

Lake Lemon 2016 Summary Results

Temperature and dissolved oxygen measurement were collected from each meter depth to allow for a full profile. 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 three sampling events at Riddle Point (Figure 1). The August dissolved oxygen concentrations averaged 8.5 mg/L in the epilimnion, an increase of approximately 1 mg/L respectively from the sample collected during late July in 2016. Anoxic conditions develop below 3 meters depth, which are likely due to significant organic matter on the lake bottom, creating a biochemical oxygen demand (BOD) that results in decomposition processes consuming all the available oxygen. Because stratification does not allow surface water to mix into this deeper water, oxygen is not replenished. The shallow depth of Reed Point and lake turbulence keep this portion of the lake well mixed and oxygenated (Figure 2).

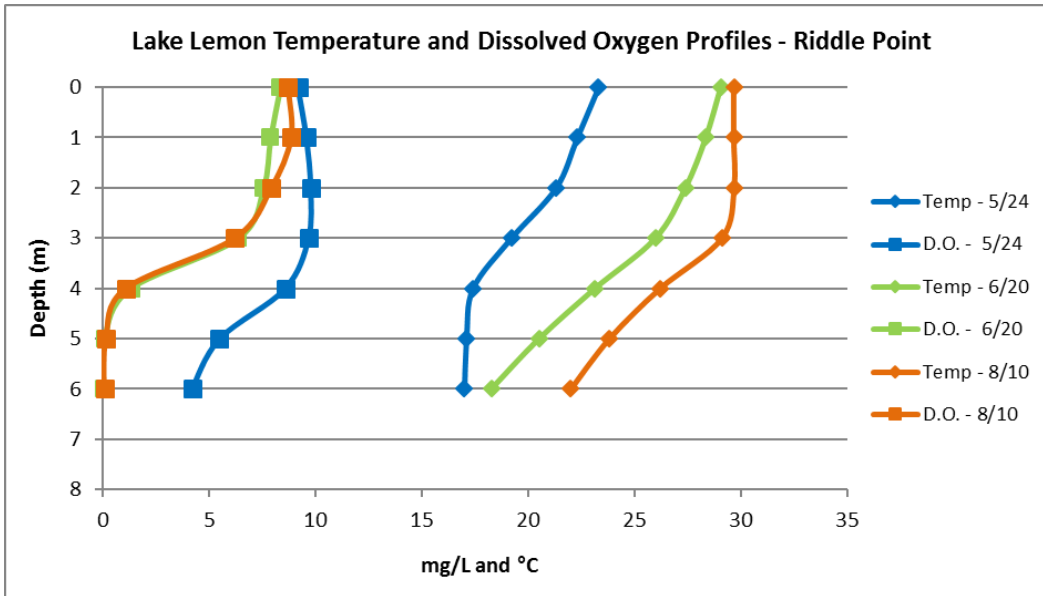


Figure 1. Temperature and dissolved oxygen profiles from all sample dates in from Indiana University at Riddle Point in 2016.

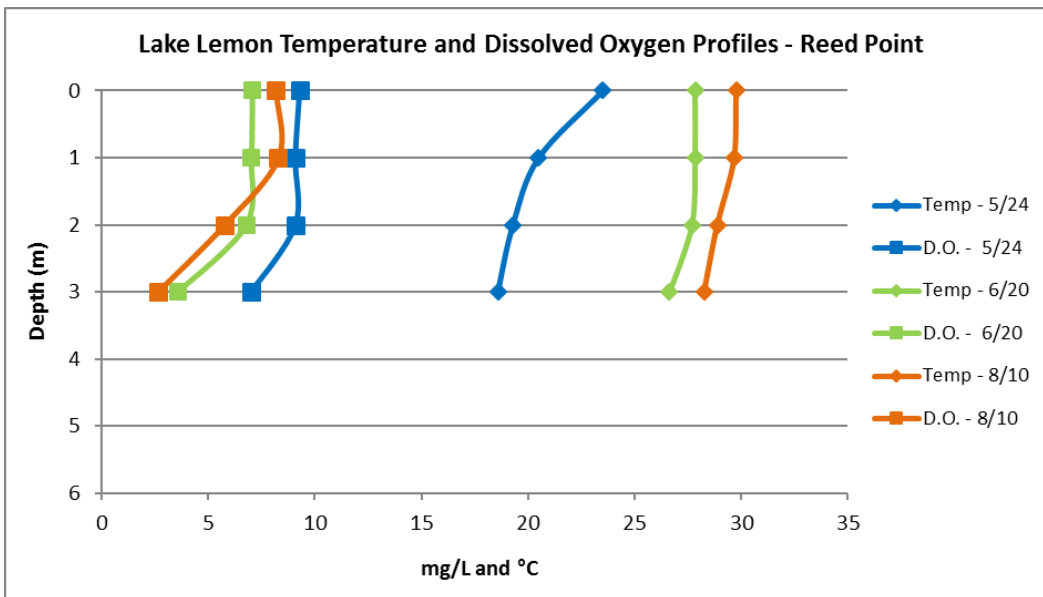


Figure 2. Temperature and dissolved oxygen profiles from all sample dates in from Indiana University at Reed Point in 2016.

Water Quality Summary. Epilimnion samples were collected from the top 2 meters of the water column, while the hypolimnion samples were collected from the 6 meter depth (19.7 ft) at Riddle Point. Reed Point samples were collected in the epilimnion only.

Table 1. Water Quality Characteristics of Lake Lemon – Riddle Point and Reed Point, 5/24/2016.

Parameter	Riddle		Reed
	Epilimnion	Hypolimnion	Epilimnion
Secchi (m)	0.9	--	0.8
Light trans @ 3' (%)	5.4	--	8.4
1% Light Level (ft)	6.25	--	5
% Water Column Oxic	100	--	100
pH	7.2	6.8	7
Conductivity (uS/cm))	171	173	181
Alkalinity (mg/L)	57	57	60
Total Suspended Solids (mg/L)	3	5.38	4.235
Nitrate (mg/L)	0.009*	0.024	0.026
Ammonia (mg/L)	0.027	0.108	0.023
Total Organic Nitrogen (mg/L)	0.282	0.309	0.24
Orthophosphate (mg/L)	0.006*	0.008*	0.006*
Total Phosphorus (mg/L)	0.056	0.071	0.068
Chlorophyll-a (ug/L)	5.9	--	11.7
Plankton (Cells/ml)	755	--	6,075
Plankton (#/L)	52,920	--	170,292
Blue-green dominance NU (%)	61.1	--	87.7
Blue-green dominance – cells/ml (%)	94.2	--	98.5

* Method Detection Limit

Table 2. Water Quality Characteristics of Lake Lemon – Riddle Point and Reed Point, 6/20/16.

Parameter	Riddle		Reed
	Epilimnion	Hypolimnion	Epilimnion
Secchi (m)	0.9	--	0.6
Light trans @ 3' (%)	8.6	--	2.8
1% Light Level (ft)	3.5	--	5
% Water Column Oxic	57.1	--	100
pH	8.4	7.2	8.1
Conductivity (uS/cm)	188	208	190
Alkalinity (mg/L)	69	81	71
Total Suspended Solids (mg/L)	--	--	--
Nitrate (mg/L)	0.009*	0.009*	0.009*
Ammonia (mg/L)	0.015*	0.015*	0.015*
Total Organic Nitrogen (mg/L)	0.309	0.582	0.512
Orthophosphate (mg/L)	0.002*	0.004*	0.002*
Total Phosphorus (mg/L)	0.026	0.055	0.043
Chlorophyll-a (ug/L)	15.9	--	33.0
Plankton (Cells/ml)	4,295	--	5,465
Plankton (#/L)	204,484	--	100,742
Blue-green dominance NU (%)	82	--	92
Blue-green dominance – cells/ml (%)	97.6	--	95.9

* Method Detection Limit

Table 3. Water Quality Characteristics of Lake Lemon – Riddle Point and Reed Point, 8/10/16.

Parameter	Riddle		Reed
	Epilimnion	Hypolimnion	Epilimnion
Secchi (m)	0.5	--	0.5
Light trans @ 3' (%)	4.4	--	3.4
1% Light Level (ft)	5.2	--	4.5
% Water Column Oxic	46	--	100
pH	7.5	6.7	6.4
Conductivity (uS/cm)	186	245	189
Alkalinity (mg/L)	76.5	114	79
Total Suspended Solids (mg/L)	11	--	10.8
Nitrate (mg/L)	0.009*	0.009*	0.009*
Ammonia (mg/L)	0.015*	1.395	0.015*
Total Organic Nitrogen (mg/L)	0.891	2.004	0.749
Orthophosphate (mg/L)	0.002*	0.22	0.002*
Total Phosphorus (mg/L)	0.039	0.246	0.059
Chlorophyll-a (ug/L)	47.5	--	50.9
Plankton (Cells/ml)	4,862	--	9,061
Plankton (#/L)	512,004	--	432,153
Blue-green dominance NU (%)	92.8	--	83.8
Blue-green dominance – cells/ml (%)	98.6	--	95.6

* 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 5.94 $\mu\text{g/L}$ in May to 47.51 $\mu\text{g/L}$ in August. Chlorophyll-a concentrations $>7 \mu\text{g/L}$ are indicative of eutrophic lake conditions. Overall, we see a seasonal pattern of nutrient increase by late summer, 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 11 and 12).

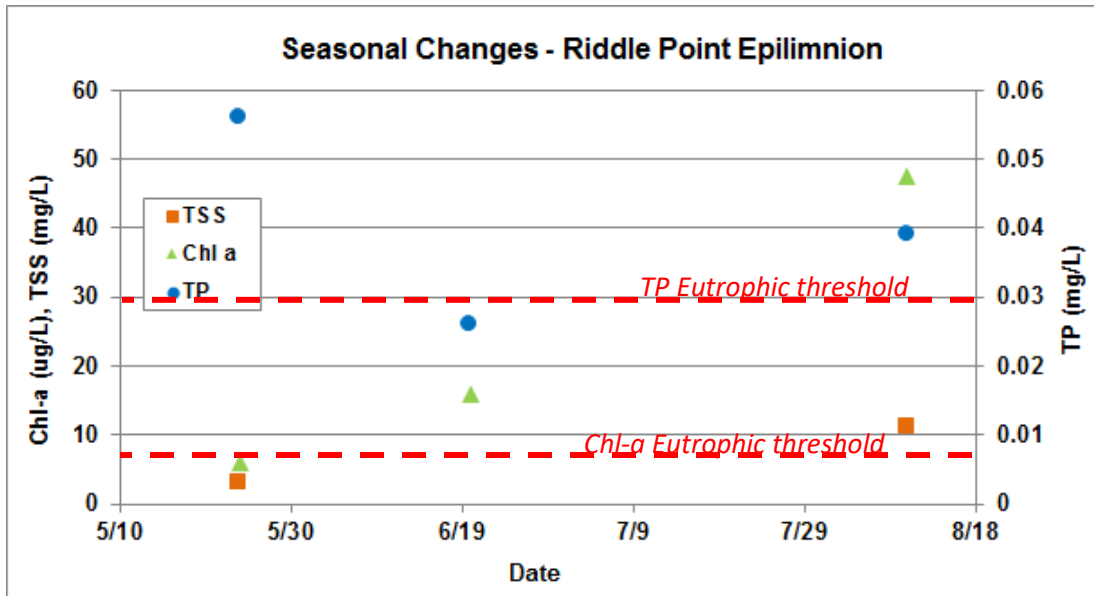


Figure 3. Seasonal changes in total phosphorus, total suspended solids, and chlorophyll-a in the surface waters (epilimnion) at Riddle Point in Lake Lemon in 2016. No TSS was collected in June.

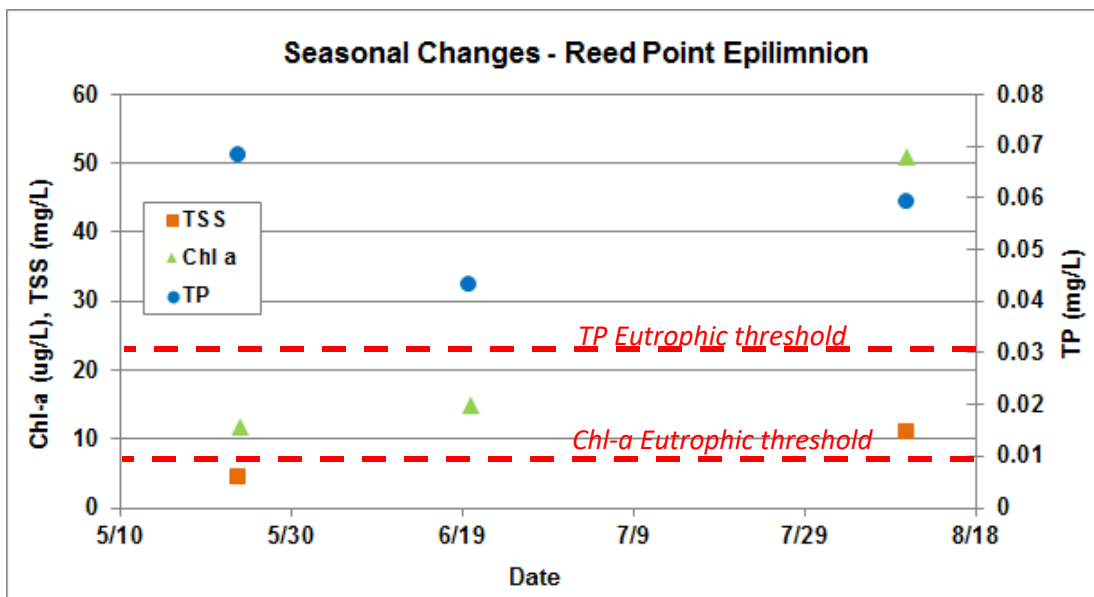


Figure 4. Seasonal changes in total phosphorus, total suspended solids, and chlorophyll-a in the surface waters (epilimnion) at Reed Point in Lake Lemon in 2016. *no TSS was collected in June.

Tributary Results

Results from the Beanblossom Creek samples are given in Table 4. Stream values generally fell within the range of lake parameters. Variation among the sample parameters was slight. Historically, most of the parameters increased throughout the summer. Solubility of oxygen in water is influenced by temperature - with less dissolved oxygen dissolving in warmer water, which is evident in the 2016 sampling results. A storm event sample was collected on July 27th (Figure 5). In addition to being collected during a storm event, the July 27th sample also followed rain events of both significant duration and magnitude. This sample had some of the highest concentrations of bacteria, phosphorus, TN, and TSS, and we see the typical decrease in alkalinity and conductivity that is representative of storm events.

Table 4. Water Quality Characteristics of Beanblossom Creek.

	5/24/16	7/27/16 (storm)
pH	7.0	5.7
Conductivity (mS/cm)	242	169
Alkalinity (mg/L)	89	71
Temperature (°C)	21.4	25.3
Dissolved Oxygen (mg/L)	8.84	6.67
Total Suspended Solids (mg/L)	0.77	234
Nitrate (mg/L)	0.009*	0.33
Ammonia (mg/L)	0.032	0.052
Total Nitrogen (mg/L)	0.208	1.003
Orthophosphate (mg/L)	0.006*	0.033
Total Phosphorus (mg/L)	0.054	0.155
<i>E. coli</i> (col/100ml)	44	12,400

* Method Detection Limit

Total suspended solids (TSS) and *E. coli* samples were collected at lake and stream tributary sites. All July samples exceeded the state standard of 200 colonies per 100 ml threshold. A storm event that occurred on June 27th likely contributed to increased bacteria. May and August samples were under the threshold values except for Knobb Creek on May 24th.

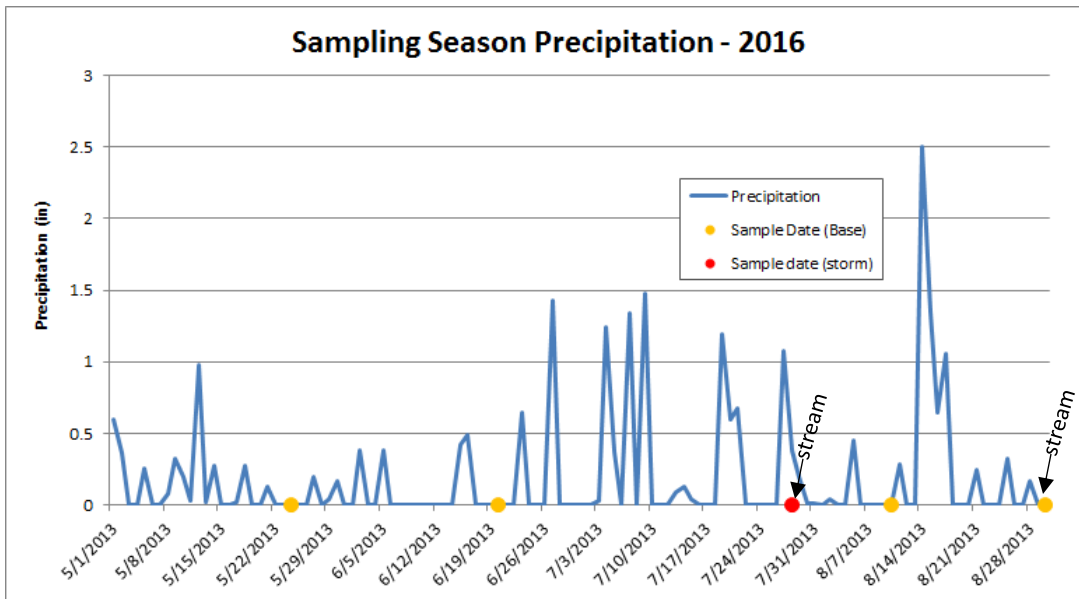


Figure 5. Precipitation amounts during the 2016 sampling season.

Table 5. *E. coli* bacteria summary for 2016 Lake Lemon samples. The state standard for full body contact and recreation is 200 colonies per 100mls.

	<i>E. coli</i> (#/100 mls)	<i>E. coli</i> (#/100 mls)	<i>E. coli</i> (#/100 mls)	TSS (mg/L)	TSS (mg/L)	TSS (mg/L)	TSS (mg/L)
	5/24/16	7/28/16 (storm)	8/30/16	5/24/16	7/28/16	8/10/16	8/30/16
Riddle Point	8	\	\	4.4	\	11	\
Reed Point	8	\	\	3.9	\	10.8	\
Chitwood #1	40	2,000	36	\	\	\	\
Chitwood #2	24	2,400	0	\	\	\	\
Beanblossom Creek	44	12,400	96	0	234	\	4.2
Bear Creek	\	4,600	184	\	8	\	6.5
Knobb Creek	436	270	52	0	11	\	2.2

\ indicate samples not collected

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.

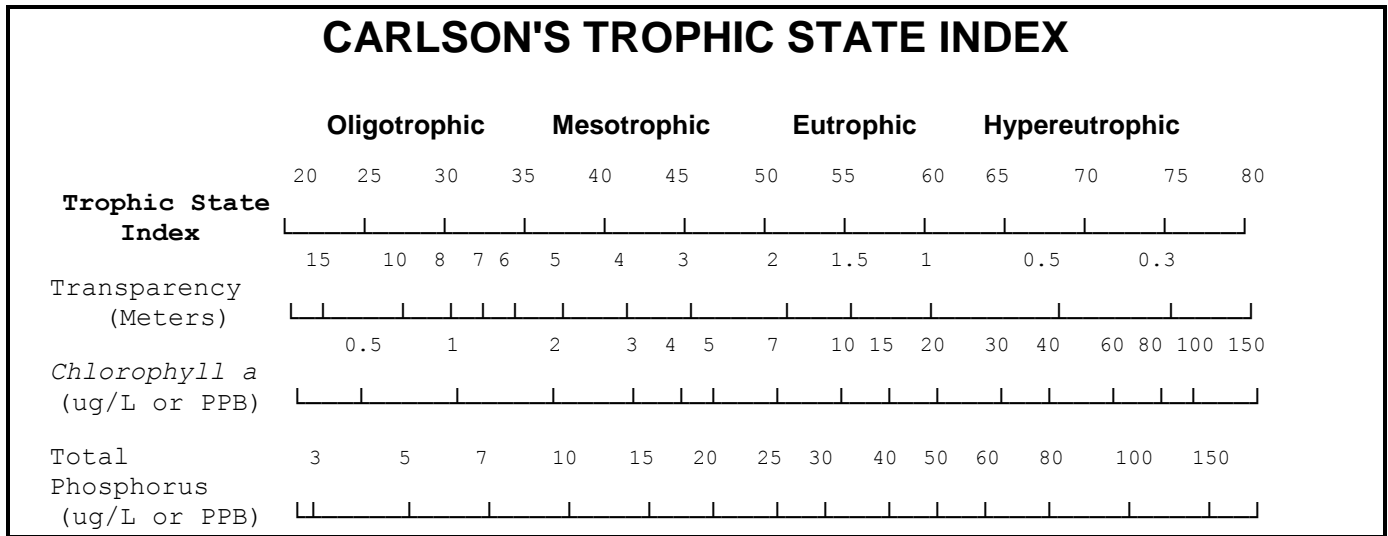


Figure 6. Carlson's trophic state index.

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.

Table 7. Summary of Trophic State Index Scores Using Mean 2016 Water Quality Data for Riddle/Reed Points.

DATE	Carlson's Secchi Disk TSI	Carlson's Total Phosphorus TSI	Carlson's Chlorophyll TSI
May	62/63	62/65	48/55
	Eutrophic	Eutrophic	Eutrophic
June	61/69	51/58	58/57
	Eutrophic	Eutrophic	Eutrophic
July	70/70	76/66	68/69
	Eutrophic	Eutrophic	Eutrophic

Riddle Pt. TP = 0.051mg/L = 51ug/L

↓

Graph on Carlson's TP scale

↓

Carlson's TSI value

How to read:

Carlson's TP TSI

65 / 88

Eutrophic/Hypereutrophic

Reed Pt. TP = 0.334mg/L = 334ug/L

↓

Graph on Carlson's TP scale

↓

Carlson's TSI value

Using Riddle Point Carlson TSI scores to look at the historic trend for Lake Lemon shows that the lake is generally characterized as eutrophic conditions. Figures 8-10 illustrate the Carlson TSI historic trends for Secchi disk, total phosphorus, and chlorophyll-a. Overall, a pattern is seen within the seasonal variation with the late spring months scoring lower (less eutrophic) while increasing during the late summer months to a eutrophic/hypereutrophic status.

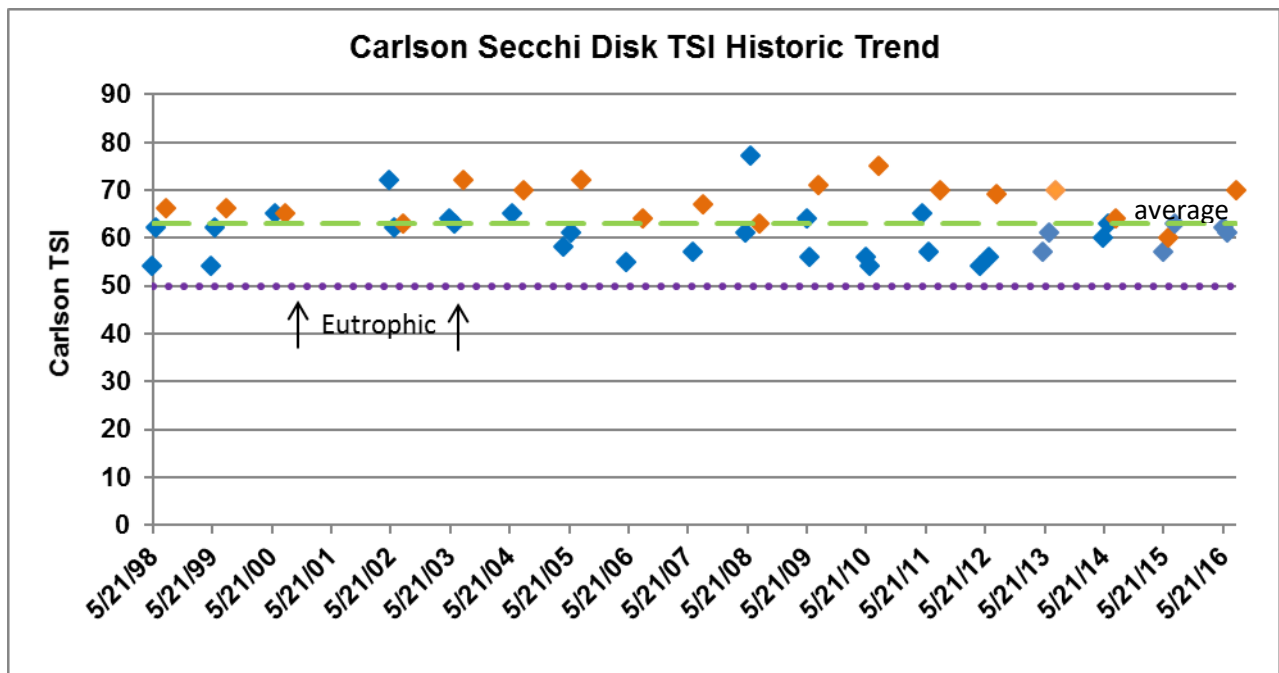


Figure 8. The 18-year historic trend for Carlson Secchi disk TSI scores. All but three late summer (August) samples, shown in orange, scored above the mean for eutrophic status. The green dashed line illustrates the 1-year mean. The purple dotted line illustrates eutrophic status for the Carlson TSI.

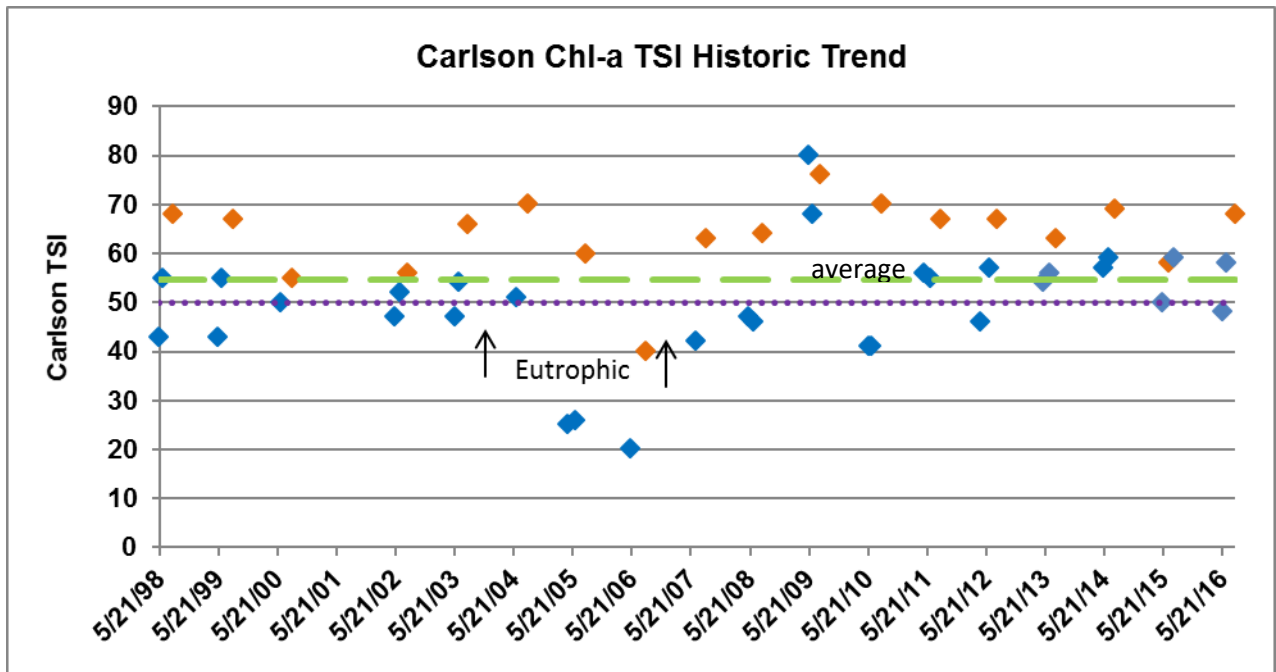


Figure 9. The 18-year historic trend for Carlson chlorophyll-a TSI scores. Most August samples, shown in orange, score above the mean for eutrophic status. The 18-year mean is just above the Carlson TSI eutrophic status score of 50 (purple dotted line).

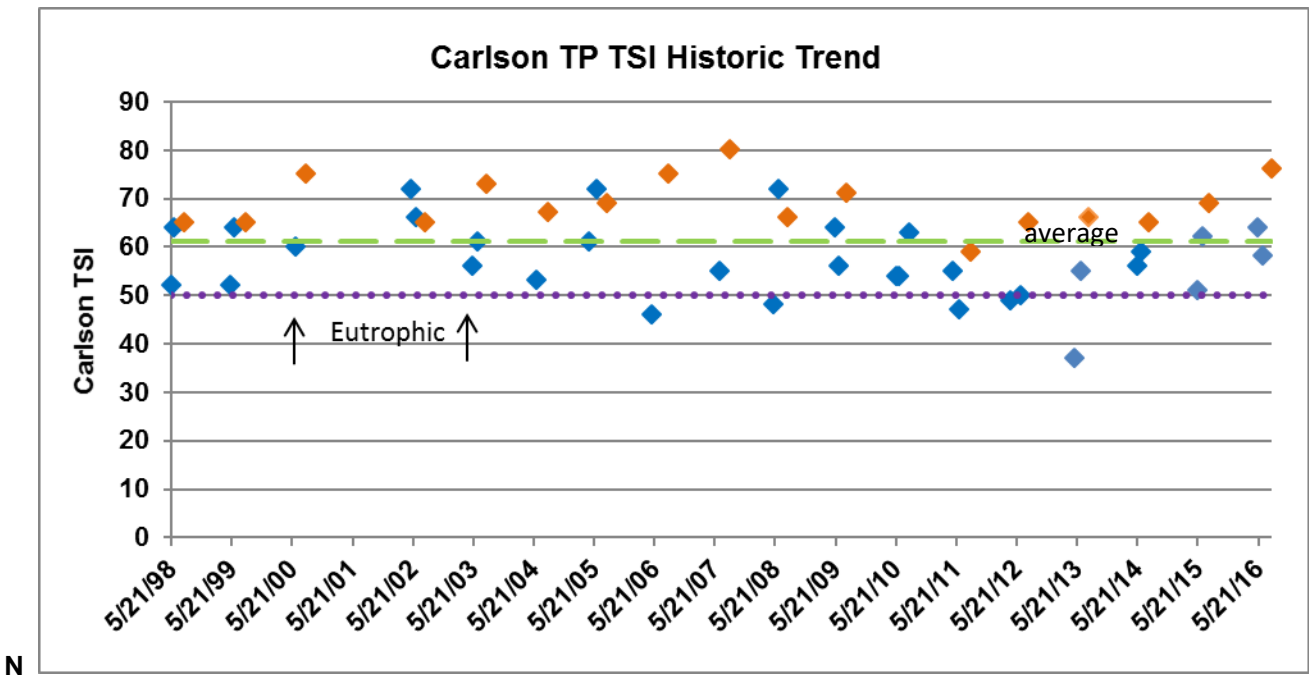


Figure 10. The 18-year historic trend for Carlson total phosphorus TSI scores. All August samples, shown in orange, score above the mean for eutrophic status. The green dashed line illustrates the 18-year mean. The purple dotted line illustrates eutrophic status for the Carlson TSI.

