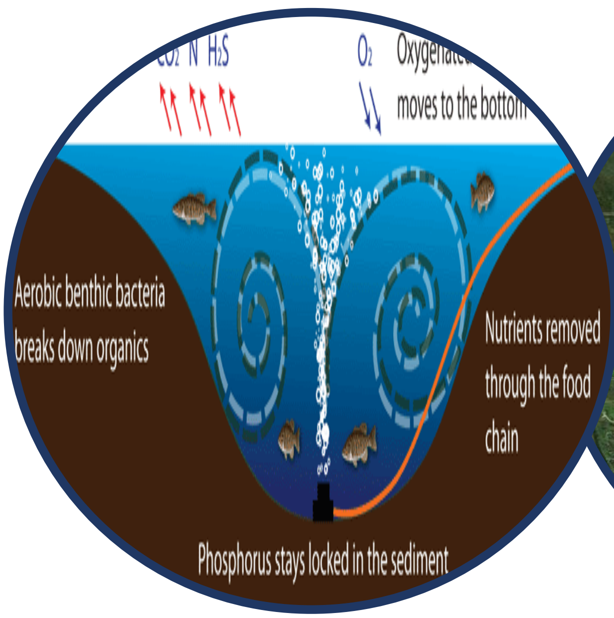
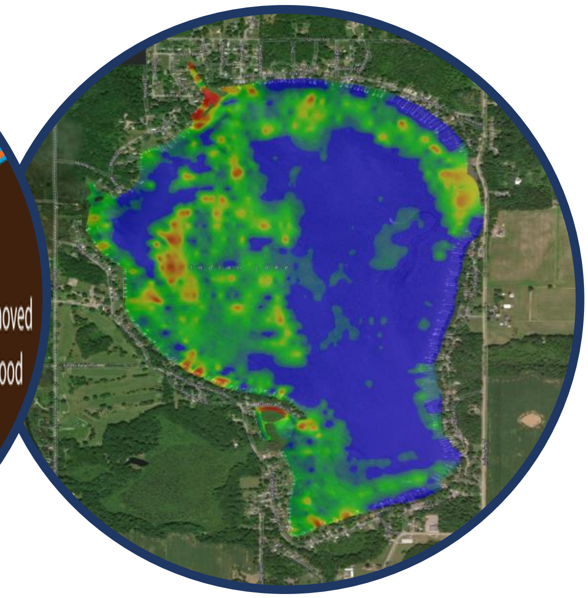
Indian Lake South Basin Laminar Flow 2015 Pre-Aeration And 2015-2017 Post-Aeration Data
Cass County, Michigan





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Pursuant to MDEQ Permit No: 15-14-0016-P

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Indian Lake South Basin Laminar Flow 2015 Pre-Aeration And 2015-2017 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, Lake Savers, LLC applied a bacteria blast to both the North and South Basins of Indian Lake via a Rule 97 permit as required.

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, motor boat 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 have been sampled in June, 2015 (baseline) and in July and October of 2015 (post-aeration) and again on June 8, 2016, July 11, 2016 and October 3, 2016 (all post-aeration) as well as on May 16, 2017, July 13, 2017, and September 13, 2017 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. There was an aquatic herbicide treatment conducted in the canal of the South Basin in 2015 and 2016 as well as 2017 as thick milfoil was found and necessitated treatment for navigational reasons.

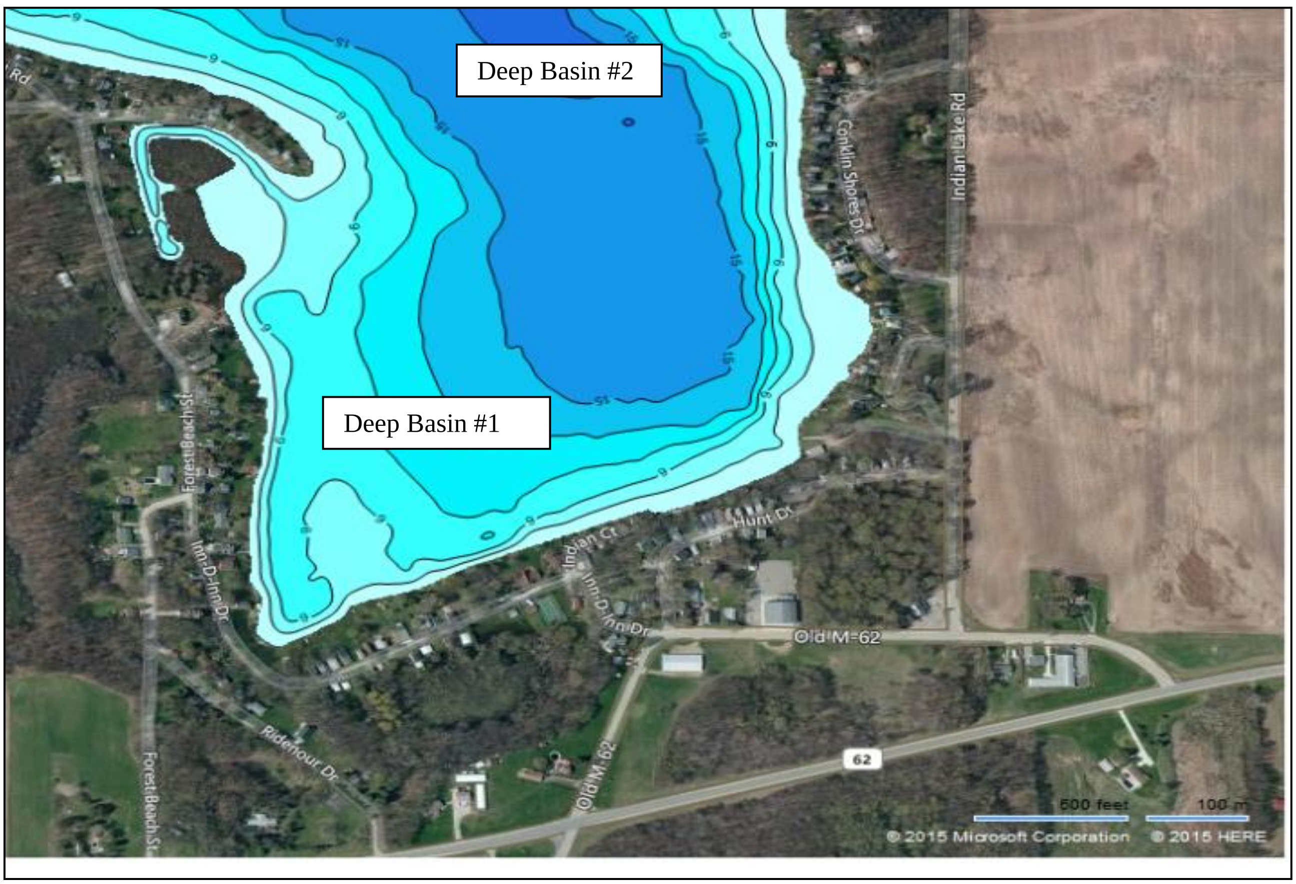

Figure 1. The Indian Lake South Basin, Cass County, MI.

2.0 INDIAN LAKE SOUTH BASIN SAMPLING METHODS

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

Pursuant to MDEQ Permit No. 15-14-0016-P, 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 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 2-foot intervals as required by MDEQ Permit No. 15-14-0016-P.

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

Since the new permit for the South Basin LFA system was initiated in May of 2015, a June 5, 2015 pre-aeration baseline data set was collected at the two deep basin sites in the South Basin. Additionally, post-aeration sample sets were collected as described above on July 13, 2015 and October 1, 2015 and again on June 8, 2016, July 11, 2016 and October 3, 2016 (all post-aeration) as well as on May 16, 2017, July 13, 2017, and September 13, 2017. 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 (2015 raw data and laboratory reports) and Appendix B (2016 raw data and laboratory reports). On June, 2015 it was mostly cloudy and 69°F with winds out of the west and 10 mph. On July 13, 2015 it was partly sunny and 70°F with winds out of the south at 5-10 mph. On October 1, 2015 it was sunny and 50 °F with winds out of the northeast at 5-15 mph. On June 8, 2016 it was sunny, 70°F, with NW winds at 10-15 mph. On July 11, 2016 it was overcast at 77°F with S winds at 5-10 mph. On October 3, 2016, it was foggy and 65°F with calm winds. On May 16, 2017 it was sunny and 80°F with winds out of the southwest and 10-15 mph. On July 13, 2017 it was mostly cloudy and 78°F with winds out of the west at 10 mph. On September 13, 2017 it was 70°F with winds out of the southeast at 5 mph.

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. A QA/QC statement of qualifications for Trace Analytical Laboratories in Muskegon, Michigan was previously submitted. The 2015-2016 data was also previously submitted but the 2017 data is attached to this report as Appendix C.

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 physical water quality data is shown in Section 3.1a below. Chemical water quality data is shown in Section 3.3c below.

3.1 a. Summary Tables of Water Quality Data:

Pre-Aeration Data Table (June 5, 2015): Site Deep Basins #1 and #2

Sampling Site	*Depth ft.*	*Water Temp ºC*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Secchi Depth (ft.)*
Deep Basin 1	0	22.6	10.6	8.6	303	--
Deep Basin 1	2	22.6	10.6	8.6	305	7.8
Deep Basin 1	4	22.6	10.7	8.6	306	--
Deep Basin 1	6	22.5	10.8	8.6	306	--
Deep Basin 1	8	22.4	10.8	8.5	307	
Deep Basin 2	0	22.6	9.7	8.7	312	--
Deep Basin 2	2	22.6	9.8	8.6	312	9.0
Deep Basin 2	4	22.6	9.9	8.6	313	--
Deep Basin 2	6	22.5	10.6	8.6	313	--
Deep Basin 2	8	22.4	10.7	8.6	313	--
Deep Basin 2	10	22.4	10.6	8.5	312	--
Deep Basin 2	12	22.4	10.6	8.6	312	--
Deep Basin 2	14	22.4	10.5	8.6	312	--
Deep Basin 2	16	22.2	10.5	8.6	312	--

Table 1. Indian Lake South Basin baseline (pre-aeration) physical water quality parameter data collected from the deep basin sites on June 5, 2015.

Post-Aeration Data Table (July 13, 2015): Site Deep Basins #1 and #2

Sampling Site	***Depth ft.***	***Water Temp ºC***	***DO mg L^{-1}***	***pH S.U.***	***Cond. µS cm^{-1}***	***Secchi Depth (ft.)***
Deep Basin 1	0	23.6	7.9	8.4	306	--
Deep Basin 1	2	23.7	7.9	8.4	306	8.0
Deep Basin 1	4	23.7	7.9	8.4	306	--
Deep Basin 1	6	23.5	8.0	8.4	306	--
Deep Basin 1	8	23.1	8.1	7.8	305	
Deep Basin 2	0	23.5	8.0	8.4	304	--
Deep Basin 2	2	23.6	8.3	8.4	301	14.0
Deep Basin 2	4	23.5	8.0	8.4	297	--
Deep Basin 2	6	23.4	8.1	8.3	299	--
Deep Basin 2	8	23.5	8.2	8.4	305	--
Deep Basin 2	10	23.4	8.1	8.4	305	--
Deep Basin 2	12	23.4	8.0	8.3	295	--
Deep Basin 2	14	23.5	8.0	8.3	301	--
Deep Basin 2	16	23.1	7.6	7.9	309	--

Table 2. Indian Lake South Basin post-aeration physical water quality parameter data collected from the deep basin sites on July 13, 2015.

Post-Aeration Data Table (October 1, 2015): Site Deep Basins #1 and #2

Sampling Site	*Depth ft.*	*Water Temp ºC*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Secchi Depth (ft.)*
Deep Basin 1	0	18.9	8.6	8.4	229	--
Deep Basin 1	2	17.6	8.5	8.4	228	8.0+
Deep Basin 1	4	16.8	8.5	8.3	228	--
Deep Basin 1	6	16.2	8.1	8.3	229	--
Deep Basin 1	8	15.5	7.0	8.4	221	
Deep Basin 2	0	19.4	8.6	8.4	231	--
Deep Basin 2	2	19.1	8.6	8.4	220	16.0+
Deep Basin 2	4	18.6	8.5	8.5	222	--
Deep Basin 2	6	17.5	8.5	8.4	226	--
Deep Basin 2	8	17.0	8.4	8.3	231	--
Deep Basin 2	10	16.6	8.2	8.4	229	--
Deep Basin 2	12	16.4	8.0	8.4	229	--
Deep Basin 2	14	16.4	8.0	8.3	224	--
Deep Basin 2	16	16.0	7.1	8.3	227	--

Table 3. Indian Lake South Basin post-aeration physical water quality parameter data collected from the deep basin sites on October 1, 2015.

Post-Aeration Data Table (June 8, 2016): Site Deep Basins #1 and #2

Sampling Site	*Depth ft.*	*Water Temp ºC*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Secchi Depth (ft.)*
Deep Basin 1	0	21.5	8.4	8.4	274	--
Deep Basin 1	2	21.4	8.5	8.4	272	10.0
Deep Basin 1	4	21.4	8.4	8.4	272	--
Deep Basin 1	6	21.2	8.4	8.4	272	--
Deep Basin 1	8	21.2	8.4	8.4	278	
Deep Basin 1	9.5	21.0	8.3	8.4	270	
Deep Basin 2	0	21.9	8.5	8.4	264	10.5
Deep Basin 2	2	21.7	8.5	8.4	271	--
Deep Basin 2	4	21.5	8.5	8.4	266	--
Deep Basin 2	6	21.4	8.4	8.4	271	--
Deep Basin 2	8	21.2	8.5	8.4	270	--
Deep Basin 2	10	21.3	8.4	8.4	271	--
Deep Basin 2	12	21.1	8.2	8.4	272	--
Deep Basin 2	14	21.2	8.1	8.4	270	--
Deep Basin 2	16	20.8	8.0	8.3	271	

Table 4. Indian Lake South Basin post-aeration physical water quality parameter data collected from the deep basin sites on June 8, 2016.

Post-Aeration Data Table (July 11, 2016): Site Deep Basins #1 and #2

Sampling Site	*Depth ft.*	*Water Temp ºC*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Secchi Depth (ft.)*
Deep Basin 1	0	27.6	8.1	8.0	272	--
Deep Basin 1	2	26.4	8.5	8.1	270	7.6
Deep Basin 1	4	26.1	8.6	8.0	268	--
Deep Basin 1	6	25.9	8.7	8.0	269	--
Deep Basin 1	8	25.5	8.8	8.0	271	
Deep Basin 1	10.0	25.4	8.8	8.0	267	
Deep Basin 2	0	26.3	8.1	8.1	238	7.6
Deep Basin 2	2	26.3	8.1	8.0	272	--
Deep Basin 2	4	26.3	8.1	8.0	278	--
Deep Basin 2	6	26.1	8.2	8.0	282	--
Deep Basin 2	8	26.0	8.2	8.1	282	--
Deep Basin 2	10	25.5	8.4	8.0	278	--
Deep Basin 2	12	25.2	8.4	8.0	282	--
Deep Basin 2	14	25.1	8.5	8.0	283	--
Deep Basin 2	16	25.1	8.5	8.0	280	

Table 5. Indian Lake South Basin post-aeration physical water quality parameter data collected from the deep basin sites on July 11, 2016.

Post-Aeration Data Table (October 3, 2016): Site Deep Basins #1 and #2

Sampling Site	*Depth ft.*	*Water Temp ºC*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Secchi Depth (ft.)*
Deep Basin 1	0	19.3	8.9	8.5	237	--
Deep Basin 1	2	19.1	8.6	8.4	245	7.7
Deep Basin 1	4	19.1	8.4	8.2	253	--
Deep Basin 1	6	18.4	8.4	8.4	239	--
Deep Basin 1	8	18.8	8.6	8.4	243	
Deep Basin 1	9	18.8	8.6	8.4	243	
Deep Basin 2	0	18.8	8.6	8.5	241	8.4
Deep Basin 2	2	19.0	8.3	8.5	241	--
Deep Basin 2	4	19.1	8.3	8.5	244	--
Deep Basin 2	6	19.1	8.6	8.5	239	--
Deep Basin 2	8	19.1	8.2	8.4	243	--
Deep Basin 2	10	19.0	9.0	8.4	241	--
Deep Basin 2	12	19.2	9.0	8.4	244	--
Deep Basin 2	14	19.1	9.1	8.3	244	--
Deep Basin 2	16	19.2	9.3	8.3	246	

Table 6. Indian Lake South Basin post-aeration physical water quality parameter data collected from the deep basin sites on October 3, 2016.

Post-Aeration Data Table (May 16, 2017): Site Deep Basins #1 and #2

Sampling Site	*Depth ft.*	*Water Temp ºC*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Secchi Depth (ft.)*
Deep Basin 1	0	18.2	8.9	7.9	273	--
Deep Basin 1	2	18.3	8.7	7.9	262	10.0+
Deep Basin 1	4	18.1	9.1	7.9	267	--
Deep Basin 1	6	17.4	9.1	8.0	271	--
Deep Basin 1	8	17.5	8.8	8.0	263	
Deep Basin 1	10	17.4	9.0	7.9	259	
Deep Basin 2	0	18.9	8.7	7.9	263	15.0
Deep Basin 2	2	18.9	8.7	7.9	259	--
Deep Basin 2	4	18.7	9.1	7.8	258	--
Deep Basin 2	6	18.9	9.1	7.9	256	--
Deep Basin 2	8	18.1	8.9	7.9	256	--
Deep Basin 2	10	17.8	9.0	7.9	257	--
Deep Basin 2	12	17.6	9.0	7.9	262	--
Deep Basin 2	14	16.7	9.1	7.9	253	--
Deep Basin 2	16	16.5	9.1	7.9	258	

Table 7. Indian Lake South Basin post-aeration physical water quality parameter data collected from the deep basin sites on May 16, 2017.

Post-Aeration Data Table (July 13, 2017): Site Deep Basins #1 and #2

Sampling Site	*Depth ft.*	*Water Temp ºC*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Secchi Depth (ft.)*
Deep Basin 1	0	25.7	7.8	8.5	292	--
Deep Basin 1	2	25.7	7.8	8.5	291	4.6
Deep Basin 1	4	25.7	7.8	8.5	291	--
Deep Basin 1	6	25.7	7.8	8.5	292	--
Deep Basin 1	8	25.6	7.7	8.4	292	
Deep Basin 1	10.0	25.5	7.1	8.0	297	
Deep Basin 2	0	25.8	8.1	8.5	291	5.2
Deep Basin 2	2	25.8	8.2	8.5	291	--
Deep Basin 2	4	25.7	8.2	8.5	291	--
Deep Basin 2	6	25.7	8.0	8.5	291	--
Deep Basin 2	8	25.7	8.0	8.5	291	--
Deep Basin 2	10	25.6	7.9	8.5	291	--
Deep Basin 2	12	25.6	7.8	8.4	291	--
Deep Basin 2	14	25.5	7.6	8.4	291	--
Deep Basin 2	16	25.1	5.6	8.0	300	

Table 8. Indian Lake South Basin post-aeration physical water quality parameter data collected from the deep basin sites on July 13, 2017.

Post-Aeration Data Table (September 13, 2017): Site Deep Basins #1 and #2

Sampling Site	*Depth ft.*	*Water Temp ºC*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Secchi Depth (ft.)*
Deep Basin 1	0	20.7	10.0	8.9	268	--
Deep Basin 1	2	20.6	10.1	8.9	268	8.0+
Deep Basin 1	4	20.5	10.1	8.9	267	--
Deep Basin 1	6	20.2	10.1	8.9	268	--
Deep Basin 1	8	20.2	10.1	8.9	269	
Deep Basin 2	0	20.5	10.1	9.0	267	15.0
Deep Basin 2	2	20.5	10.3	8.9	267	--
Deep Basin 2	4	20.5	10.3	8.9	267	--
Deep Basin 2	6	20.4	10.3	8.9	267	--
Deep Basin 2	8	20.2	10.3	8.9	267	--
Deep Basin 2	10	20.1	10.3	8.9	268	--
Deep Basin 2	12	20.0	10.2	8.9	268	--
Deep Basin 2	14	19.9	9.9	8.9	270	--
Deep Basin 2	16	19.9	6.7	8.7	272	

Table 9. Indian Lake South Basin post-aeration physical water quality parameter data collected from the deep basin sites on September 13, 2017.

Pre-Aeration Data Tables (June 5, 2015): Site Deep Basins #1 and #2

Sampling Site	*Depth (ft.)*	*Total Phosphorus (mg/L)*	*Ortho-Phosphorus (mg/L)*	*Total Suspended Solids (mg/L)*	*Chlorophyll-a (μg/L)*
Deep Basin 1	0	0.019	<0.010	<10	--
Deep Basin 1	4	<0.010	<0.010	<10	0
Deep Basin 1	8	0.370	< 0.010	280	--
Deep Basin 2	0	0.014	<0.010	<10	--
Deep Basin 2	8	<0.010	<0.010	<10	0
Deep Basin 2	16	0.018	<0.010	<10	--

Table 10. Indian Lake South Basin baseline (pre-aeration) chemical water quality parameter data collected from the deep basin sites on June 5, 2015.

Post-Aeration Data Tables (July 13, 2015): Site Deep Basins #1 and #2

Sampling Site	*Depth (ft.)*	*Total Phosphorus (mg/L)*	*Ortho-Phosphorus (mg/L)*	*Total Suspended Solids (mg/L)*	*Chlorophyll-a (μg/L)*
Deep Basin 1	0	<0.010	<0.010	<10	--
Deep Basin 1	4	0.013	<0.010	<10	0
Deep Basin 1	8	0.012	< 0.010	<10	--
Deep Basin 2	0	<0.010	<0.010	<10	--
Deep Basin 2	8	<0.010	<0.010	<10	0
Deep Basin 2	16	<0.010	<0.010	<10	--

Table 11. Indian Lake South Basin post-aeration chemical water quality parameter data collected from the deep basin sites on July 13, 2015.

Post-Aeration Data Tables (October 1, 2015): Site Deep Basins #1 and #2

Sampling Site	*Depth (ft.)*	*Total Phosphorus (mg/L)*	*Ortho-Phosphorus (mg/L)*	*Total Suspended Solids (mg/L)*	*Chlorophyll-a (µg/L)*
Deep Basin 1	0	<0.010	<0.010	<10	--
Deep Basin 1	4	0.015	<0.010	<10	0.890
Deep Basin 1	8	<0.010	< 0.010	<10	--
Deep Basin 2	0	<0.010	<0.010	<10	--
Deep Basin 2	8	<0.010	<0.010	<10	0.712
Deep Basin 2	16	<0.010	<0.010	<10	--

Table 12. Indian Lake South Basin post-aeration chemical water quality parameter data collected from the deep basin sites on October 1, 2015.

Post-Aeration Data Tables (June 8, 2016): Site Deep Basins #1 and #2

Sampling Site	*Depth (ft.)*	*Total Phosphorus (mg/L)*	*Ortho-Phosphorus (mg/L)*	*Total Suspended Solids (mg/L)*	*Chlorophyll-a (µg/L)*
Deep Basin 1	0	0.015	<0.010	<10	--
Deep Basin 1	6	0.015	<0.010	12	--
Deep Basin 1	9.5	0.022	< 0.010	<10	-0.134
Deep Basin 2	0	0.022	<0.010	<10	--
Deep Basin 2	8	0.021	<0.010	<10	1.87
Deep Basin 2	16	0.024	<0.010	<10	--

Table 13. Indian Lake South Basin baseline (post-aeration) chemical water quality parameter data collected from the deep basin sites on June 8, 2016.

Post-Aeration Data Tables (July 11, 2016): Site Deep Basins #1 and #2

Sampling Site	*Depth (ft.)*	*Total Phosphorus (mg/L)*	*Ortho-Phosphorus (mg/L)*	*Total Suspended Solids (mg/L)*	*Chlorophyll-a (µg/L)*
Deep Basin 1	0	0.022	<0.010	<10	--
Deep Basin 1	6	0.019	<0.010	<10	--
Deep Basin 1	10	0.021	< 0.010	<10	1.28
Deep Basin 2	0	0.015	<0.010	<10	--
Deep Basin 2	8	0.027	<0.010	<10	--
Deep Basin 2	16	0.028	<0.010	10	-14.4

Table 14. Indian Lake South Basin post-aeration chemical water quality parameter data collected from the deep basin sites on July 11, 2016.

Post-Aeration Data Tables (October 3, 2016): Site Deep Basins #1 and #2

Sampling Site	*Depth (ft.)*	*Total Phosphorus (mg/L)*	*Ortho-Phosphorus (mg/L)*	*Total Suspended Solids (mg/L)*	*Chlorophyll-a (µg/L)*
Deep Basin 1	0	<0.010	<0.010	<10	--
Deep Basin 1	4	<0.010	<0.010	<10	--
Deep Basin 1	8	<0.010	< 0.010	<10	-0.534
Deep Basin 2	0	<0.010	<0.010	<10	--
Deep Basin 2	8	<0.010	<0.010	<10	--
Deep Basin 2	16	0.013	<0.010	<10	4.27

Table 15. Indian Lake South Basin post-aeration chemical water quality parameter data collected from the deep basin sites on October 3, 2016.

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Post-Aeration Data Tables (May 16, 2017): Site Deep Basins #1 and #2

Sampling Site	*Depth (ft.)*	*Total Phosphorus (mg/L)*	*Ortho-Phosphorus (mg/L)*	*Total Suspended Solids (mg/L)*	*Chlorophyll-a (µg/L)*
Deep Basin 1	0	0.060	<0.010	26	--
Deep Basin 1	6	0.014	<0.010	<10	--
Deep Basin 1	10	0.016	< 0.010	<10	1.96
Deep Basin 2	0	0.024	<0.010	<10	--
Deep Basin 2	8	0.018	<0.010	<10	--
Deep Basin 2	16	0.016	<0.010	<10	0.534

Table 16. Indian Lake South Basin baseline (post-aeration) chemical water quality parameter data collected from the deep basin sites on May 16, 2017.

Post-Aeration Data Tables (July 13, 2017): Site Deep Basins #1 and #2

Sampling Site	*Depth (ft.)*	*Total Phosphorus (mg/L)*	*Ortho-Phosphorus (mg/L)*	*Total Suspended Solids (mg/L)*	*Chlorophyll-a (µg/L)*
Deep Basin 1	0	0.010	<0.010	<10	--
Deep Basin 1	6	0.013	<0.010	<10	--
Deep Basin 1	10	0.014	< 0.010	<10	-0.915
Deep Basin 2	0	0.012	<0.010	<10	--
Deep Basin 2	8	<0.010	<0.010	<10	--
Deep Basin 2	16	<0.010	<0.010	<10	0

Table 17. Indian Lake South Basin post-aeration chemical water quality parameter data collected from the deep basin sites on July 13, 2017.

Post-Aeration Data Tables (September 13, 2017): Site Deep Basins #1 and #2

Sampling Site	*Depth (ft.)*	*Total Phosphorus (mg/L)*	*Ortho-Phosphorus (mg/L)*	*Total Suspended Solids (mg/L)*	*Chlorophyll-a (µg/L)*
Deep Basin 1	0	0.013	<0.010	<10	--
Deep Basin 1	4	0.010	<0.010	<10	--
Deep Basin 1	8	0.011	< 0.010	<10	0
Deep Basin 2	0	0.012	<0.010	<10	--
Deep Basin 2	8	0.011	<0.010	<10	--
Deep Basin 2	16	<0.010	<0.010	<10	0

Table 18. Indian Lake South Basin post-aeration chemical water quality parameter data collected from the deep basin sites on September 13, 2017.

3.2-3.3 b and c. Water Profiles. Profiles for all parameters were not derived due to the lack of distinct differences from top to bottom in the measured parameters.

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

Algal Community Composition Data Graph (Figures 2-4):

The genera present in 2015 included the Chlorophyta (green algae): *Chlorella* sp., *Scenedesmus* sp., *Gleocystis* sp., *Rhizoclonium* sp., *Closterium* sp., *Haematococcus* sp., *Ulothrix* sp., *Pandorina* sp., *Chloromonas* sp., and *Mougeotia* sp., *Pediastrum* sp.; the Cyanophyta (blue-green algae): *Oscillatoria* sp.; the Bascillariophyta (diatoms): *Synedra* sp., *Fragilaria* sp. *Cymbella* sp., and *Navicula* sp.

The genera present in 2016 included the Chlorophyta (green algae): *Chlorella* sp., *Scenedesmus* sp., *Mougeotia* sp., *Rhizoclonium* sp., *Haematococcus* sp., *Ulothrix* sp., *Chloromonas* sp., and *Pediastrum* sp.; the Cyanophyta (blue-green algae): *Oscillatoria* sp. and *Microcystis* sp.; the Bascillariophyta (diatoms): *Synedra* sp., *Fragilaria* sp. *Cymbella* sp., *Stephanodiscus* sp., and *Navicula* sp.

The genera present in 2017 included the Chlorophyta (green algae): *Chlorella* sp., *Scenedesmus* sp., Rhizoclonium sp., *Mougeotia* sp., *Haematococcus* sp., *Chloromonas* sp., and *Pediastrum* sp.; the Cyanophyta (blue-green algae): *Oscillatoria* sp. and *Microcystis* sp.; the Bascillariophyta (diatoms): *Synedra* sp., *Cymbella* sp., *Stephanodiscus* sp., and *Navicula* sp.

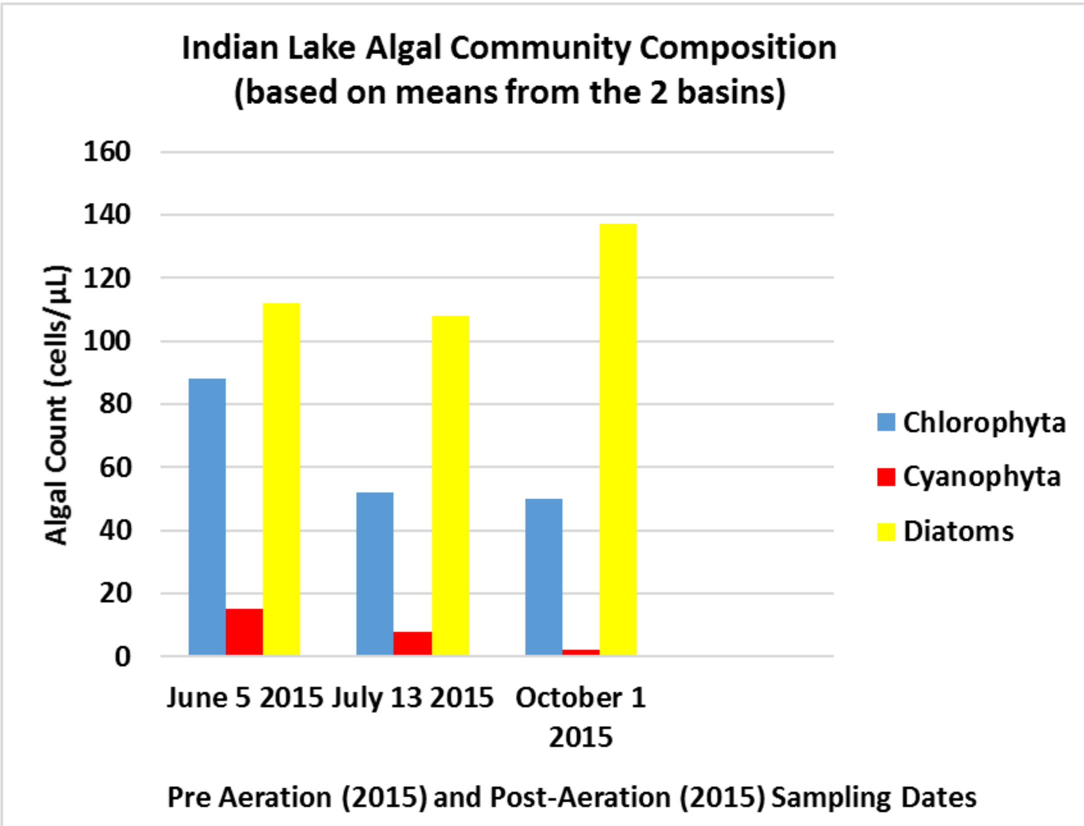

Figure 2. Relative abundance of algal taxa in Indian Lake South Basin (pre and post aeration 2015). Note: The two basins are actually meaning the two sampling sites in the South Basin.

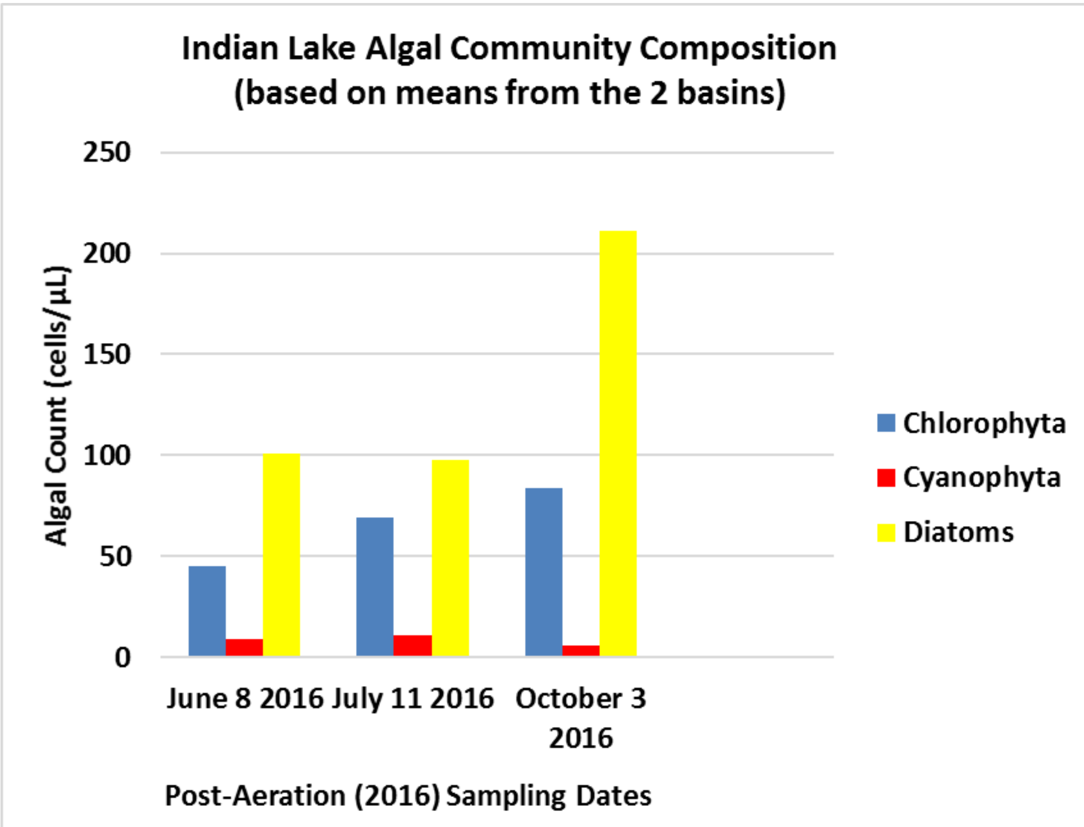

Figure 3. Relative abundance of algal taxa in Indian Lake South Basin (post aeration 2016).
Note: The two basins are actually meaning the two sampling sites in the South Basin.

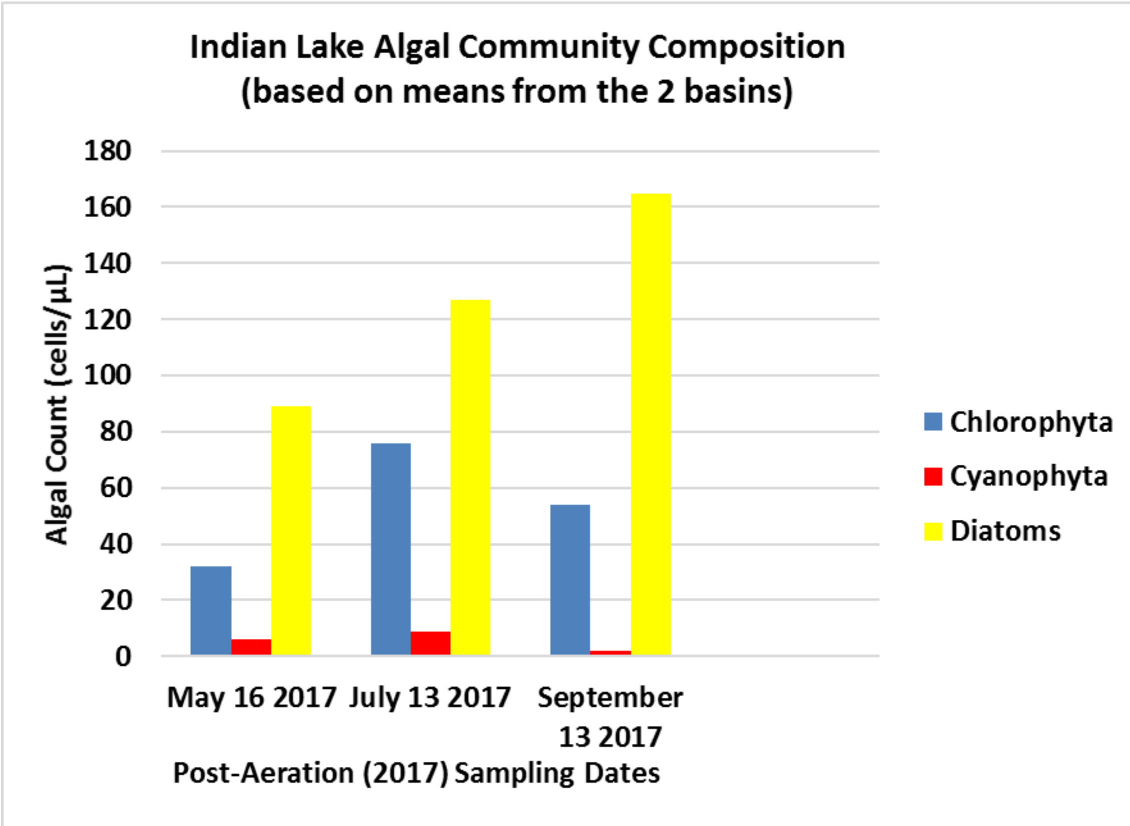

Figure 4. Relative abundance of algal taxa in Indian Lake South Basin (post aeration 2017). Note: The two basins are actually meaning the two sampling sites in the South Basin.

3.5 e. Reference to Raw Data and QA/QC Information (2015 data and 2016 data previously submitted. See Appendix C for 2017 data):

All raw data, field forms, chain of custody forms, laboratory reports for baseline (June 5, 2015) and post-aeration July-October, 2015 and June-October, 2016 data can be found in Appendix A and B, respectively, along with the QA/QC statement from Trace Analytical Laboratory in Muskegon, Michigan were previously submitted. See Appendix C for all forms for the 2017 permit data.

Parameter	Analytical Method	Technique	Method Detection Level	Sample Holding Time	Accuracy	Analytical Laboratory
Total Phosphorus	SM 4500-P E-11	See Lab report from Trace	0.010 mg/L	28 days; cool 4°C, pH <2	See Lab report from Trace	Trace Analytical Labs, Inc.
Ortho-phosphorus	SM 4500-P E-11	See Lab report from Trace	0.010 mg/L	28 days; cool 4°C, pH <2	See Lab report from Trace	Trace Analytical Labs, Inc.
Total Suspended Solids	SM 2540 D-11	See Lab report from Trace	10 mg/L	7 days, 4°C	See Lab report from Trace	Trace Analytical Labs, Inc.
Chlorophyll-a	SM 10200H	See Lab report from Trace	-100 mg/m^3	48 hours	See Lab report from Trace	Trace Analytical Labs, Inc.

Table 19. Chemical water quality parameter analytical method summary table.

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 with a Rule 97 permit from Lake Savers, LLC.

For 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. Thus, the LFA system is effective at destratification and the water temperatures are within a favorable range for a warm water fishery.

For 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. The LFA system has slightly lowered conductivity values compared to baseline but values remain in a favorable range for inland lakes.

For 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. This represents a minimal change in pH since the LFA operation began.

For 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. These DO concentrations are favorable for the health of the lake and the warm water fishery present.

For 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 which means the water clarity on the lake is increasing overall due to the LFA system (likely from algal reductions).

For Nutrients (Phosphorus and Ortho-Phosphorus):

The mean ortho-phosphorus concentrations pre-aeration (2015) and post-aeration (2016-207) 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 LFA system has reduced phosphorus from several years ago but it appears to be stabilized now and in recent years.

For 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. 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.

For 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 flurometer 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.

4.2 Status of Herbicide Treatments or Other Methods:

There was an aquatic herbicide treatment for the treatment of invasive hybrid watermilfoil in the canal of the Indian Lake South Basin on August 14, 2015 and another one also of 3.85 acres in the South Basin canal on June 13, 2016 conducted by PLM. No other lake management activities such as other herbicide treatments, mechanical harvesting or dredging have either been reported during the 2015-2016 season in the South Basin. On June 21, 2017, PLM treated approximately 3.6 acres of hybrid watermilfoil in the South Basin canal with Clipper and an additional 3.35 acres of hybrid watermilfoil with triclopyr just outside of the canal as needed.

4.3 c. 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. Since no microbes or enzymes were applied in 2015 or 2016, these results are due to the LFA system and not the combined impacts of LFA with bioaugmentation. One AVAS aquatic vegetation survey was conducted on June 5, 2015 and again on June 8, 2016 and again on June 19, 2017. The milfoil cover was 1.1% in 2016 and was only found in the canals, along with some Curly-leaf Pondweed also in the canals and some near the south shore of the South Basin. None of the South Basin invasives were treated except in the canals. There is still a healthy balance of native biodiversity in the South Basin, consisting of Illinois Pondweed, Small-leaf Pondweed, Wild Celery, Large-leaf Pondweed, Clasping-leaf Pondweed, Chara, and Variable-leaf Pondweed. In 2017, the percent cover of milfoil was 6.0% which is an increase since 2016 but may be due to increases in water clarity. Many areas had “a” level milfoil which did not necessitate treatment. Also, the herbicide treatments conducted in 2015-2017 were applied in the canals or just outside of the canals which are not aerated so no treatments interfered with measurements on the LFA system.

APPENDIX A

2015 RAW DATA, FIELD FORMS, LAB REPORTS (PREVIOUSLY SUBMITTED)

APPENDIX B

2016 RAW DATA, FIELD FORMS, LAB REPORTS (PREVIOUSLY SUBMITTED)

APPENDIX C

2017 RAW DATA, FIELD FORMS, LAB REPORTS