Indian Lake South Basin Laminar Flow 2018-2020
Post-Aeration Data
Cass County, Michigan

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1.0 PROJECT INTRODUCTION

Indian Lake is located in Sections 30 and 31 of Silver Creek Township (T.5S, R.16W) in Cass County, Michigan. The lake surface area is approximately 499 acres (Michigan Department of Natural Resources, 2001) and may be classified as a eutrophic aquatic ecosystem with a central deep basin and a moderate-sized littoral zone. Indian Lake has a maximum depth of 30.0 feet (confirmed by RLS in 2014 through depth contour mapping). The lake bottom consists primarily of sandy substrate, along with marl and organic matter deposits. Indian Lake has a lake perimeter of approximately 4.65 miles. The South Basin itself is approximately 88 acres with a deep basin of 16.0 feet.

Indian Lake 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 hybrid watermilfoil growth and nuisance cyanobacteria algal blooms. Previous aquatic plant herbicide and algae treatments have proven ineffective and the local residents have desired a more holistic approach to addressing both the algae and aquatic plant issues as well as the dissolved oxygen depletion issues associated with lake stratification later in the summer season on the lake.

1.1 a. Summary of Indian Lake South Basin Aeration Operations:

Laminar Flow Aeration (LFA) was originally installed throughout the Indian Lake South Basin in 2010 by Lake Savers, LLC. The LFA system consists of 14 ceramic diffusers powered by onshore compressors. The aeration system was activated on April 1, 2015 and on April 1, 2016 and deactivated for the season on November 30, 2015 and on November 30, 2016. No bioaugmentation was applied to the South Basin in 2015 or 2016. In 2017-2019, Lake Savers, LLC applied a bacteria blast to both the North and South Basins of Indian Lake via a Rule 97 permit as required. A BioBlast microbe and enzyme treatment was applied to the lake in August 2019 by EverBlue Lakes, LLC.

1.2 b. Summary of Aeration Operation Purpose/Goals:

The Indian Lake South Basin is a small portion of Indian Lake, but it is utilized by the residents for fishing, swimming, motorboat activity, and waterfront living. The Indian Lake Improvement Association had considered the possibility of dredging as this occurred many years ago but deemed it too expensive and thus desired to utilize aeration and bioaugmentation to reduce organic muck and aquatic vegetation in the South Basin.

The residents desired a lake restoration strategy that would make the basin healthier and accomplish the following objectives:

The primary objectives of the implemented LFA system for Indian Lake South Basin include:

1) Reduction of nuisance submersed aquatic vegetation
2) Maintenance of the lake's excellent water quality during this process
3) Reduction of nuisance algae in the South Basin

1.3 c. Lake Map, Sampling Locations, Management Activities:

Figure 1. below shows the two deep basins in Indian Lake South Basin that were sampled on May 16, 2018, July 12, 2018, and September 7, 2018, and May 12, 2019, July 22, 2019, and October 3, 2019 and May 27, 2020, July 30, 2020, and September 13, 2020 for multiple biotic and abiotic parameters to evaluate the efficacy of the LFA system and determine if the LFA system is having any impacts on the Indian Lake South Basin aquatic ecosystem. Aquatic herbicide treatments were conducted in the canal of the South Basin in 2018-2020 as in previous years to address the thick milfoil and Curly-leaf Pondweed growth.

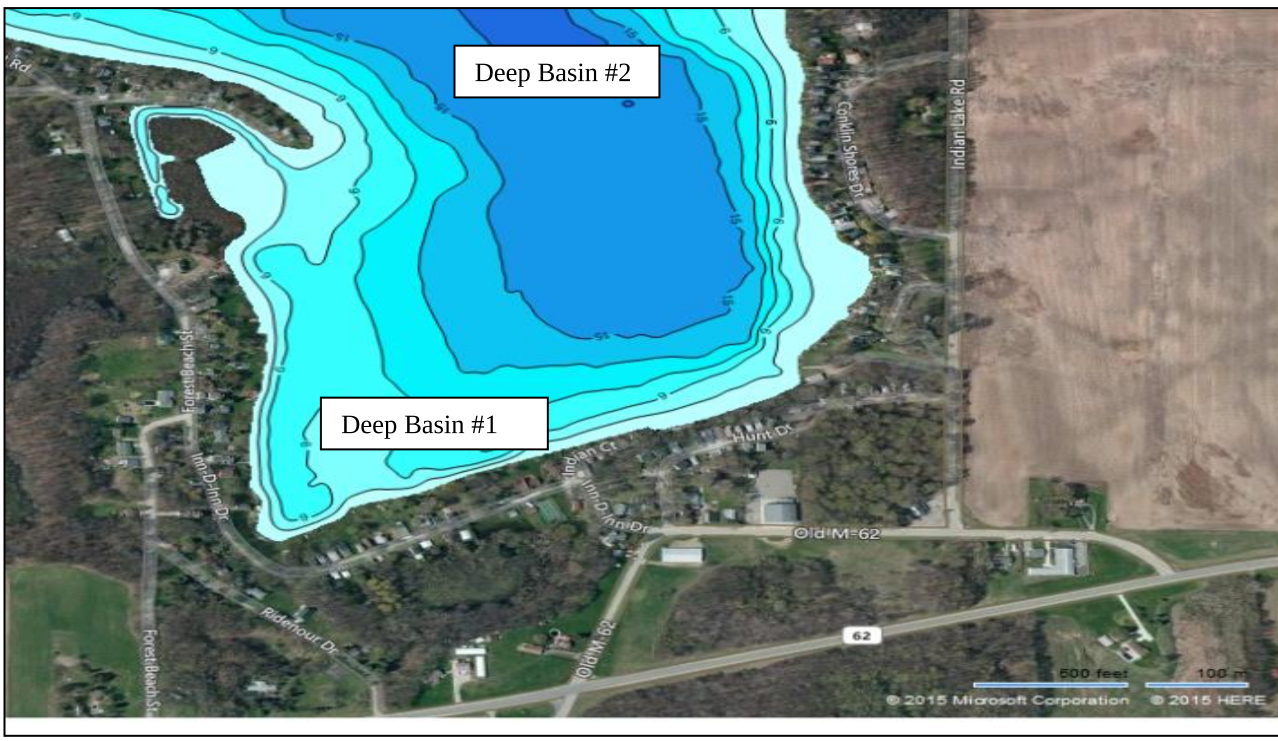

Figure 1. The Indian Lake South Basin, Cass County, MI.

2.0 INDIAN LAKE SOUTH BASIN SAMPLING METHODS

2.1 a. Summary of Equipment/Sampling Devices/Replicates:

Chemical water samples were collected at the specified depths (top, middle, and bottom of the two sampling sites) using a 4-liter VanDorn horizontal water sampler with weighted messenger (Wildco® brand). As required by the permit, three samples per parameter were collected per sampling location.

Water quality physical parameters (such as water temperature, dissolved oxygen, conductivity, and pH) were measured with a calibrated Eureka Manta II® multi-probe meter at top, middle, and bottom depths of the two deep basins. As required by the permit, one set of measurements as a profile per deep basin sampling location was collected for each sampling date. Additionally, temperature, pH, conductivity, and dissolved oxygen were measured at 0.5-meter intervals

2.2 b. Sampling Dates, Locations, Weather, & WQ Parameters Measured:

Post-aeration water quality data was collected by RLS on May 16, 2018, July 12, 2018, and September 7, 2018 and May 12, 2019, July 22, 2019, and October 3, 2019 and May 27, 2020, July 30, 2020, and September 13, 2020 All water quality samples were collected from the Indian Lake South Basin locations according to Figure 1 above.

Weather conditions were recorded on the data sheets in Appendix A (2020 raw data and laboratory reports). Previously submitted reports also had accompanying appendices with all raw field and laboratory data.

2.3 c. Summary of Standard Methods for Processing/Analysis of Samples:

Water quality chemical parameters such as total phosphorus, ortho-phosphorus, total suspended solids, and chlorophyll-a were analyzed at Trace Analytical Laboratories in Muskegon, Michigan. According to the laboratory reports generated by Trace labs, the method used for total phosphorus and ortho-phosphorus analysis was SM 4500-P E-11. The analytical method used to determine total suspended solids was SM 2540 D-11. The analytical method used to measure chlorophyll-a was SM 10200H. Ammonia nitrogen was determined with method EPA 350.1, nitrate nitrogen was determined with method EPA 353.2, and total Kjeldahl nitrogen was determined with EPA 351.2 A QA/QC statement of qualifications for Trace Analytical Laboratories in Muskegon, Michigan was previously submitted.

Prior to analysis of the samples as described above, water samples were placed in clean, unpreserved polyethylene bottles for ortho-phosphorus and total suspended solids and placed in H_2SO_4-preserved, clean, polyethylene bottles for total phosphorus analysis. Chlorophyll-*a* samples were placed in glass brown amber 1-liter bottles with glutaraldehyde as a preservative and analyzed within 1 week after collection.

All water samples were maintained on ice in a large cooler prior to being placed into the laboratory fridge. Samples used for microscopic analysis of algal community composition were preserved with glutaraldehyde and counted with a Sedgewick Rafter® Counting Cell under high power objective on a bright-field Accuscope® compound microscope. Multiple 1 micro-liter (µL) aliquots were used to determine the relative abundance of algal genera in the samples.

3.0 INDIAN LAKE SOUTH BASIN PARAMETERS TO SAMPLE AND RESULTS

All 2018 post-aeration physical water quality data is shown in Section 3.1a below. 2018 post-aeration Chemical water quality data is shown in Section 3.3c below.

3.1 a. Summary Tables of Water Quality Data:

3.2-3.3 b and c. Water Profiles. Profiles for all parameters are shown below for varying depths in the South Basin of Indian Lake.

Table 1. Indian Lake South Basin post-aeration physical water quality parameter data collected from the deep basin sites on May 16, 2018.

Post-Aeration Data Table (May 16, 2018): Site South Deep Basins #1 and #2

Sampling Site	***Depth (m)***	***Water Temp ºC***	***DO mg L^{-1}***	***pH S.U.***	***Cond. µS cm^{-1}***	***Secchi Depth (ft)***
Deep Basin 1	0	21.0	8.8	8.3	282	--
Deep Basin 1	0.5	19.3	8.9	8.4	280	13.2
Deep Basin 1	1.0	19.2	8.9	8.4	281	--
Deep Basin 1	1.5	18.8	8.9	8.4	280	--
Deep Basin 1	2.0	18.6	9.2	8.4	279	--
Deep Basin 1	2.5	18.5	9.7	8.6	276	--
Deep Basin 1	3.0	18.4	9.9	8.5	279	--
Deep Basin 1	3.5	18.1	9.2	8.5	281	--
Deep Basin 2	0	20.5	8.8	8.3	281	13.0
Deep Basin 2	0.5	19.5	8.9	8.3	280	--
Deep Basin 2	1.0	19.0	8.8	8.3	280	--
Deep Basin 2	1.5	18.8	8.8	8.3	280	--
Deep Basin 2	2.0	18.6	8.9	8.3	280	--
Deep Basin 2	2.5	18.5	8.9	8.3	280	--
Deep Basin 2	3.0	18.4	8.8	8.3	281	--
Deep Basin 2	3.5	18.1	8.8	8.3	281	--
Deep Basin 2	4.0	17.9	8.6	8.3	281	--
Deep Basin 2	4.5	17.7	8.5	8.3	282	--
Deep Basin 2	5.0	17.4	8.4	8.2	285	--
Deep Basin 2	5.5	16.8	4.0	7.7	304	--

Table 2. Indian Lake South Basin post-aeration physical water quality parameter data collected from the deep basin sites on July 12, 2018.

Post-Aeration Data Table (July 12, 2018): Site South Deep Basins #1 and #2

Sampling Site	*Depth (m)*	*Water Temp ºC*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Secchi Depth (ft)*
Deep Basin 1	0.5	28.4	7.9	8.6	300	5.7
Deep Basin 1	1.0	28.3	8.1	8.6	300	--
Deep Basin 1	1.5	28.1	8.2	8.6	300	--
Deep Basin 1	2.0	28.1	8.1	8.6	301	--
Deep Basin 1	2.5	28.0	8.1	8.5	301	--
Deep Basin 1	3.0	27.8	7.6	8.5	303	--
Deep Basin 2	0.5	28.7	8.4	8.7	300	5.6
Deep Basin 2	1.0	28.4	8.5	8.1	300	--
Deep Basin 2	1.5	28.3	8.5	8.6	300	--
Deep Basin 2	2.0	28.2	8.5	8.6	300	--
Deep Basin 2	2.5	28.1	8.5	8.6	300	--
Deep Basin 2	3.0	27.9	8.4	8.6	301	--
Deep Basin 2	3.5	27.7	7.9	8.5	302	--
Deep Basin 2	4.0	27.5	7.5	8.4	303	--
Deep Basin 2	4.5	27.4	7.2	8.4	304	--
Deep Basin 2	5.0	27.2	6.3	8.2	306	--

Table 3. Indian Lake South Basin post-aeration physical water quality parameter data collected from the deep basin sites on September 7, 2018.

Post-Aeration Data Table (September 7, 2018): Site South Deep Basins #1 and #2

Sampling Site	*Depth (m)*	*Water Temp ºC*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Secchi Depth (ft)*
Deep Basin 1	0	25.2	8.4	8.7	289	--
Deep Basin 1	0.5	25.2	8.3	8.7	289	5.5
Deep Basin 1	1.0	25.2	8.2	8.7	289	--
Deep Basin 1	1.5	25.1	8.1	8.7	289	--
Deep Basin 1	2.0	25.1	8.1	8.7	289	
Deep Basin 1	2.5	25.1	8.1	8.7	289	
Deep Basin 1	3.0	25.1	8.1	8.7	290	
Deep Basin 2	0	25.4	8.5	8.7	290	
Deep Basin 2	0.5	25.5	8.3	8.7	290	
Deep Basin 2	1.0	25.4	8.2	8.7	290	5.5
Deep Basin 2	1.5	25.5	8.1	8.7	290	--
Deep Basin 2	2.0	25.5	8.1	8.7	290	--
Deep Basin 2	2.5	25.4	8.1	8.7	290	--
Deep Basin 2	3.0	25.4	8.1	8.7	290	--
Deep Basin 2	3.5	25.3	8.1	8.7	290	--
Deep Basin 2	4.0	25.2	8.0	8.7	290	--
Deep Basin 2	4.5	25.0	8.0	8.7	290	--
Deep Basin 2	5.0	25.0	8.0	8.7	290	

Table 4. Indian Lake South Basin baseline (post-aeration) chemical water quality parameter data collected from the deep basin sites on May 16, 2018.

Post-Aeration Data Tables (May 16, 2018): Site South Deep Basins #1 and #2

Sampling Site	*Depth (m)*	*Total Phosphorus (mg/L)*	*Ortho-Phosphorus (mg/L)*	*Total Suspended Solids (mg/L)*	*Chlorophyll-a (µg/L)*
Deep Basin 1	0	0.021	<0.010	<10	--
Deep Basin 1	1.5	0.013	<0.010	<10	--
Deep Basin 1	3.5	0.014	< 0.010	<10	0.534
Deep Basin 2	0	0.013	<0.010	<10	--
Deep Basin 2	3.5	0.010	<0.010	<10	--
Deep Basin 2	5.5	0.014	<0.010	<10	0.890

Table 5. Indian Lake South Basin post-aeration chemical water quality parameter data collected from the deep basin sites on July 12, 2018.

Post-Aeration Data Tables (July 12, 2018): Site Deep Basins #1 and #2

Sampling Site	*Depth (m)*	*Total Phosphorus (mg/L)*	*Ortho-Phosphorus (mg/L)*	*TKN (mg/L)*	*TIN (mg/L)*	*Total Suspended Solids (mg/L)*	*Chlorophyll-a (µg/L)*
Deep Basin 1	0.5	0.022	<0.010	1.2	0.024	12	--
Deep Basin 1	1.5	0.033	<0.010	0.6	<0.010	<10	--
Deep Basin 1	3.0	0.021	< 0.010	0.5	<0.010	<10	-1.07
Deep Basin 2	0.5	0.029	<0.010	0.7	<0.010	<10	--
Deep Basin 2	3.0	0.012	<0.010	0.5	<0.010	<10	--
Deep Basin 2	5.0	0.013	<0.010	--	0.013	<10	--

Table 6. Indian Lake South Basin post-aeration chemical water quality parameter data collected from the deep basin sites on September 7, 2018.

Post-Aeration Data Tables (September 7, 2018): Site South Deep Basins #1 and #2

Sampling Site	***Depth (m)***	***Total Phosphorus (mg/L)***	***Ortho-Phosphorus (mg/L)***	***TKN (mg/L)***	***TIN (mg/L)***	***Total Suspended Solids (mg/L)***	***Chlorophyll-a (µg/L)***
Deep Basin 1	0	0.023	<0.010	<0.5	<0.010	<10	--
Deep Basin 1	1.5	0.022	<0.010	0.6	0.018	<10	--
Deep Basin 1	3.0	<0.010	< 0.010	0.7	0.018	<10	-1.78
Deep Basin 2	0	0.019	<0.010	0.7	<0.010	<10	--
Deep Basin 2	2.5	0.025	<0.010	1.0	0.019	<10	--
Deep Basin 2	4.5	<0.010	<0.010	1.0	0.010	<10	0.356

Table 7. Chemical water quality parameters collected at Site #1 South on 12 May 2019.

Depth (m)	**TP (mg/l)**	**TIN (mg/l)**	**NO3 (mg/l)**	**NO2 (mg/l)**	**NH3 (mg/l)**	**TKN (mg/l)**	**Chlorophyll a (mg/m3)**	**TSS (mg/l)**	**Ortho-P (mg/l)**
0	0.014	0.24	0.21	<0.10	0.029	<0.50	0	12	<0.010
1.5	0.018	0.026	<0.10	<0.10	0.026	<0.50		16	<0.010
3.0	0.015	0.018	<0.10	<0.10	0.018	<0.50		16	<0.010

Table 8. Physical water quality parameters collected at site #1 South on 12 May 2019.

Depth (m)	**Temp (°C)**	**DO (mg/l)**	**pH (SU)**	**Cond (µS/cm)**	**TDS (mg/l)**	**Secchi (ft)**
0	14.01	10.18	8.25	283.4	181.4	5.8
0.5	13.90	10.42	8.45	282.6	180.9	
1.0	13.98	10.44	8.46	283.1	181.2	
1.5	13.87	10.42	8.47	282.7	181.1	
2.0	13.59	10.49	8.49	334.0	215.6	
2.5	13.44	10.62	8.49	376.1	238.4	
3.0	13.42	10.62	8.48	381.7	242.7	

Table 9. Chemical water quality parameters collected at Site #2 South on 12 May 2019.

Depth (m)	TP (mg/l)	TIN (mg/l)	NO3 (mg/l)	NO2 (mg/l)	NH3 (mg/l)	TKN (mg/l)	Chlorophyll a (mg/m3)	TSS (mg/l)	Ortho-P (mg/l)
0	0.016	0.020	<0.10	<0.10	0.020	<0.50	0	<10	<0.010
2.5	0.016	0.016	<0.10	<0.10	0.016	<0.50		<10	<0.010
5.5	0.015	0.035	<0.10	<0.10	0.035	<0.50		<10	<0.010

Table 10. Physical water quality parameters collected at site #2 South on 12 May 2019.

Depth (m)	Temp (°C)	DO (mg/l)	pH (SU)	Cond (µS/cm)	TDS (mg/l)	Secchi (ft)
0	13.58	10.19	8.48	385.8	246.6	5.9
0.5	13.85	10.21	8.47	389.8	250.8	
1.0	13.84	10.23	8.47	389.7	246.4	
1.5	13.84	10.24	8.47	381.4	248.9	
2.0	13.82	10.24	8.47	381.8	243.3	
2.5	13.80	10.25	8.47	389.8	247.8	
3.0	13.64	10.28	8.46	382.9	248.8	
3.5	13.40	10.28	8.47	368.4	234.7	
4.0	13.38	10.25	8.47	373.4	236.1	
4.5	13.32	10.24	8.47	298.1	202.2	
5.0	13.26	10.22	8.46	283.7	181.6	
5.5	13.12	6.33	8.10	472.1	293.5	

Table 11. Chemical water quality parameters collected at Site #1 South on 22 July 2019.

Depth (m)	TP (mg/l)	TIN (mg/l)	NO3 (mg/l)	NO2 (mg/l)	NH3 (mg/l)	TKN (mg/l)	Chlorophyll a (mg/m3)	TSS (mg/l)	Ortho-P (mg/l)
0	0.013	0.024	<0.10	<0.10	0.024	0.74	1.60	22	<0.010
	0.020	0.036	<0.10	<0.10	0.036	1.40		18	<0.010
	0.021	0.031	<0.10	<0.10	0.031	0.87		16	<0.010

Table 12. Physical water quality parameters collected at site #1 South on 22 July 2019.

Depth (m)	Temp (°C)	DO (mg/l)	pH (SU)	Cond (µS/cm)	TDS (mg/l)	Secchi (ft)
0	27.77	7.69	8.45	302.0	196.1	6.6
0.5	27.79	7.63	8.45	318.5	193.8	
1.0	27.80	7.61	8.43	309.9	186.5	
1.5	27.80	7.63	8.40	293.5	187.1	
2.0	27.81	7.63	8.33	301.4	195.0	
2.5	27.81	7.63	8.31	304.2	202.7	
3.0	27.81	7.63	8.25	302.5	190.7	

Table 13. Chemical water quality parameters collected at Site #2 South on 22 July 2019.

Depth (m)	TP (mg/l)	TIN (mg/l)	NO3 (mg/l)	NO2 (mg/l)	NH3 (mg/l)	TKN (mg/l)	Chlorophyll a (mg/m3)	TSS (mg/l)	Ortho-P (mg/l)
0	0.012	0.028	<0.10	<0.10	0.028	0.62	0	10	<0.010
	0.023	0.036	<0.10	<0.10	0.036	1.10		<10	<0.010
	0.016	0.026	<0.10	<0.10	0.026	0.72		12	<0.010

Table 14. Physical water quality parameters collected at site #2 South on 12 May 2019.

Depth (m)	Temp (°C)	DO (mg/l)	pH (SU)	Cond (µS/cm)	TDS (mg/l)	Secchi (ft)
0	27.79	7.49	8.48	291.3	187.3	6.8
0.5	27.84	7.47	8.47	289.5	185.3	
1.0	27.81	7.48	8.43	290.2	185.8	
1.5	27.80	7.50	8.43	291.2	185.4	
2.0	27.80	7.50	8.43	290.9	186.4	
2.5	27.78	7.51	8.40	292.8	188.3	
3.0	27.80	7.50	8.35	292.8	189.5	
3.5	27.81	7.50	8.30	300.6	189.2	
4.0	27.78	7.50	8.28	290.1	185.8	
4.5	27.77	7.50	8.27	290.1	186.9	
5.0	27.67	7.49	8.26	289.9	185.5	
5.5	27.42	5.24	8.23	300.7	208.8	

Table 15. Chemical water quality parameters collected at Site #1 South on 3 Oct 2019.

Depth (m)	TP (mg/l)	TIN (mg/l)	NO3 (mg/l)	NO2 (mg/l)	NH3 (mg/l)	TKN (mg/l)	Chlorophyll a (mg/m3)	TSS (mg/l)	Ortho-P (mg/l)
0	<0.010	0.22	0.19	<0.10	0.031	0.51	0	18	<0.010
1.5	<0.010	0.20	0.16	<0.10	0.036	<0.50		14	<0.010
3.0	<0.010	0.22	0.19	<0.10	0.033	<0.50		20	<0.010

Table 16. Physical water quality parameters collected at Site #1 South.

Depth (m)	Temp (°C)	DO (mg/l)	pH (SU)	Cond (µS/cm)	TDS (mg/l)	Secchi (ft)
0	18.85	7.66	8.43	289.5	188.3	5.3
0.5	18.85	7.64	8.43	289.6	188.3	
1.0	18.81	7.51	8.41	290.3	188.4	
1.5	18.80	7.47	8.40	290.4	188.6	
2.0	18.78	7.41	8.37	290.6	188.7	
2.5	18.75	7.30	8.34	291.0	188.7	
3.0	18.75	7.19	8.32	293.1	203.5	

Table 17. Chemical water quality parameters collected at Site #2 South on 3 Oct 2019.

Depth (m)	TP (mg/l)	TIN (mg/l)	NO3 (mg/l)	NO2 (mg/l)	NH3 (mg/l)	TKN (mg/l)	Chlorophyll a (mg/m3)	TSS (mg/l)	Ortho-P (mg/l)
0	<0.010	0.24	0.21	<0.10	0.031	<0.50	0.801	12	<0.010
2.5	<0.010	0.31	0.28	<0.10	0.033	<0.50		10	<0.010
5	<0.010	0.26	0.23	<0.10	0.037	<0.50		<10	<0.010

Table 18. Physical water quality parameters collected at Site #2 South on 3 Oct 2019.

Depth (m)	Temp (°C)	DO (mg/l)	pH (SU)	Cond (µS/cm)	TDS (mg/l)	Secchi (ft)
0	18.88	7.71	8.44	290.2	187.8	5.2
0.5	18.88	7.70	8.43	289.8	187.9	
1.0	18.87	7.62	8.40	290.1	188.2	
1.5	18.86	7.58	8.40	290.1	188.2	
2.0	18.86	7.51	8.39	290.2	188.2	
2.5	18.85	7.49	8.39	290.4	188.5	
3.0	18.75	7.46	8.36	291.3	188.8	
3.5	18.68	7.31	8.33	291.3	188.6	
4.0	18.64	7.22	8.32	291.3	188.8	
4.5	18.63	7.01	8.30	291.4	188.9	
5.0	18.60	6.95	8.27	291.6	189.1	
5.5	18.54	6.87	8.24	292.9	211.2	

Table 19. Chemical water quality parameters collected at Site #1 South on 27 May 2020.

Depth (m)	TP (mg/l)	TIN (mg/l)	NO3 (mg/l)	NO2 (mg/l)	NH3 (mg/l)	TKN (mg/l)	Chlorophyll a (mg/m3)	TSS (mg/l)	Ortho-P (mg/l)
0	0.018	<0.010	<0.10	<0.10	<0.010	0.54	0	<10	0.011
1.5	0.017	<0.010	<0.10	<0.10	<0.010	<0.50		<10	<0.010
3.0	0.020	<0.010	<0.10	<0.10	<0.010	0.52		<10	<0.010

Table 20. Physical water quality parameters collected at site #1 South on 27 May 2020.

Depth (m)	Temp (°C)	DO (mg/l)	pH (SU)	Cond (µS/cm)	Secchi (ft)
0	26.3	9.1	8.3	299	
0.5	26.3	9.1	8.4	299	
1.0	26.2	9.0	8.4	299	
1.5	25.9	8.9	8.4	298	5.9
2.0	25.5	8.9	8.4	298	
2.5	25.4	8.9	8.4	295	
3.0	22.9	9.0	8.4	295	

Table 21. Chemical water quality parameters collected at Site #2 South on 27 May 2020.

Depth (m)	TP (mg/l)	TIN (mg/l)	NO3 (mg/l)	NO2 (mg/l)	NH3 (mg/l)	TKN (mg/l)	Chlorophyll a (mg/m3)	TSS (mg/l)	Ortho-P (mg/l)
0	0.018	<0.010	<0.10	<0.10	<0.010	0.58	0	<10	<0.010
2.5	0.018	<0.010	<0.10	<0.10	<0.010	0.63		<10	<0.010
5.5	0.017	<0.010	<0.10	<0.10	<0.010	<0.50		<10	<0.010

Table 22. Physical water quality parameters collected at site #2 South on 27 May 2020.

Depth (m)	Temp (°C)	DO (mg/l)	pH (SU)	Cond (µS/cm)	Secchi (ft)
0	26.4	8.8	8.5	300	6.1
0.5	26.4	8.8	8.5	301	
1.0	26.3	8.7	8.5	301	
1.5	26.0	8.7	8.5	301	
2.0	25.9	8.9	8.4	301	
2.5	25.9	8.9	8.4	301	
3.0	23.5	8.8	8.4	300	
3.5	23.5	8.8	8.4	300	
4.0	23.4	8.8	8.4	297	
4.5	23.4	8.8	8.4	297	
5.0	23.1	8.8	8.4	297	
5.5	22.0	8.8	8.4	297	

Table 23. Chemical water quality parameters collected at Site #1 South on 30 July 2020.

Depth (m)	TP (mg/l)	TIN (mg/l)	NO3 (mg/l)	NO2 (mg/l)	NH3 (mg/l)	TKN (mg/l)	Chlorophyll a (mg/m3)	TSS (mg/l)	Ortho-P (mg/l)
0	0.027	0.032	<0.10	<0.10	0.032	<0.50	0	<10	<0.010
1.5	0.021	0.022	<0.10	<0.10	0.022	0.56	0	<10	<0.010
3.0	0.020	0.010	<0.10	<0.10	0.010	<0.50	0	<10	<0.010

Table 24. Physical water quality parameters collected at site #1 South on 30 July 2020.

Depth (m)	Temp (°C)	DO (mg/l)	pH (SU)	Cond (µS/cm)	Secchi (ft)
0	27.9	7.9	8.5	319	5.1
0.5	27.9	7.9	8.5	319	
1.0	27.9	8.1	8.5	319	
1.5	27.6	8.0	8.5	333	
2.0	27.5	7.8	8.5	314	
2.5	27.2	7.9	8.5	309	
3.0	26.8	7.6	8.5	315	

Table 25. Chemical water quality parameters collected at Site #2 South on 30 July 2020.

Depth (m)	TP (mg/l)	TIN (mg/l)	NO3 (mg/l)	NO2 (mg/l)	NH3 (mg/l)	TKN (mg/l)	Chlorophyll a (mg/m3)	TSS (mg/l)	Ortho-P (mg/l)
0	0.020	0.022	<0.10	<0.10	0.022	<0.50	0	10	<0.010
2.5	0.021	0.024	<0.10	<0.10	0.024	<0.50	0	<10	<0.010
5.5	0.020	0.023	<0.10	<0.10	0.023	<0.50	0.801	12	<0.010

Table 26. Physical water quality parameters collected at site #2 South on 30 July 2020.

Depth (m)	Temp (°C)	DO (mg/l)	pH (SU)	Cond (µS/cm)	Secchi (ft)
0	27.8	8.1	8.4	320	5.9
0.5	27.6	8.1	8.4	320	
1.0	27.6	8.0	8.4	320	
1.5	27.4	8.0	8.4	320	
2.0	27.3	8.0	8.4	320	
2.5	26.5	8.0	8.4	320	
3.0	26.5	8.0	8.4	318	
3.5	26.1	8.0	8.4	318	
4.0	25.9	8.0	8.4	318	
4.5	25.8	7.9	8.4	314	
5.0	25.8	7.8	8.3	312	
5.5	25.8	7.8	8.3	339	

Table 27. Chemical water quality parameters collected at Site #1 South on 13 September 2020.

Depth (m)	TP (mg/l)	TIN (mg/l)	NO3 (mg/l)	NO2 (mg/l)	NH3 (mg/l)	TKN (mg/l)	Chlorophyll a (mg/m3)	TSS (mg/l)	Ortho-P (mg/l)
0	0.021	0.180	0.120	<0.10	0.054	0.62	0	<10	<0.010
1.5	0.018	0.180	0.130	<0.10	0.052	0.60		<10	<0.010
3.0	0.026	0.210	0.160	<0.10	0.052	0.67		<10	<0.010

Table 28. Physical water quality parameters collected at Site #1 South on 13 September 2020

Depth (m)	Temp (°C)	DO (mg/l)	pH (SU)	Cond (µS/cm)	Secchi (ft)
0	23.6	8.1	8.6	325	5.9
0.5	23.6	8.1	8.6	325	
1.0	23.4	8.0	8.5	325	
1.5	23.1	7.8	8.5	325	
2.0	23.1	7.8	8.5	325	
2.5	23.0	7.8	8.5	329	
3.0	23.0	7.8	8.5	331	

Table 29. Chemical water quality parameters collected at Site #2 South on 13 September 2020.

Depth (m)	TP (mg/l)	TIN (mg/l)	NO3 (mg/l)	NO2 (mg/l)	NH3 (mg/l)	TKN (mg/l)	Chlorophyll a (mg/m3)	TSS (mg/l)	Ortho-P (mg/l)
0	0.013	0.200	0.160	<0.10	0.048	0.52	0	<10	<0.010
2.5	<0.010	0.180	0.140	<0.10	0.042	<0.50		<10	<0.010
5	0.012	0.190	0.150	<0.10	0.043	0.65		<10	<0.010

Table 30. Physical water quality parameters collected at Site #2 South on 13 September 2020.

Depth (m)	Temp (°C)	DO (mg/l)	pH (SU)	Cond (µS/cm)	Secchi (ft)
0	23.6	7.5	8.4	322	5.2
0.5	23.5	7.7	8.4	322	
1.0	23.4	7.5	8.4	322	
1.5	23.4	7.4	8.4	322	
2.0	23.3	7.4	8.4	322	
2.5	23.0	7.4	8.4	320	
3.0	23.0	7.3	8.3	318	
3.5	22.9	7.4	8.3	314	
4.0	22.9	7.4	8.3	308	
4.5	21.5	7.4	8.3	311	
5.0	21.5	7.2	8.3	322	
5.5	20.9	6.9	8.1	330	

3.4 d. Summary Tables/Figures for Indian Lake South Basin Phytoplankton Community:

Algal Community Composition Data Graph (Figures 2 and 3):

2018-2019 algal relative abundance data was previously submitted. The genera present in 2020 included the Chlorophyta (green algae): *Chlorella* sp., *Mougeotia* sp., *Scenedesmus* sp., *Rhizoclonium* sp., *Haematococcus* sp., *Cladophora* sp., *Chloromonas* sp., and *Pediastrum* sp.; the Cyanophyta (blue-green algae): *Microcystis* sp. and *Oscillatoria* sp.; the Bascillariophyta (diatoms): *Synedra* sp., *Navicula* sp., *Cymbella* sp., and *Stephanodiscus* sp.

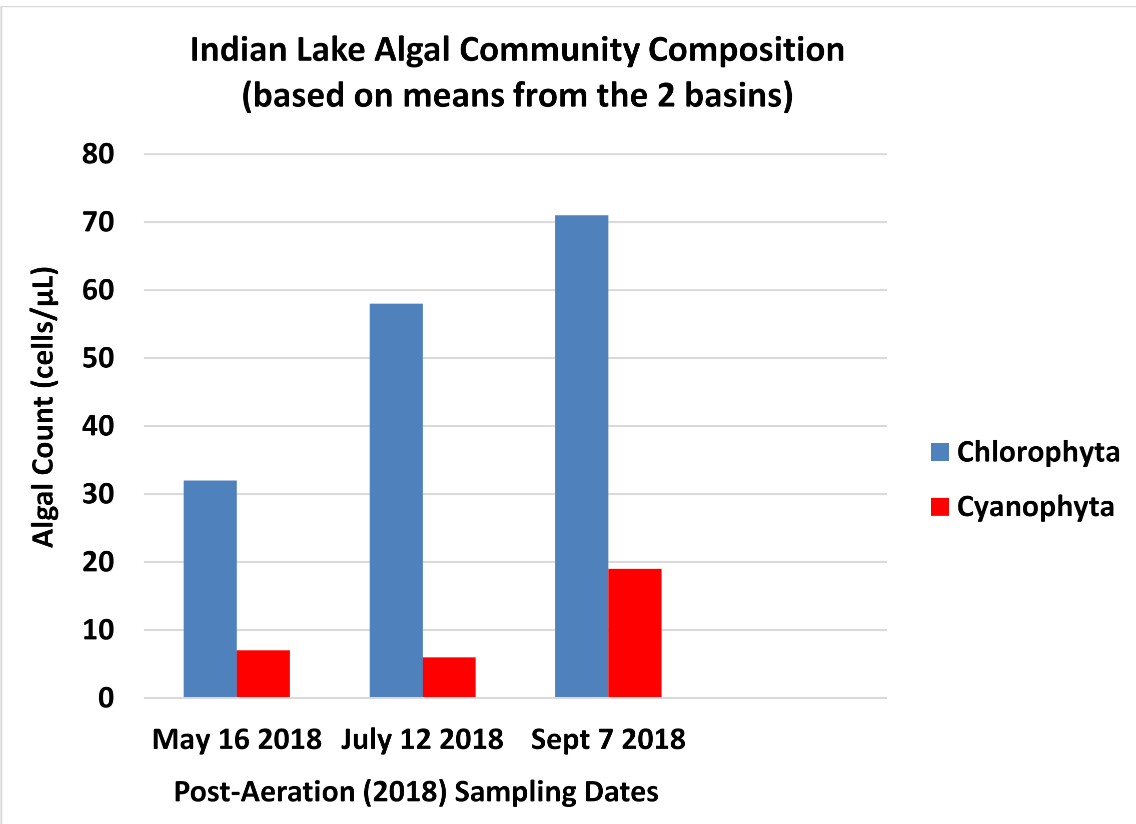

Figure 2. Relative abundance of algal taxa in Indian Lake South Basin (post aeration 2018). Note: The two basins are actually meaning the two sampling sites in the South Basin.

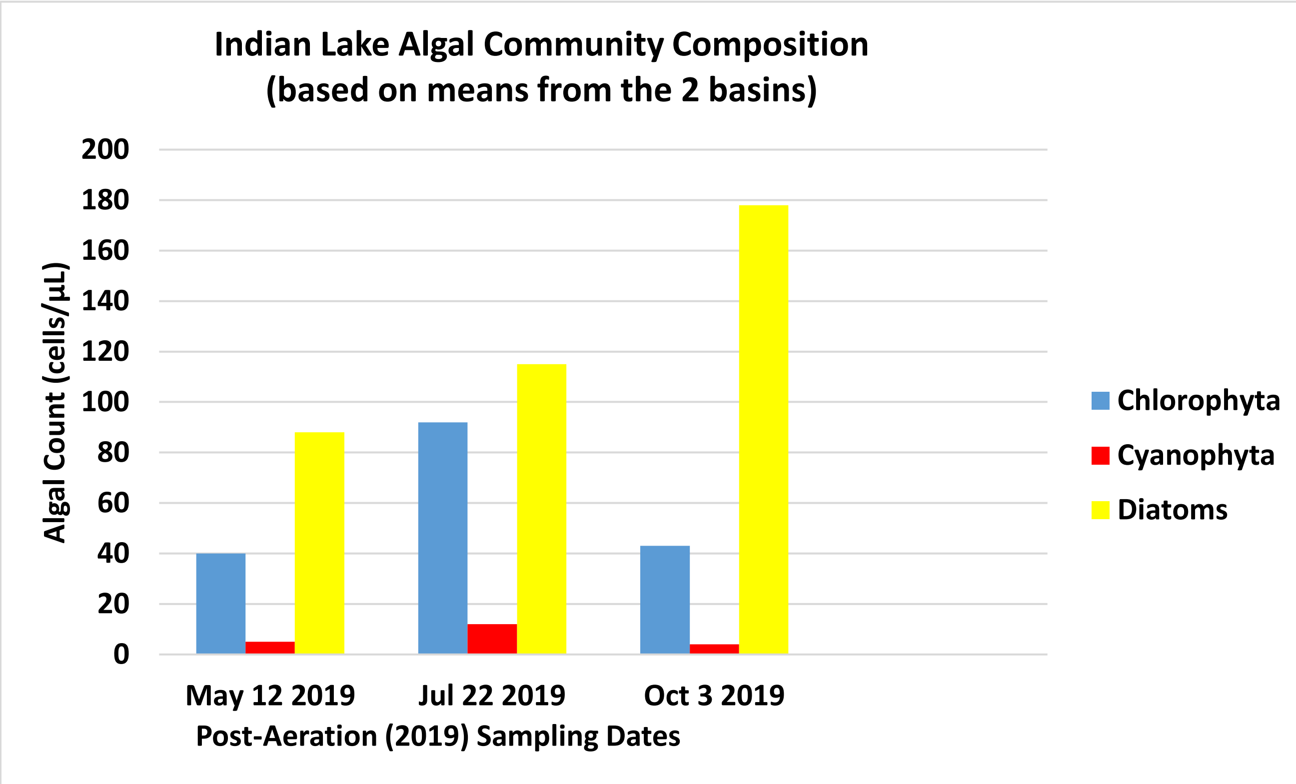

Figure 3. Relative abundance of algal taxa in Indian Lake South Basin (post aeration 2019). Note: The two basins are actually meaning the two sampling sites in the South Basin.

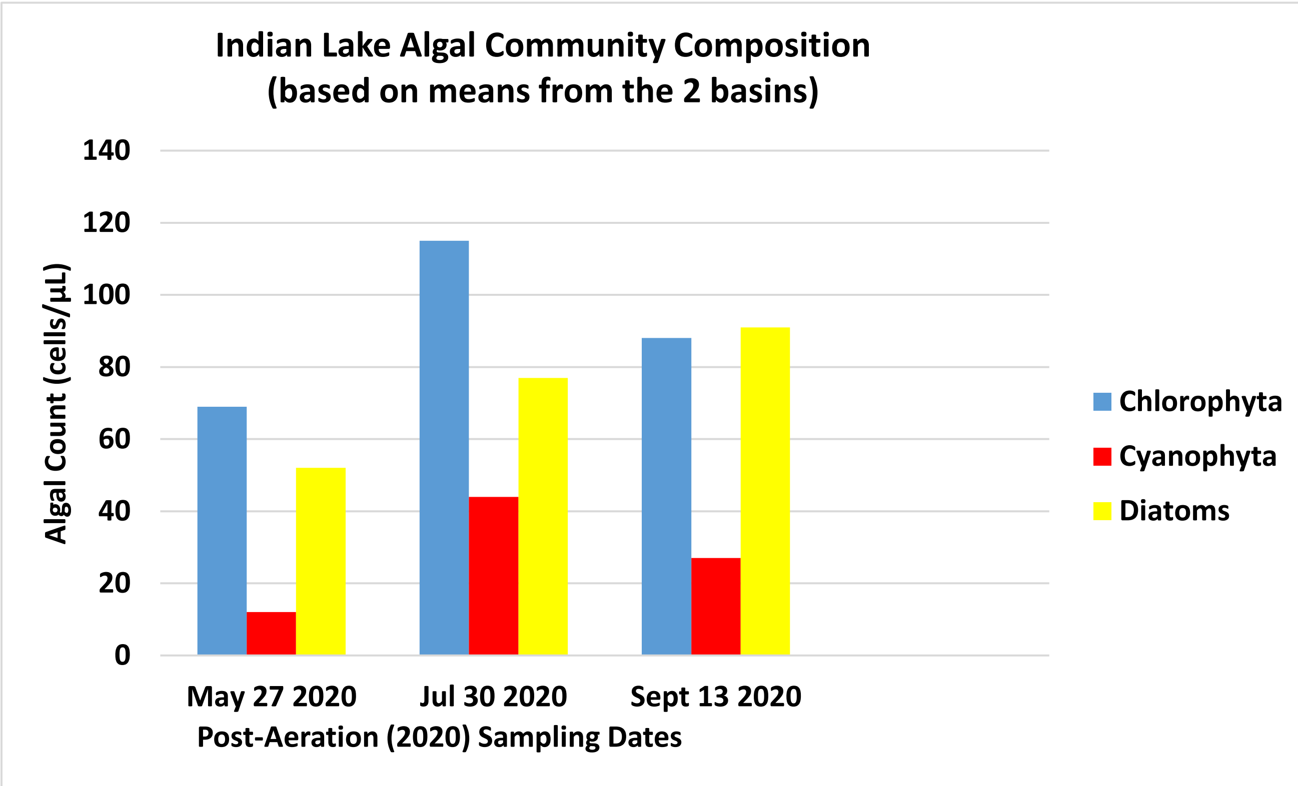

Figure 4. Relative abundance of algal taxa in Indian Lake South Basin (post aeration 2020). Note: The two basins are actually meaning the two sampling sites in the South Basin.

3.5 e. Reference to Raw Data and QA/QC Information (See Appendix A for 2020 data):

All raw data, field forms, chain of custody forms, laboratory reports for 2020 post-aeration May-September data can be found in Appendix A. 2018-2019 data was previously submitted.

4.0 CONCLUSIONS

4.1 a. Narrative Summary of Water Quality Trends:

This section is to report measured trends in all evaluated parameters that may be due to the activity of the LFA system with bioaugmentation. Note: Bioaugmentation was not supplied in 2015-2016 so no Rule 97 was applied for by Lake Savers, LLC. It was however applied in 2017-2019 with a Rule 97 permit from Lake Savers, LLC. In 2021 and beyond, the new LFA permit will require additional data such as total inorganic nitrogen, total Kjeldahl nitrogen, and zooplankton as well as required lake scans.

Water Temperature:
Neither of the two deep basins exhibited stratification prior to implementation of LFA (June 5, 2015) or on July 13, 2015 or during any sampling periods in 2016. Interestingly, there was a 3.4°C water temperature difference during the October 1, 2015 sampling event. The reason for this difference five months after activation of the LFA system is unclear since the system usually destratifies the water column and makes the water temperature uniform from the surface to the bottom. The water temperatures in 2016 were quite uniform from top to bottom (<2.0°C difference) but water temperatures were slightly higher than in 2015 since air temperatures were at a record high in 2016. In 2017, there was a temperature difference of < 2°C among the sampling depths and basins with an overall mean temperature of 21.3±3.3°C. In 2018, there was a temperature difference of around 2.9-3.7°C in May followed by a <2°C change in July and negligible change in September. This demonstrates that the lake destratification occurs progressively throughout the season. In 2019, water temperatures were near isothermic with less than a 1°C difference from the surface to the bottom. In 2020, water temperatures varied by 2-5°C.

Conductivity:
The mean conductivity of deep basins #1 and #2 was 305 and 312 mS/cm, respectively pre-aeration on June 5, 2015. On July 13, 2015, the mean conductivity of deep basins #1 and #2 was 306 and 302 mS/cm, respectively post-aeration. On October 1, 2015 (post-aeration) the mean conductivity of deep basins #1 and #2 was 227 mS/cm for each basin. Thus, the conductivity has declined since aeration began. In 2016, the mean conductivity overall was 262 mS/cm which is lower than in 2015. This may be due to the aeration system since we would expect the conductivity to be higher in warmer waters which was not the case. The mean conductivity in 2017 was 274±14 mS/cm which is less than 2015 but greater than 2016. In 2018, the mean conductivity was 290±8.8 mS/cm which is slightly higher than in recent years but when the standard deviation is considered, this mean is similar to recent years.

In 2019, the mean conductivity was 314±42 mS/cm which given the standard deviation is similar to recent years but with higher maximum values recorded in 2019. In 2020, the mean conductivity was 313±12 mS/cm which is almost equal to 2019.

pH:
The mean pH of deep basins #1 and #2 was 8.6 S.U. pre-aeration on June 5, 2015. The mean pH of deep basins #1 and #2 was 8.3 S.U. post-aeration on July 13, 2015. The mean pH of deep basins #1 and #2 was 8.4 S.U. post-aeration on October 1, 2015. The pH range in 2016 was 8.0-8.5 S.U. with a mean of 8.3 S.U. The mean pH in 2017 was 8.4±0.4 S.U. which is similar to previous years. The mean pH in 2018 was 8.5±0.2 S.U. which is ideal. The mean pH in 2019 was 8.4±0.2 which is also ideal. The mean pH in 2020 was 8.4±0.1 S.U. which is ideal.

Dissolved Oxygen:
The mean dissolved oxygen (DO) concentration pre-aeration for deep basins #1 and #2 was 10.7 mg/L and 10.3 mg/L respectively on June 5, 2015. The mean dissolved oxygen (DO) concentration post-aeration for deep basins #1 and #2 was 8.0 mg/L and 8.0 mg/L respectively on July 13, 2015. The mean dissolved oxygen (DO) concentration post-aeration for deep basins #1 and #2 was 8.1 mg/L and 8.2 mg/L respectively on October 1, 2015. The mean DO concentration in 2016 was 8.5 mg/l which is favorable given the higher water and air temperatures. Thus, dissolved oxygen slightly declined since June of 2015 with operation of the LFA system but increased again in 2016 and 2017. The mean DO concentration increased to 8.8±1.1 mg/L in 2017. The mean DO concentration in 2018 was 8.3±0.2 mg/L which is lower than in 2017 but higher than previous years. This is favorable since the water temperatures were higher in 2018 and warmer water usually holds less oxygen. These DO concentrations are favorable for the health of the lake and the warm water fishery present. In 2019, the mean DO concentration was 8.3±1.4 mg/L which is favorable. In 2020, the mean DO concentration was 8.4±0.6 mg/L which is favorable.

Secchi Transparency:
The mean Secchi transparency for deep basins #1 and #2 pre-aeration on June 5, 2015 was 7.8 feet and 9.0 feet, respectively. The mean Secchi transparency for deep basins #1 and #2 post-aeration on July 13, 2015 was 8.0 feet and 14.0 feet, respectively. The mean Secchi transparency for deep basins #1 and #2 post-aeration on October 1, 2015 was 8.0+ feet and 16.0+ feet, respectively. In 2016, the mean Secchi transparency was 8.6 feet which is favorable. Thus, the Secchi transparency (clarity) of the Indian Lake South Basin increased in both deep basins with a 7.0-foot increase in deep basin #2 in 2015. In 2016, the Secchi transparency was highest in June, likely due to less algae in the water at that time. The mean Secchi transparency in 2017 was 9.6±4.6 feet and in 2018 the mean Secchi transparency was 8.1±3.9 feet. This was due to the transparency falling from 13.1 feet in May to 5.6 feet by September. Since the TSS concentrations and the chlorophyll-a were low, the clarity was reduced due to tannins in the water column. The mean Secchi in 2019 was overall lower at 5.9±0.7 feet. This correlates with the observed lower clarity in the North Basin as well. The mean Secchi in 2020 was 5.7±0.4 feet which is lower than past years.

Nutrients (Phosphorus and Ortho-Phosphorus):

The mean ortho-phosphorus concentrations pre-aeration (2015) and post-aeration (2016-2020) were all < 0.010 mg/l in both of the basins which means little phosphorus is available to water column biota.

The mean total phosphorus concentration pre-aeration in deep basins #1 and #2 was 0.133 mg/L and 0.014 mg/L on June 5, 2015. The mean total phosphorus concentration post-aeration in deep basins #1 and #2 was 0.011 mg/L and < 0.010 mg/L on July 13, 2015. The mean total phosphorus concentration post-aeration in deep basins #1 and #2 was 0.012 mg/L and < 0.010 mg/L on October 1, 2015. The elevated TP concentration in early June of 2015 may have been attributed to nutrient loading from heavy rains that occurred in spring and early summer of 2015. The LFA system appears to have reduced these TP concentrations during the summer of 2015. In 2016, the mean TP concentration was 0.017 mg/L which is favorable and below the eutrophic threshold and the mean ortho-phosphorus concentration was still <0.010 mg/L which is ideal and means that low amounts of phosphorus are bioavailable to algae. The mean TP concentration in 2017 was 0.016±0.01 mg/L which is favorable. The mean TP in 2018 was 0.018±0.0 mg/L which is also favorable. The LFA system has overall reduced phosphorus in the lake. The mean TP in 2019 was low at 0.014±0.0 mg/L which is quite favorable. In addition, all of the ortho-phosphorus values in 2019 were below detection at <0.010 mg/L. The mean TP in 2020 was 0.019±0.0 mg/L which is higher than in recent years.

Total Suspended Solids:

The total suspended solids were elevated pre-aeration on June 5, 2015 with means of 100 mg/L and < 10 mg/L for deep basins #1 and #2, respectively. The reasons for that result may be connected to the observed nutrient loads from heavy rainfall that occurred in spring and early summer of 2015. Both post-aeration dates of July 13, 2015 and October 1, 2015 were associated with TSS values < 10 mg/L. In 2016, all but two measurements were < 10 mg/L with one value at 10 and another at 12 mg/L. The mean TSS in 2017 was 10.9±3.8 mg/L which is low and favorable. In 2018 all but one TSS value were < 10 mg/L with the highest value recorded in deep basin #1 in July at 12 mg/L which is still low. These values are ideal and explain the continued and increased water clarity throughout the season. The LFA system appears to have a reducing effect on total suspended solids. The mean TSS in 2019 was 13.7±4.0 mg/L and was slightly higher than in previous years and correlates with the lower Secchi transparency. The mean TSS in 2020 was 10.1±0.5 mg/L which is lower than in recent years.

Algae/Chlorophyll-*a*:

The mean chlorophyll-a concentration pre-aeration on June 5, 2015 was 0 µg/L and post-aeration on July 13, 2015 was also 0 µg/L. Post-aeration on October 1, 2015, the chlorophyll-a increased slightly to 0.890 µg/L in deep basin #1 and 0.712 µg/L in deep basin #2. This increase is negligible and could have been attributed to a seasonal attribute. The mean chlorophyll-a concentration in 2016 was 1.2 µg/L which is favorable and surprising given the higher water and air temperatures. The algal community composition changed with a measured decline in Cyanophyta (blue-green algae) and a decrease in green algae but an increase in diatoms between pre-aeration on June 5, 2015 and by post-aeration on October 1, 2015.

This is beneficial because diatoms are associated with good water quality. In 2016, the blue-green algae declined and green algae and diatoms increased. The LFA system is therefore not increasing the presence of less preferred algae in the water column of Indian Lake South Basin. We took in situ measurements of chl-a at all depths in 2016 with a Turner Designs fluorometer and these values were higher than the ones recorded by TRACE Analytical Laboratories, Inc. We are not sure why the discrepancies have occurred but are using the values provided by TRACE. In 2017, the mean chlorophyll-a concentration was 0.4±0.8 µg/L which is low and favorable and supports the LFA system effects on water clarity as well. In 2018, the mean chl-a concentration was 0.356±0.4 which was quite low. The mean chlorophyll-a concentration in 2019 was 0.400±0.7 µg/L which is slightly higher than last year. The mean chlorophyll-a concentration in 2020 was 0.100±0.3 µg/L which is low.

4.2 b. Conclusion on Efficacy of Aeration for Indian Lake South Basin:

Based on the goals listed in section 1.2 above, the LFA system does not appear to be negatively impacting the water quality of Indian Lake South Basin. In fact, the nutrients have decreased in the South Basin since operation of the LFA system began. Total suspended solids also declined since LFA operations began with the exception in 2019, and this may have been attributed to either runoff or influx of solids from the north inlet. Although the water quality data collected in the South Basin was overall favorable in 2018-2020, there is concern regarding the influx of tannins and nutrients from the inlet in the absence of the inlet barrier or other improvements.