LAKE LEMON MONITORING PROGRAM

2018 Results Summary

Prepared for:

Lake Lemon Conservancy District

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Lake Lemon 2018 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 2018. IU has provided full sampling methods to the LLCD.

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

Lake Lemon 2018 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. The temperature profile illustrates the seasonal variation in water temperature and thermal stratification that occurs as the surface water warms. The upper 3 meters of water remained oxygenated during all four sampling events at Riddle Point (Figure 1). The August dissolved oxygen concentrations averaged 8.7 mg/L in the epilimnion, a slight increase of approximately 0.5 mg/L respectively from the sample collected during July of 2018. Anoxic conditions develop below 3 meters depth 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 keep this area of the lake well mixed and oxygenated (Figure 2).

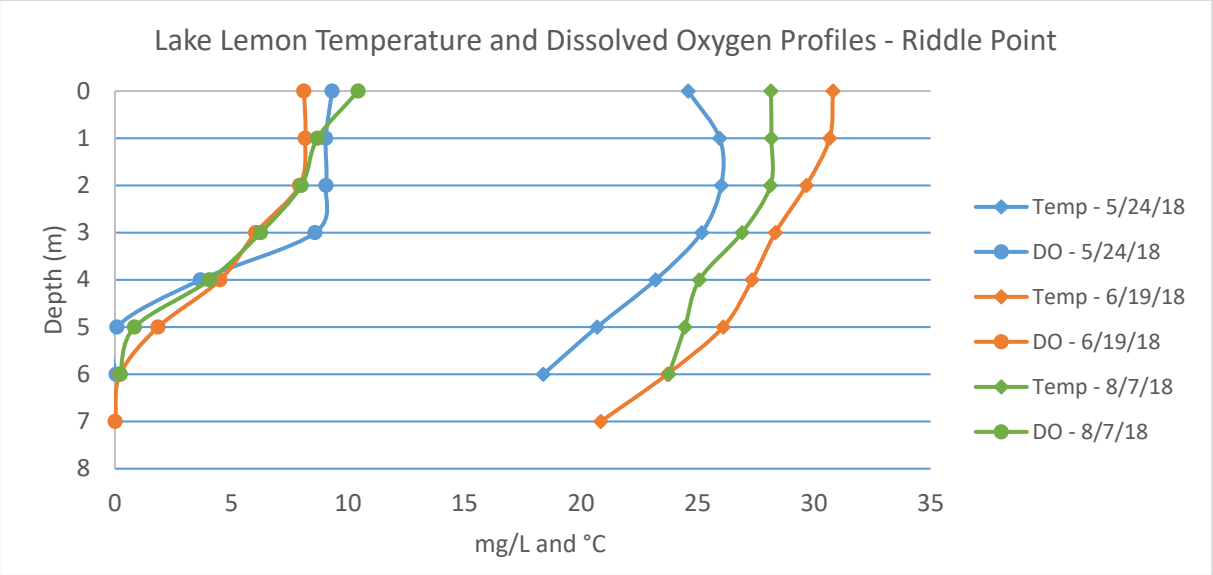

Figure 1. Temperature and dissolved oxygen profiles from all sample dates in from Indiana University at Riddle Point in 2018.

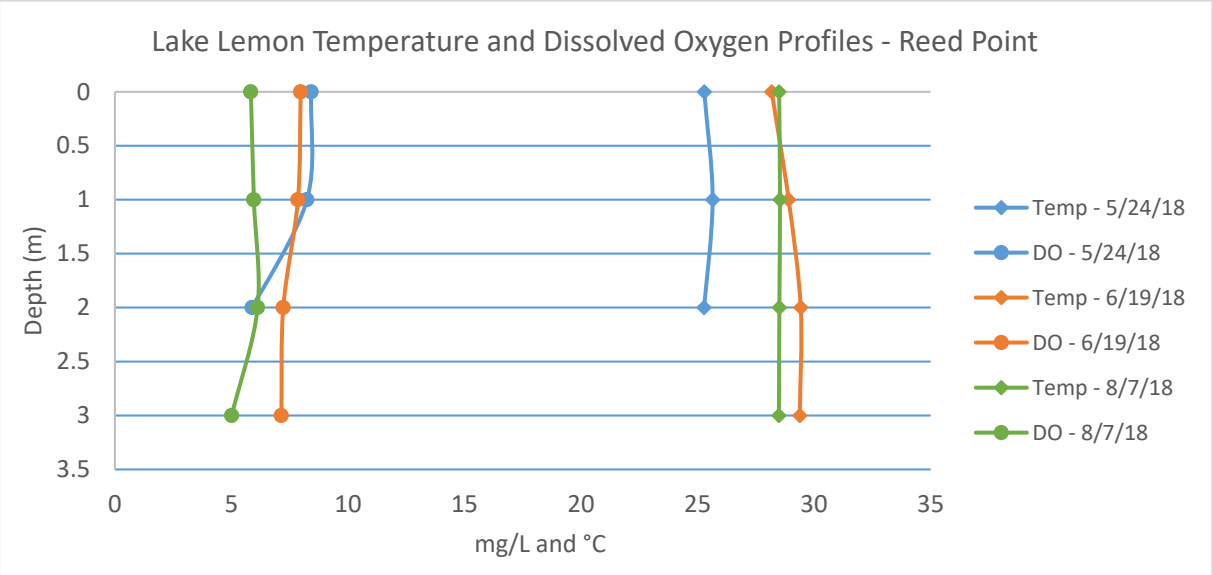

Figure 2. Temperature and dissolved oxygen profiles from all sample dates in from Indiana University at Reed Point in 2018.

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 samples in the epilimnion only at Reed Point.

Table 1. Water Quality Characteristics of Lake Lemon – Riddle Point and Reed Point, 5/24/2018.

Parameter	Riddle		Reed
	Epilimnion	Hypolimnion	Epilimnion
Secchi (m)	1.7	--	0.9
Light trans @ 3' (%)	31	--	5
1% Light Level (ft)	13.4	--	8.2
% Water Column Oxic	71	--	100
pH	7.6	6.84	7.45
Conductivity (uS/cm))	163.5	136.8	--
Alkalinity (mg/L)	52	55	59
Total Suspended Solids (mg/L)	5.19	12.92	11.94
Nitrate (mg/L)	0.090	0.090	0.094
Ammonia (mg/L)	0.032	0.018	0.027
Total Nitrogen (mg/L)	--	--	--
Orthophosphate (mg/L)	0.006	0.005	0.005
Total Phosphorus (mg/L)	--	0.027	--
Chlorophyll-*a* (ug/L)	5.20	--	7.42
Plankton (Cells/ml)	3,409	--	2,469
Plankton (#/L)	1,312,123	--	1,176,853
Blue-green dominance NU (%)	9	--	2
Blue-green dominance – cells/ml (%)	51	--	21

* Method Detection Limit

Table 2. Water Quality Characteristics of Lake Lemon – Riddle Point and Reed Point, 6/19/18.

Parameter	Riddle		Reed
	Epilimnion	Hypolimnion	Epilimnion
Secchi (m)	1.25	--	0.65
Light trans @ 3' (%)	3.396	--	10.571
1% Light Level (ft)	14.4	--	9.5
% Water Column Oxic	71	--	100
pH	7.9	7.0	7.6
Conductivity (uS/cm)	173.4	194.5	185.6
Alkalinity (mg/L)	62	75	69
Total Suspended Solids (mg/L)	--	--	--
Nitrate (mg/L)	0.073	0.029	0.069
Ammonia (mg/L)	0.031	0.322	0.066
Total Nitrogen (mg/L)	1.089	1.153	0.356
Orthophosphate (mg/L)	0.005	0.017	0.007
Total Phosphorus (mg/L)	0.032	0.078	0.026
Chlorophyll-a (ug/L)	7.96	--	12.37
Plankton (Cells/ml)	13,399	--	21,204
Plankton (#/L)	1,447,393	--	2,110,218
Blue-green dominance NU (%)	78	--	71
Blue-green dominance – cells/ml (%)	97	--	92

* Method Detection Limit

Table 3. Water Quality Characteristics of Lake Lemon – Riddle Point and Reed Point, 8/07/18.

Parameter	Riddle		Reed
	Epilimnion	Hypolimnion	Epilimnion
Secchi (m)	0.6	--	0.55
Light trans @ 3' (%)	8.67	--	3.57
1% Light Level (ft)	8.2	--	5.58
% Water Column Oxic	71	--	100
pH	8	7.4	7.6
Conductivity (uS/cm))	148.8	153.9	158
Alkalinity (mg/L)	86	91	77
Total Suspended Solids (mg/L)	--	--	--
Nitrate (mg/L)	--	--	--
Ammonia (mg/L)	0.014	0.014	0.014
Total Nitrogen (mg/L)	0.445	0.839	0.782
Orthophosphate (mg/L)	0.01	0.054	0.011
Total Phosphorus (mg/L)	0.016	0.035	0.04
Chlorophyll-a (ug/L)	27.21	--	22.27
Plankton (Cells/ml)	26,330	--	21,677
Plankton (#/L)	3,530,558	--	2,881,260
Blue-green dominance NU (%)	81	--	73
Blue-green dominance – cells/ml (%)	96	--	93

* Method Detection Limit

Chlorophyll-*a,* which is a measure of the primary pigment in algae, is a direct measure of algal productivity. In the integrated samples from the surface to the 2-meter depth, the chlorophyll-*a* concentrations ranged from 5.20 µg/L in May to 27.21 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 (Figure 3 and 4).

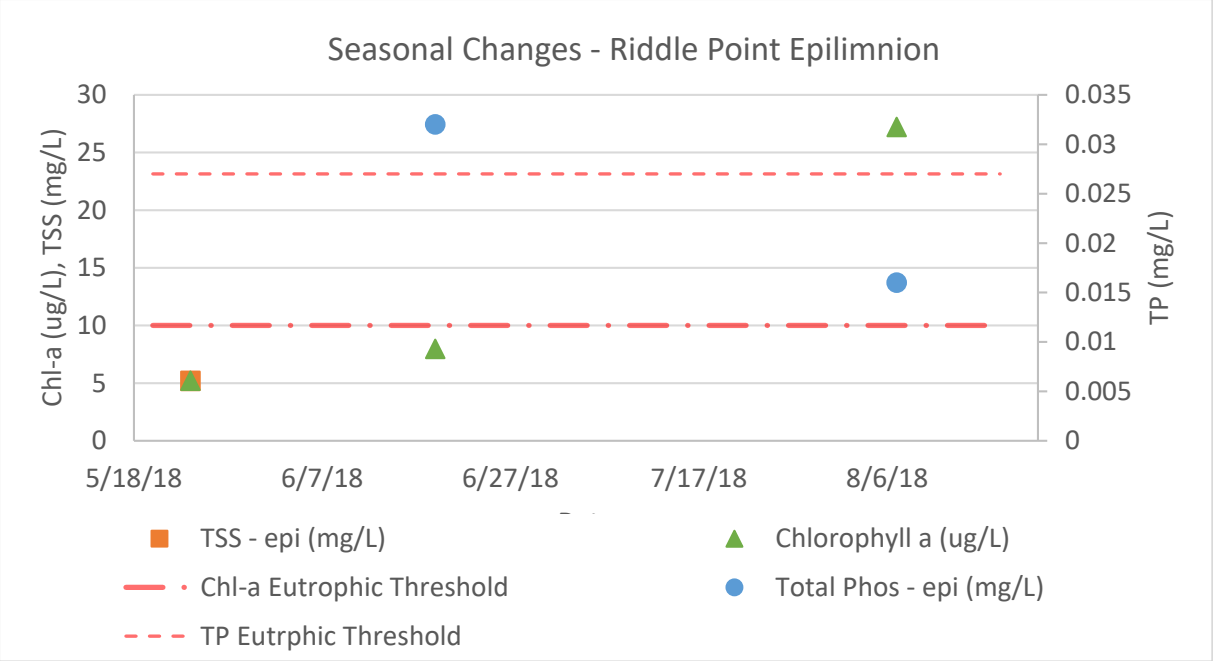

Figure 3. Seasonal changes in total phosphorus, total suspended solids, and chlorophyll-*a* in the surface waters (epilimnion) at Riddle Point in Lake Lemon in 2018.

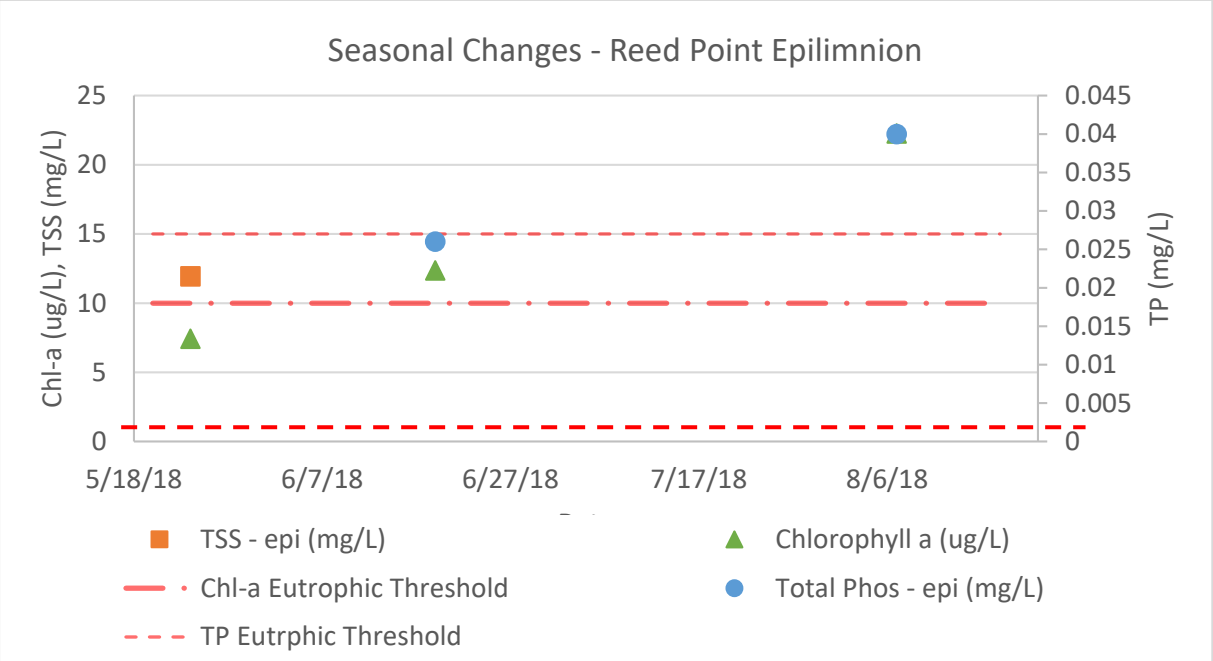

Figure 4. Seasonal changes in total phosphorus, total suspended solids, and chlorophyll-*a* in the surface waters (epilimnion) at Reed Point in Lake Lemon in 2018.

Tributary Samples IU collected turbidity and E. coli in 2018. The state standard for full body contact and recreation is 200 colonies per 100mls.

Table 4. Turbidity and E. coli for 2018.

	E. coli (#/100 mls)	*E. coli* (#/100 mls)	*E. coli* (#/100 mls)	Turbidity (NTU)	Turbidity (NTU)	Turbidity (NTU)
	5/24/18	**6/14/18 (Storm)**	**8/7/18**	**5/24/18**	**6/14/18 (Storm)**	**8/7/18**
Chitwood #1	790	4,000	300	12.5	17.9	32.1
Chitwood #2	92	1,100	300	8.1	13.4	12.3
Chitwood Channel	800	2,100	700	10.9	52.1	37
Chitwood Stream	550	3,300	10,900	3.73	202	61.2
Beanblossom Creek	68	5,100	3,000	4.09	32	6.91
Bear Creek	350	8,800	7,800	5.2	110	102
Knobb Creek	630	10,000	10,400	37.5	220	51.8

*The stream flowing into the Chitwood area from across the road was very low during August sample event.

In order to help identify the problem areas for bacteria and sediment, IU has added multiple sampling sites (Figure 5). The LLCD and IU selected sites in an attempt to address concerns of citizens and to identify solutions for bacteria challenges. Storm sample collection on 6/14/2018 is to demonstrate possible worst-case scenarios for bacteria. These concentrations are well over full body contact standards during many sampling events.

Figure 5. Sampling locations for the Lake Lemon Water Monitoring Program for the Chitwood area for 2017 and 2018.

The LLCD Board asked us to look at the historical bacteria trends. The results from sampling events at the Chitwood sites show the water exceeds EPA standards for recreation over 50% of the time, for *E. coli* from 2015-2018 (Figure 6).

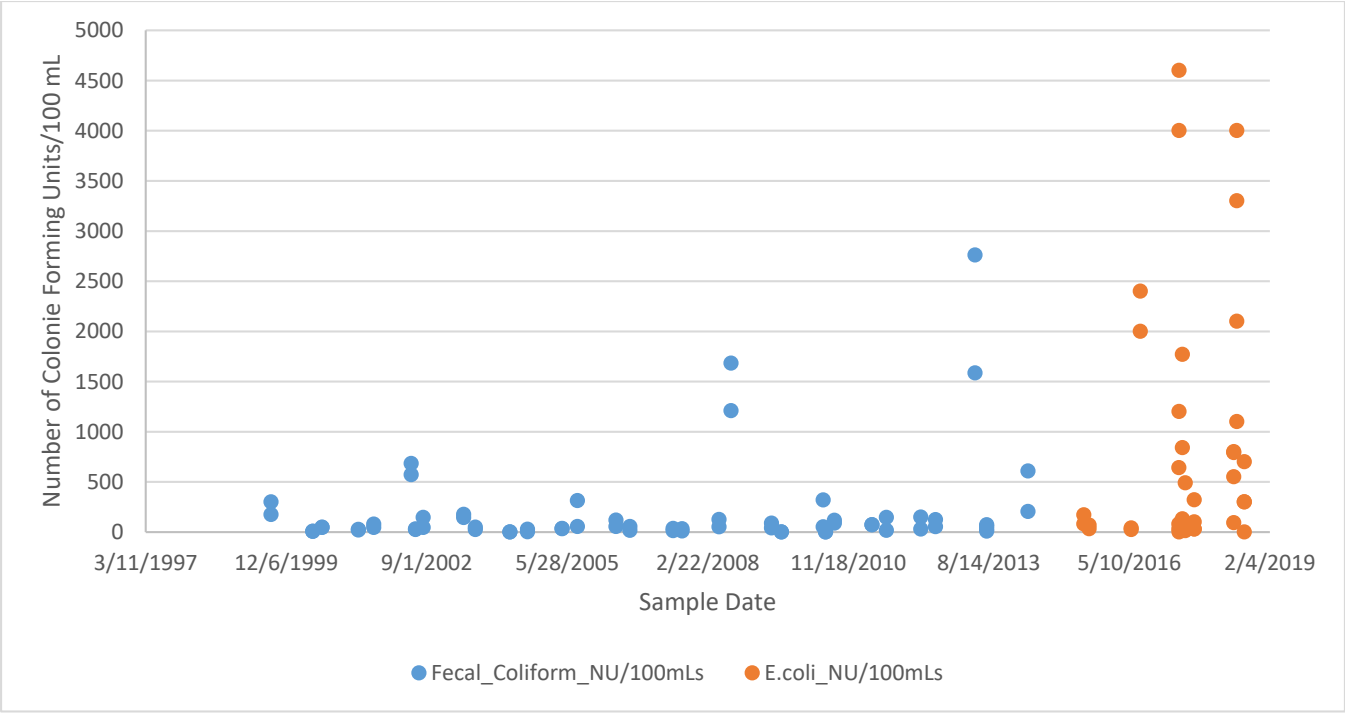

Figure 6. Changes in Fecal Coliform and *E. coli* concentrations in Chitwood area as part of the Lake Lemon watershed from 1998 to 2018. Note that 20 of the 39 events from 2015 and 2018 exceeded 200 CFU/100 mLs. (Two outliers have been removed for display purposes).

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.

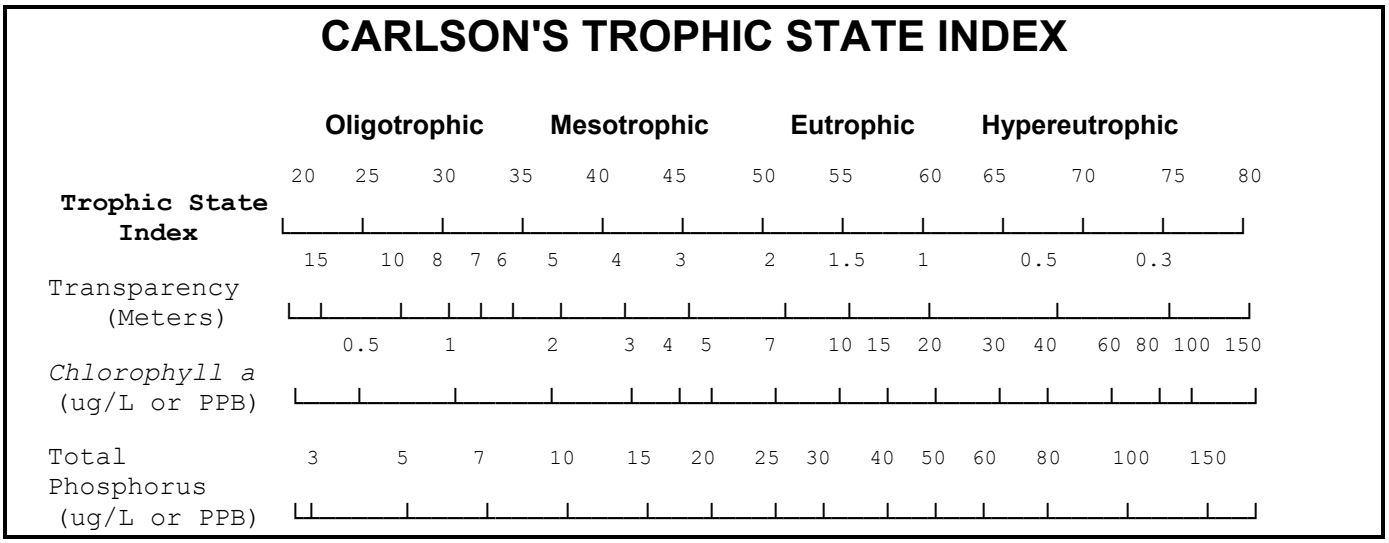

Figure 7. Carlson's trophic state index.

Table 6. 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*. 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.

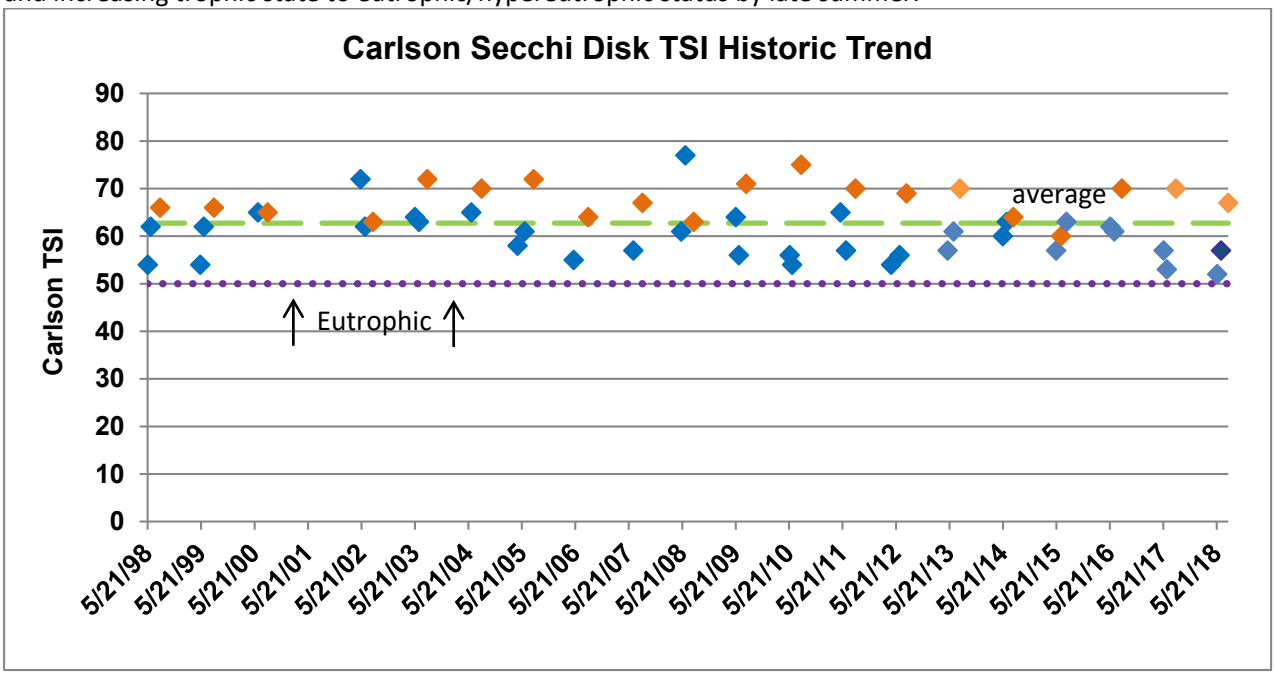

Figure 8. The 20-year historic trend for Carlson Secchi disk TSI scores. Orange represents the August samples. The green dashed line illustrates the 1-year mean. The purple dotted line illustrates eutrophic status for the Carlson TSI.

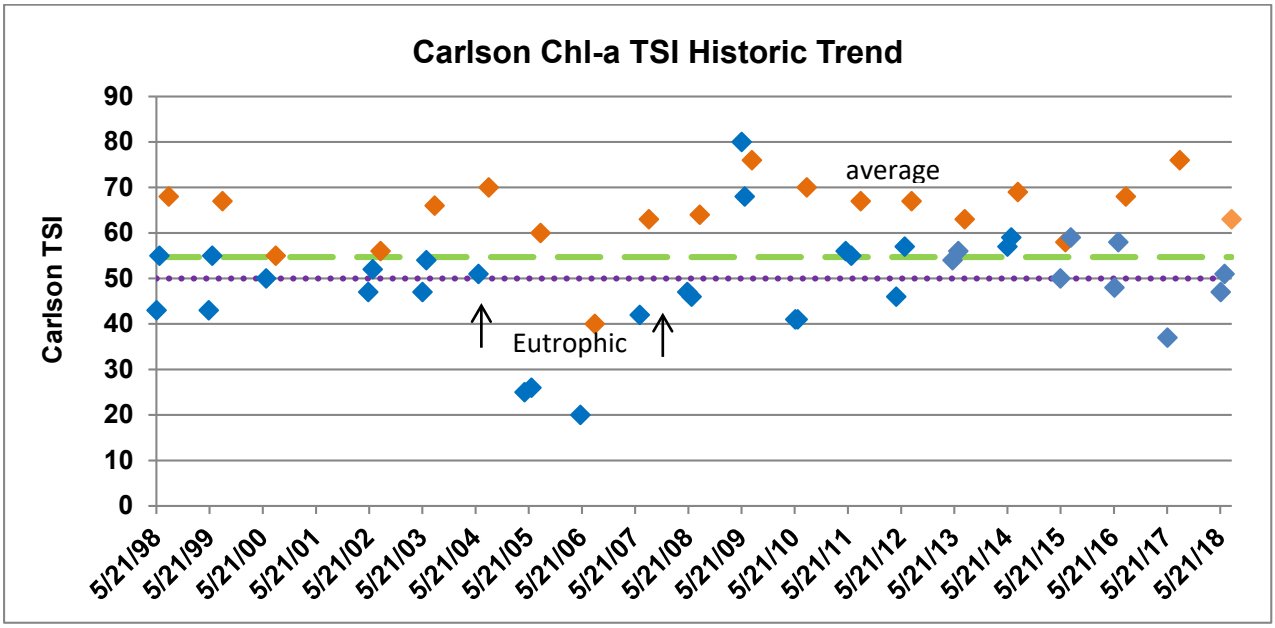

Figure 9. The 20-year historic trend for Carlson chlorophyll-*a* TSI scores. Most August samples, shown in orange, score above the mean for eutrophic status. The 20-year mean is just above the Carlson TSI eutrophic status score of 50 (purple dotted line).

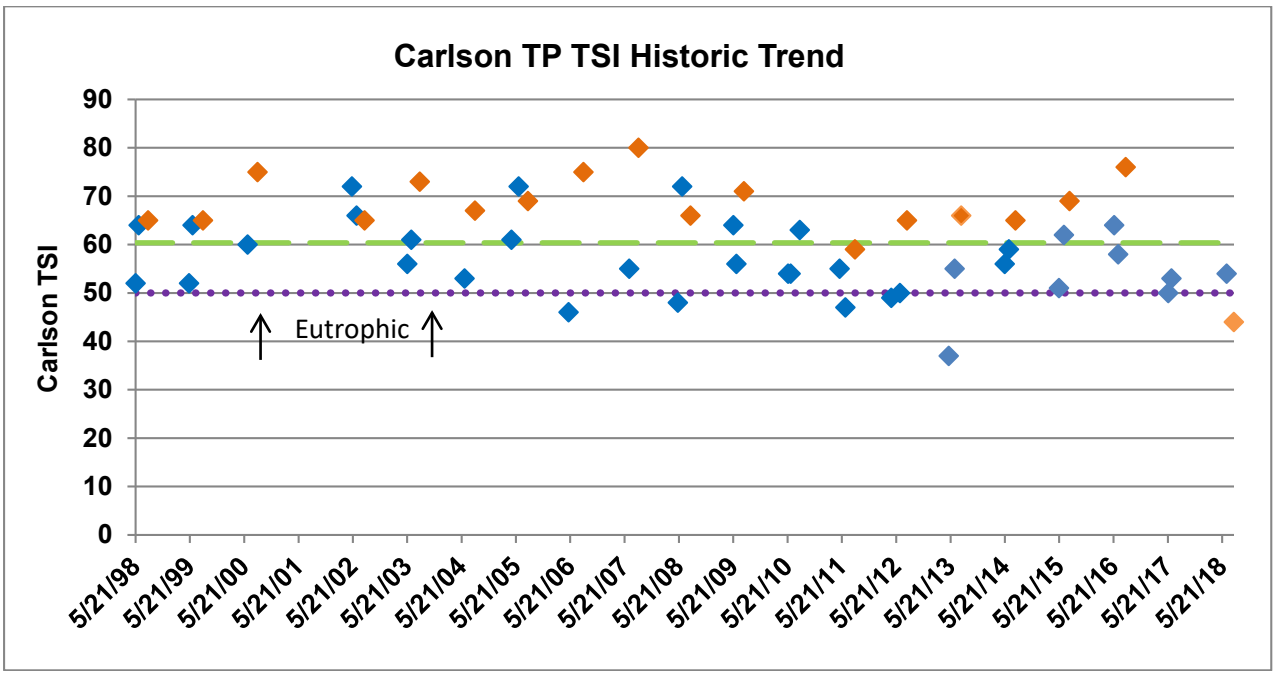

Figure 10. The 20-year historic trend for Carlson total phosphorus TSI scores. All August samples, shown in orange, score above the mean for eutrophic status. The green dashed line illustrates the 20-year mean. The purple dotted line illustrates eutrophic status for the Carlson TSI.

In July of 2018 due to increased concerns of toxin producing algae samples the LLCD lake manager collected water samples at various sites around the lake and IU assessed for toxin producing algae. IU taxonomist found all samples to be below the threshold for recreation advisories of 100,000 cells/mL. We find the highest cell counts in the overflow pond; however, the cell counts in lake samples are similar to the overflow in 2018. IU will continue to monitor these sites this summer and propose further recommendations as needed.

Figure 12. Sampling locations for the Lake Lemon Water Monitoring Program for the Chitwood area for 2018.

Lake Lemon Water Monitoring Conclusions and Recommendations

Further conclusions and recommendations are pending discussion with Lake Manager and Board of Directors.