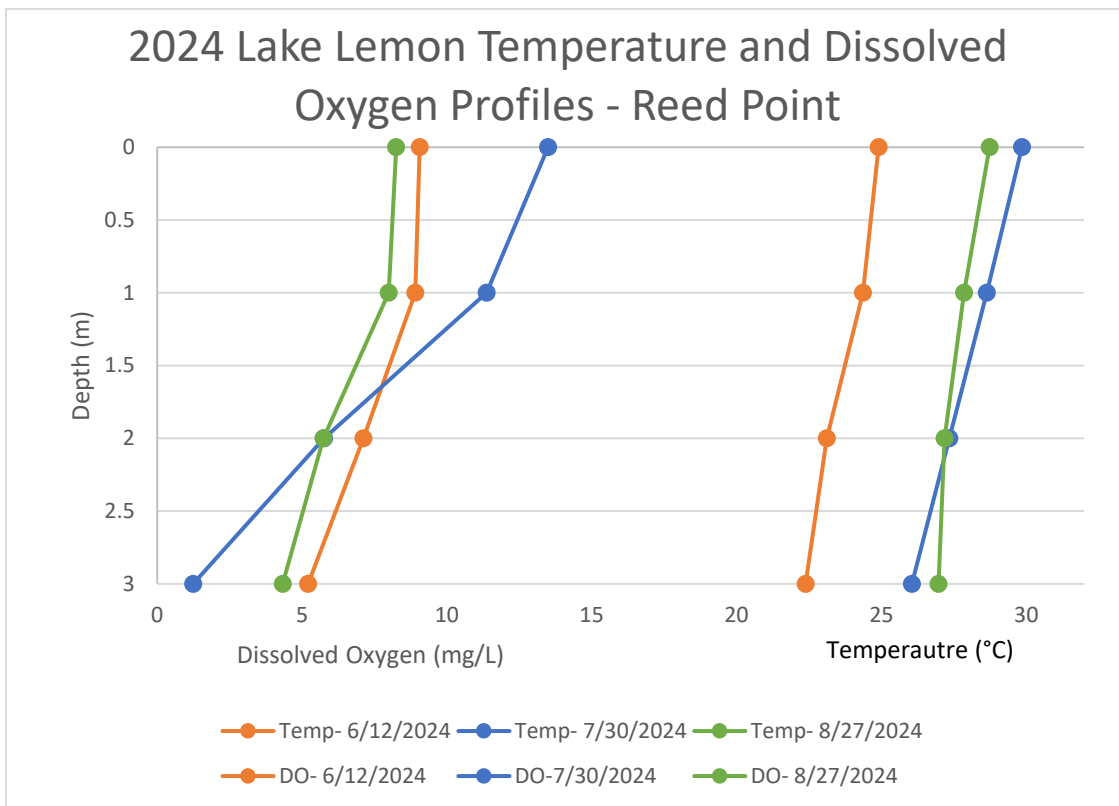


Figure 4 Temperature and dissolved oxygen profiles from all sample dates from Indiana University at Reed Point in 2024.

Water Quality Summary

IU collected epilimnion samples from the top 2 meters of the water column and hypolimnion at 6 meters depth (19.7 ft) at Riddle Point. IU collected an integrated epilimnion sample only this summer.

Table 1 Water Quality Characteristics of Lake Lemon – Riddle Point and Reed Point, 6/12/2024.

Parameter	Riddle		Reed
	Epilimnion	Hypolimnion	Epilimnion
Secchi (m)	0.95	--	0.675
Light trans @ 1m (%)	20.2	--	19
1% Light Level (ft)	9.8	--	7.5
% Water Column Oxic	85.7	--	100
pH	7.42	6.74	7.85
Conductivity (uS/cm))	168.76	193.14	174.34
Acid Neutralizing Capacity (mg/L)	66.5	71.25	68
Nitrate (mg/L)	0.0237	0.0052	0.0034
Ammonia (mg/L)	0.2004	0.19005	0.0761
Total Nitrogen (mg/L)	0.308	0.3256	0.4807
Orthophosphate (mg/L)	0.0067	0.0067	0.0061
Total Phosphorus (mg/L)	0.054	0.0556	0.0555
Chlorophyll- <i>a</i> (ug/L)	14.0885	--	11.454
Plankton (Cells/mL)	9,985	--	11,141
Blue-green (Cells/mL)	7,867	--	8,409
HAB (Cells/mL)	3,033	--	2,582
HAB %	30	--	23
<i>E. coli</i> (#/100 mls)	0	--	2

Table 2 Water Quality Characteristics of Lake Lemon – Riddle Point and Reed Point, 7/30/2024.

Parameter	Riddle		Reed
	Epilimnion	Hypolimnion	Epilimnion
Secchi (m)	0.68	--	0.48
Light trans @ 1m (%)	--	--	--
1% Light Level (ft)	1.4	--	1
% Water Column Oxic	57.1	--	100
pH	8.91	7.45	8.42
Conductivity (uS/cm)	167.32	204.15	171.09
Acid Neutralizing Capacity (mg/L)	77.5	102	79
Nitrate (mg/L)	0.0187	0.0211	0.0197
Ammonia (mg/L)	0.0882	1.09595	0.2047
Total Nitrogen (mg/L)	0.8629	1.5476	0.6794
Orthophosphate (mg/L)	0.0084	0.15785	0.0071
Total Phosphorus (mg/L)	0.0595	0.21955	0.0639
Chlorophyll-a (ug/L)	48.311	--	56.824
Plankton (Cells/ml)	303,622	--	301,989
Blue-green (Cells/mL)	294,033	--	288,157
HAB (Cells/mL)	272,180	--	256,201
HAB %	90	--	85
<i>E. coli</i> (#/100 mls)	3	--	7
Cylindrospermopsin (µg/L)	not detected	--	not detected

Table 3 Water Quality Characteristics of Lake Lemon – Riddle Point and Reed Point, 8/27/2024.

Parameter	Riddle		Reed
	Epilimnion	Hypolimnion	Epilimnion
Secchi (m)	0.55	--	0.55
Light trans @ 1m (%)	3.99	--	3.23
1% Light Level (ft)	5.6	--	4.3
% Water Column Oxic	42.9	--	75
pH	9.5	7.41	9.03
Conductivity (uS/cm)	203.07	224.29	204.4
Acid Neutralizing Capacity (mg/L)	68.5	85	79
Nitrate (mg/L)	0.0339	0.05455	0.0262
Ammonia (mg/L)	0.0202	0.48115	0.2694
Total Nitrogen (mg/L)	1.0194	1.51034	1.1101
Orthophosphate (mg/L)	0.006	0.0324	0.0041
Total Phosphorus (mg/L)	0.0914	0.1226	0.0791
Chlorophyll-a (ug/L)	52.5325	--	49.982
Plankton (Cells/ml)	285,276	--	217,148
Blue-green (Cells/mL)	269,443	--	193,148
HAB (Cells/mL)	190,129	--	142,432
HAB %	67	--	66
<i>E. coli</i> (#/100 mls)	3	--	1
Cylindrospermopsin (µg/L)	not detected	--	not detected

Primary Productivity

Chlorophyll-a, which is a measure of the primary pigment in algae, is a direct measure of algal productivity. In the integrated epilimnion samples from the surface to the 2-meter depth, the chlorophyll-*a* concentrations ranged from 11.5 µg/L in June to 56.8 µg/L in August. Chlorophyll-*a* concentrations >7 µg/L are indicative of eutrophic lake conditions. Overall, we see a seasonal pattern of nutrient increase by late summer as total phosphorous concentrations increase, which is characteristic of Lake Lemon. This pattern is mirrored by increases in chlorophyll-*a* concentrations. This suggests that conditions exist for increasing growth of algae during the growing season (Figures 5 and 6).

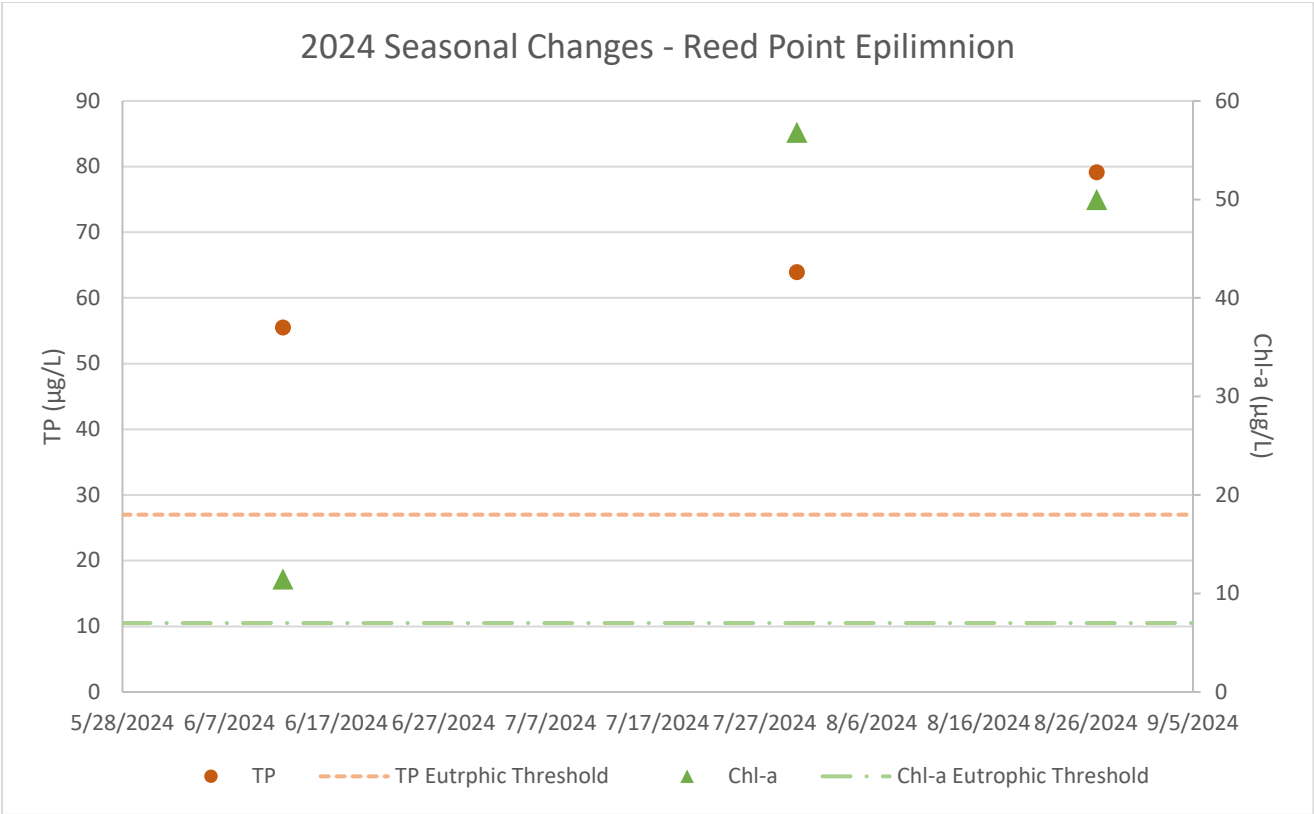


Figure 5 Seasonal changes in total phosphorus and chlorophyll-a in the surface waters (epilimnion) at Reed Point in Lake Lemon in 2024.

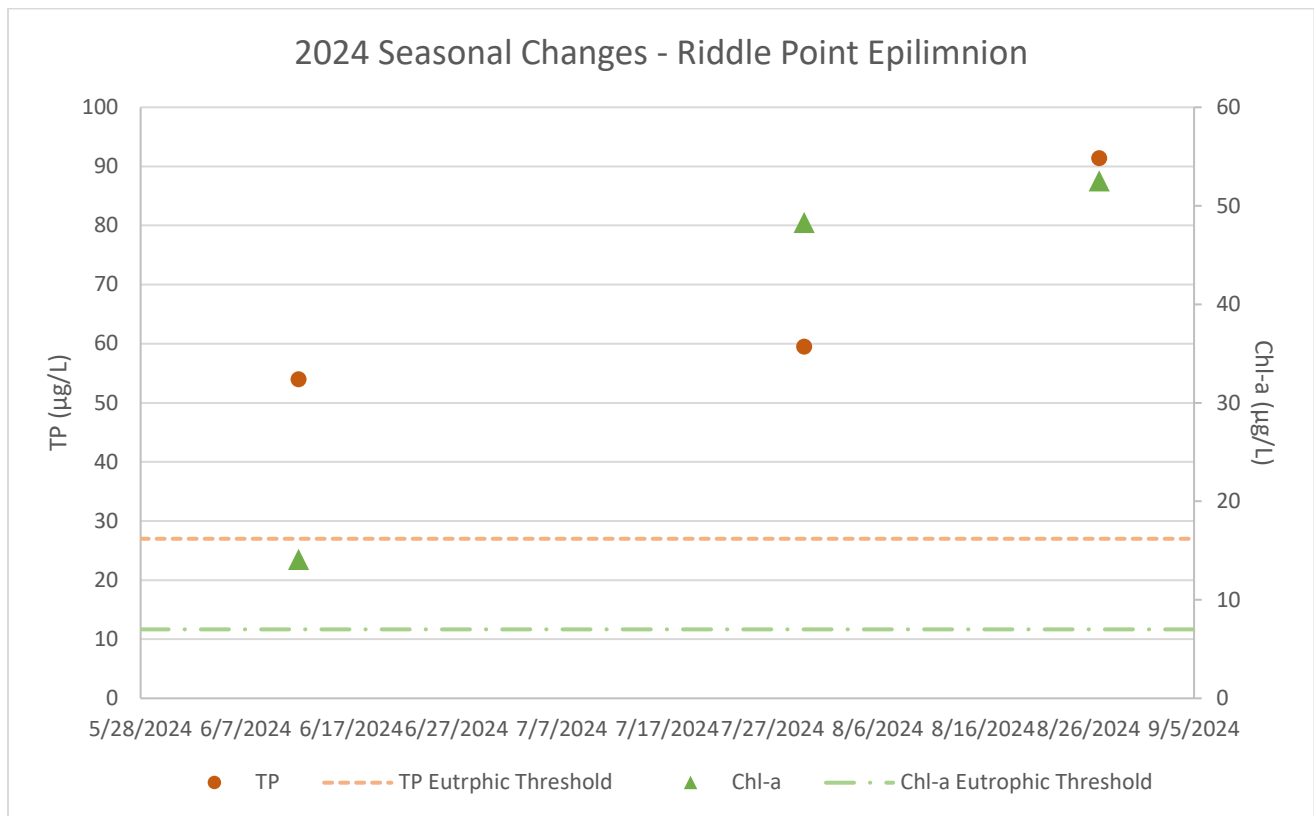


Figure 6 Seasonal changes in total phosphorus and chlorophyll-a in the surface waters (epilimnion) at Riddle Point in Lake Lemon in 2024.

Bacteria at Beach and Tributaries

IU collected *E. coli* samples around the Lake Lemon watershed in 2024 (Tables 4 and 5). The state standard for full body contact and recreation is 200 colonies per 100mLs. This year, only one instance of *E. coli* exceeding this standard was recorded in the entire watershed. Additionally, water levels were low for the August sampling event with the Knob Creek site being dry. Weekly monitoring of the beach—and its lower level of *E. coli* compared to the rest of the watershed—continues to bring down the historical count of EPA *E. coli* standard exceedances for recreation at Lake Lemon and its tributaries from 36% to 32% (Figure 7).

Table 4 Tributary *E. coli* for 2024.

	<i>E. coli</i> (#/100 mls)	<i>E. coli</i> (#/100 mls)
	7/30/24	8/27/24
Beanblossom Creek	24	32
Bear Creek	92	42
Chitwood Channel	52	18
Knob Creek	120	--
Possum Trot	124	10
Shuffle Creek	60	28

Table 5 Lemon Beach *E. coli* for 2024.

Lake Lemon Beach	<i>E. coli</i> (#/100 mls)	Lake Lemon Beach	<i>E. coli</i> (#/100 mls)
5/13/2024	124	7/15/2024	2
5/16/2024	70	7/22/2024	36
5/20/2024	18	7/30/2024	25
5/29/2024	26	8/5/2024	12
6/5/2024	8	8/12/2024	4
6/12/2024	3	8/19/2024	470
6/17/2024	40	8/21/2024	2
6/24/2024	48	8/28/2024	24
7/2/2024	2	9/5/2024	1
7/8/2024	4		

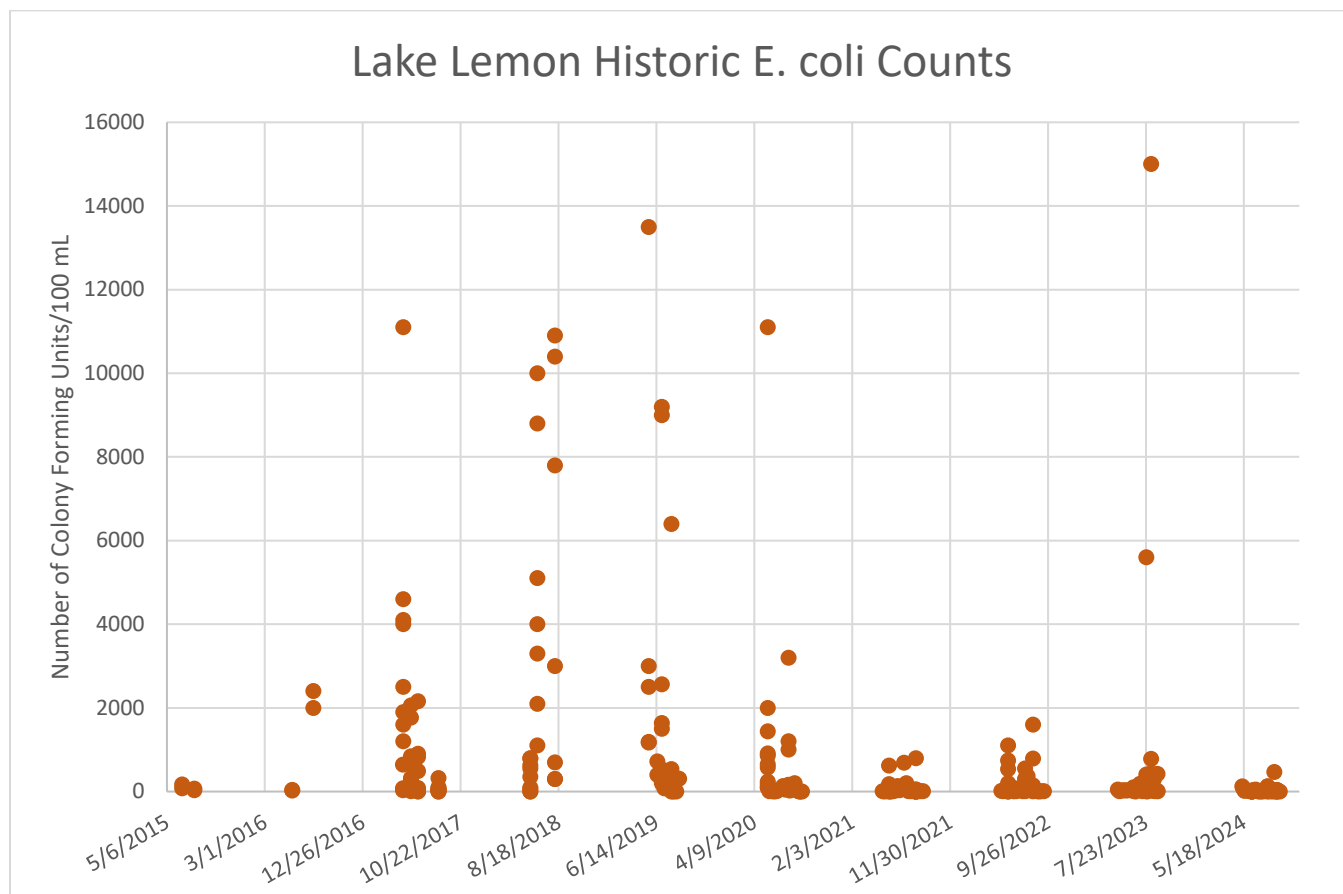


Figure 7 Changes in *E. coli* concentrations at Lake Lemon beach and tributaries during sample events from 2015 to 2024. Note that 96 of the 302 events exceeded 200 CFU/100 mLs.

Phytoplankton at Beach and Overflow Pond

In the fourth year of expanded harmful algal bloom (HAB) monitoring, a weekly beach sample was taken over the course of late summer (Table 6). Unlike the last few years, there was no clear pattern for the phycocyanin value from the sonde to initiate sending out samples for HAB analysis. Instead, we decided to use the chlorophyll- α concentration from the lab to at least capture high algal biomass. Once the beach reached a concentration of at least 50 $\mu\text{g/L}$ of chlorophyll, we sent out for algal taxa counts every other week. As with previous years, the beach peaked in total algal as well as HAB concentrations in late July/early August.

The fluorometric sonde readings were inconclusive based on the phytoplankton counts. Where there was a majority of HAB cells, phycocyanin was lower. As overall algal biomass decreased, HABs included phycocyanin did not similarly decrease as seen especially in the September sampling event. In addition to monitoring for HAB cells, we also tested for the presence of the algal toxin cylindrospermopsin in late summer at the beach as well as within the lake (Tables 2, 3, and 6). No detectable limit was found at any site.

Table 6 Phytoplankton counts at Lake Lemon Beach during the 2024 summer season with in-situ phycocyanin measurements, lab chlorophyll-a and cylindrospermopsin concentrations.

Site	Date	Plankton (Cells/mL)	HAB (Cells/mL)	HAB %	Phycocyanin (RFU)	Chl- α ($\mu\text{g/L}$)	Cylindrospermopsin ($\mu\text{g/L}$)
Beach	6/5/2024	--	--	--	13.703	--	--
	6/12/2024	--	--	--	4.166	6.186	--
	6/17/2024	--	--	--	3.314	10.527	--
	6/24/2024	--	--	--	3.013	11.368	--
	7/2/2024	--	--	--	5.172	27.586	--
	7/8/2024	--	--	--	12.155	30.999	--
	7/15/2024	--	--	--	5.359	43.761	--
	7/22/2024	--	--	--	15.241	39.65	not detected
	7/30/2024	--	--	--	3.278	59.979	not detected
	8/5/2024	440,483	383,660	87	5.709	47.726	not detected
	8/12/2024	--	--	--	13.202	57.627	not detected
	8/19/2024	380,655	287,444	76	5.924	53.827	not detected
	8/21/2024	432,294	291,842	68	8.41	57.26	not detected
	8/28/2024	--	--	--	10.720	33.834	not detected
	9/5/2024	195,341	105,192	54	8.231	35.116	not detected

Trophic State

The trophic state of a lake helps characterize the level of productivity and the expected life that may exist in a lake. The overall classifications of lakes can help with comparison across lakes as well as from year to year. We use Carlson's Trophic State as it was developed based on lakes similar to those in Indiana.

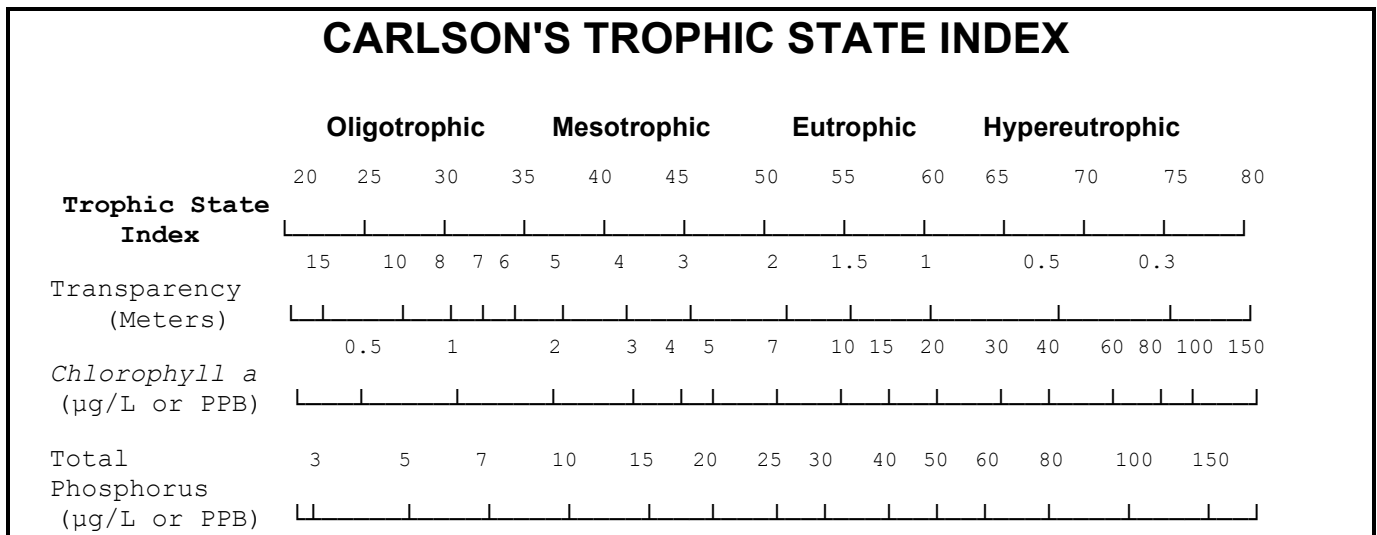


Figure 8 Carlson's trophic state index.

Table 7 Characteristics of trophic state categories.

Classification	Transparency	Nutrients	Algae	D.O.	Fish
Oligotrophic	clear	Low TP < 6 µg/L	few algae	Hypo has D.O.	can support salmonids (trout and salmon)
Mesotrophic	Less clear	Moderate TP 10-30 µg/L	healthy populations of algae	Less D.O. in hypo	lack of salmonids
Eutrophic	transparency <2 meters	High TP > 35 µg/L	abundant algae and weeds	No D.O. in the hypo during the summer	Warmwater fisheries only. Bass may dominate.
Hypereutrophic	transparency <1 meter	extremely high TP > 80 µg/L	thick algal scum Dense weeds	No D.O. in the hypo during the summer	Rough dominate. Summer fish kills possible.

We use Riddle Point Carlson TSI scores to look at the historic trend for Lake Lemon demonstrating that the lake is generally characterized as eutrophic. Figures 9-11 illustrate the Carlson TSI historic trends for Secchi disk, total phosphorus, and chlorophyll-*a*. Blue dots represent May, June, and early July samples while the orange dots represent the last summer samples, usually late July or August. The eutrophic status for Carlson TSI across the three parameters is 50 and represented in each figure by a purple dotted line. The 26-year mean for each reading: Secchi disk, chlorophyll-*a*, and total phosphorus is above this Carlson TSI eutrophic status score. Overall, a pattern of seasonal variation of lower scores (less eutrophic) in the spring and increasing trophic state to eutrophic/hypereutrophic status by late summer exists during the monitoring of Lake Lemon. As evident by the graphs, rarely do any of the late summer samples fall below the eutrophic categorization. This only happened once in 2006 for chlorophyll-*a* and once in 2018 for total phosphorus. All Secchi disk TSI values in late summer are above eutrophic status.

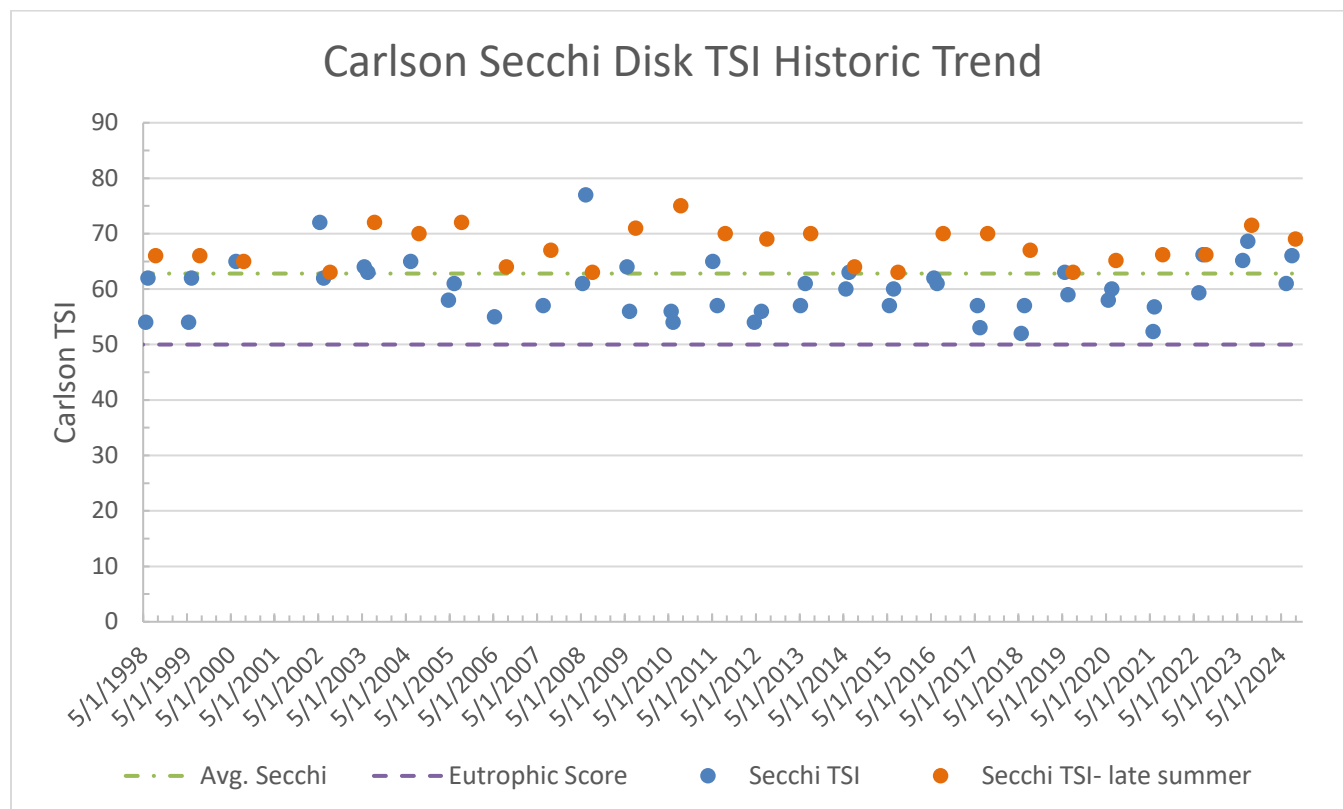


Figure 9 The 26-year historic trend for Carlson Secchi disk TSI scores in blue and orange with the average Secchi across this timeframe as the green dashed line.

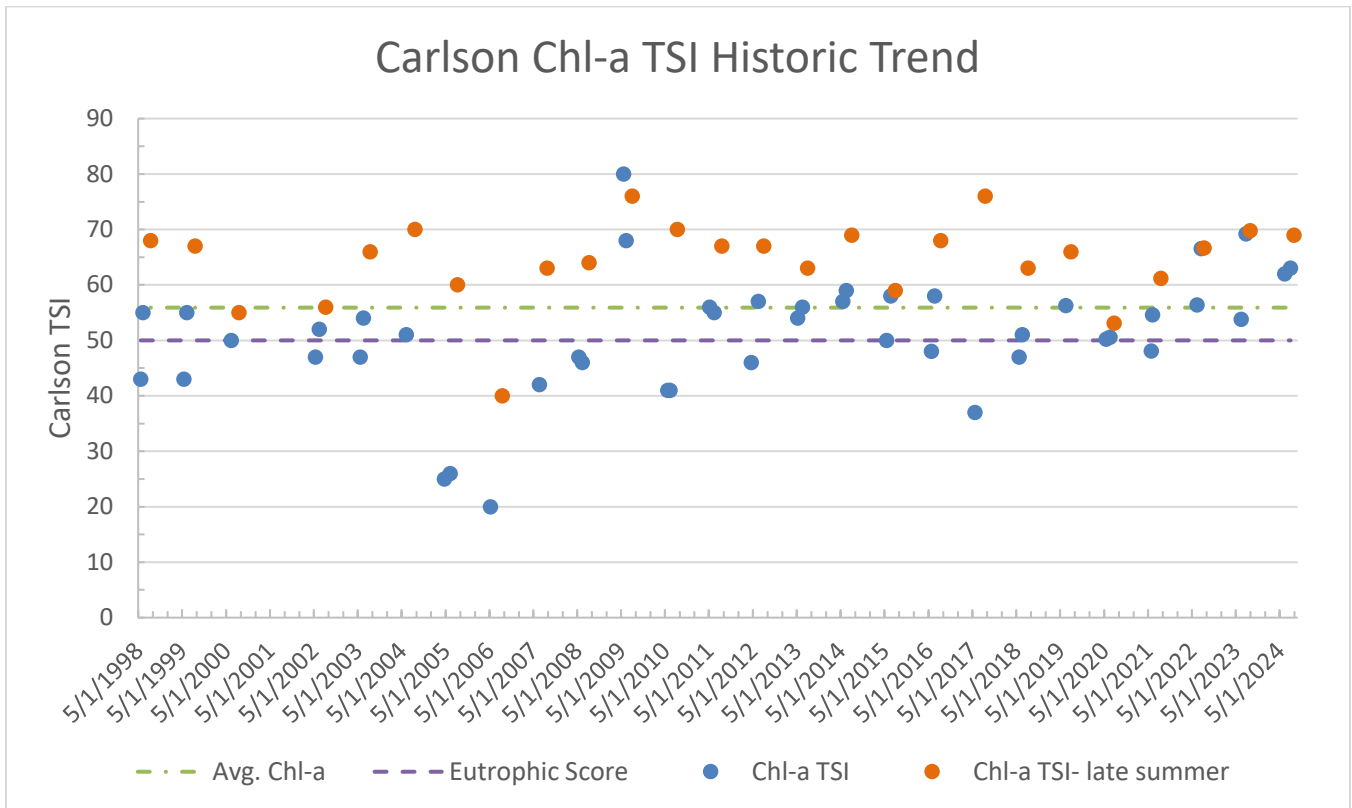


Figure 8 The 26-year historic trend for Carlson chlorophyll-a TSI scores in blue and orange with the average chlorophyll-a across this timeframe as the green dashed line.

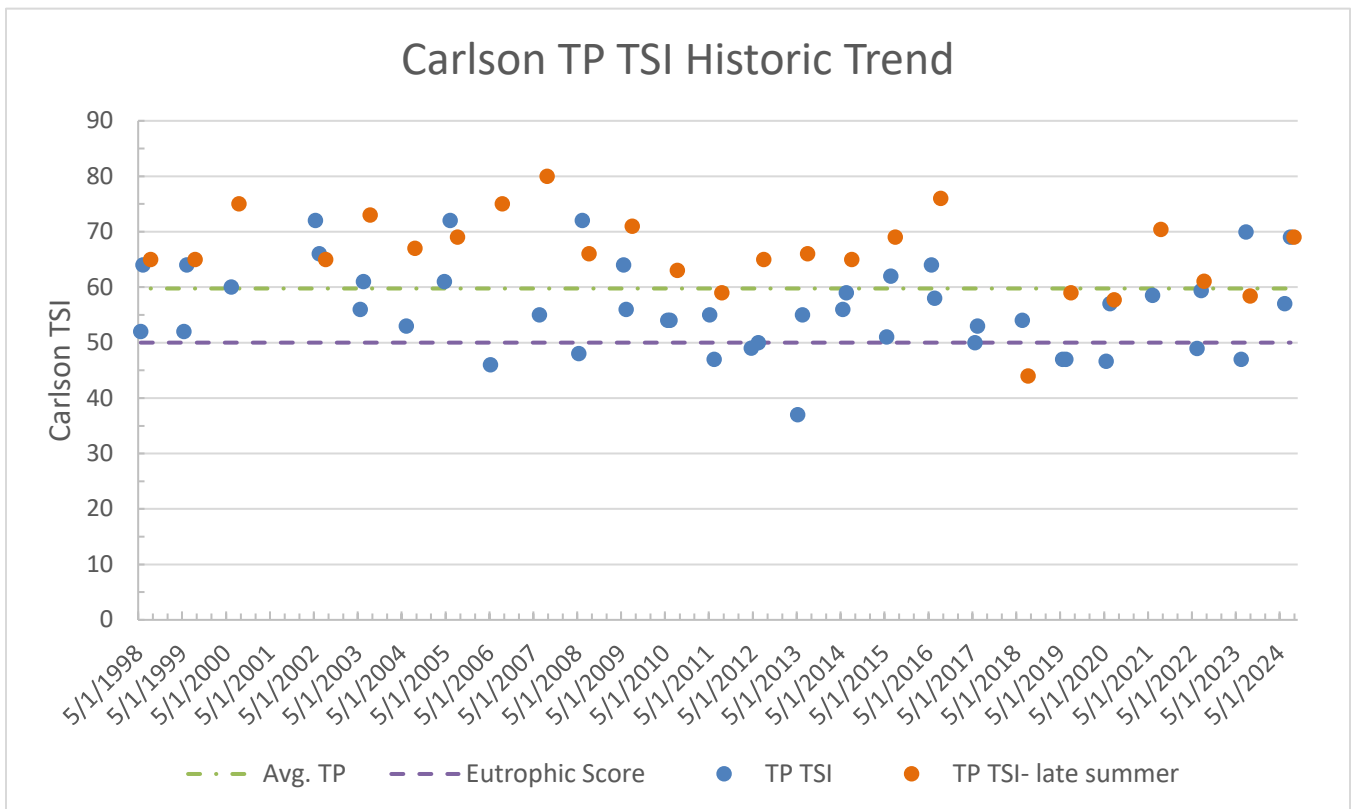


Figure 11 The 26-year historic trend for Carlson total phosphorus TSI scores in blue and orange with the average TP across this timeframe as the green dashed line.

Lake Lemon Water Monitoring Conclusions and Recommendations

We monitor for harmful algal blooms (HABs) in Lake Lemon due to their potential of producing toxins. With the additional testing of the cyanobacteria-produced toxin, cylindrospermopsin, real-time conditions can be taken into consideration on the effects to human health. Due to the inconsistencies we have encountered with the fluorometric sonde readings that are similarly seen in other labs, toxin screening could be a better tool for immediate, cost-effective decision-making at the lake. Contracting with Phycotech for algal analysis can confirm changes to species composition if adjustments are needed as to the specific toxin to screen. We recommend regular beach monitoring for HABs and will continue to monitor the Reed and Riddle Point during normal sampling events in June, July, and August. We also recommend continuing to monitor algal blooms in 2024 and using the contract lab Phycotech for speed and consistency of results.

As to cost-saving monitoring strategies, decisions on what the is the main concern on which management decisions at the beach will be made. If human health is of interest, toxin screening is a reliable candidate. If monitoring for the effects of significant changes to the reservoir and its ecosystem like dredging or large wakes is the more important matter, then routine sampling each year is a more suitable method to address those concerns. Until a decision is made, we will continue to build off the cost-saving exploration of using readily available, real-time resources for HAB monitoring by measuring algal pigments at the beach during sampling events. We will keep working with the Lake Manager to develop the best strategy for monitoring HABs as well as overall lake status.

Bacteria issues are still a challenge in the incoming tributaries to the lake, especially after storm events. We recommend continuing to monitor the stream inlets.