Long Lake 2022 Aquatic Vegetation, Water Quality, and 2023 Management Recommendations Report

November, 2022

Prepared for: Long Lake Property Owners Association & Plainfield Township

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AN ANNUAL PROGRESS REPORT OF AQUATIC VEGETATION AND WATER QUALITY IN LONG LAKE IOSCO COUNTY, MICHIGAN

November, 2022

1.0 EXECUTIVE SUMMARY

Aquatic Vegetation Analyses and Treatments & Water Quality Assessments:

This report describes the current distribution of native and exotic submersed, floating-leaved, and emergent aquatic plants, including the exotic species, Eurasian Watermilfoil (*Myriophyllum spicatum;* EWM) and Purple Loosestrife (*Lythrum salicaria*) within and around Long Lake, Iosco County, Michigan. During the original lake management plan study in August of 2012, Long Lake was infested with nearly 266 acres of EWM that was widely distributed around the lake. Genetic analysis of the stems showed that the milfoil was of the Eurasian strain and had not yet hybridized with native milfoils in the lake. A whole-lake survey and scan of aquatic vegetation data conducted on June 2, 2022 and a follow-up survey on September 2, 2022 indicated that 3.6 acres of invasive EWM and 64 acres of invasive Curly-leaf Pondweed were found and treated on June 7, 2022. A mid-July survey revealed that an additional 16.0 acres of nuisance native vegetation and algae required treatment. A late season September 2, 2022 survey determined that the 2022 treatments were very effective.

The biodiversity of native species such as Wild Celery (*Vallisneria americana*), Richardson's Pondweed (*Potamogeton richardsonii*), Northern Watermilfoil (*Myriophyllum sibiricum*), Coontail (*Ceratophyllum demersum*), and the low-growing Southern Naiad (*Najas guadalupensis*) remains high in areas previously dominated by the exotic EWM. This is favorable because these plants represent a great diversity of plant structures that house different macroinvertebrate communities which feed fish.

There are currently a total of 28 native aquatic plant species in and around Long Lake, which includes 21 submersed, 4 floating-leaved, and 3 emergent aquatic plant species.

Long Lake Water Quality Overview:

The water clarity of the lake continues to be moderately high and helps support abundant aquatic plant growth in many areas. Levels of nutrients such as phosphorus and nitrogen remain moderate compared to other lakes of similar size but it evident that the inlet nutrient concentrations are higher and that they are an ample source of nutrients to the lake. Total phosphorus has been increasing over the years on the lake bottom and this is due to runoff and the use of septic systems and fertilizers. Furthermore, these parameters will decline in quality with increased runoff and rainfall. The alkalinity and pH of the lake water are indicative of a well-buffered lake and are consistent with other Michigan inland lakes.

Phytoplankton communities within the lake appear to be balanced between the diatom and green-algae communities with fewer blue-green algae. Green algae and diatoms are the preferred food choices for zooplankton. Nutrient levels in the lake are high enough to create algal blooms in shallow or stagnant areas and also dense filamentous blooms in the main lake areas. Removal of too much submersed aquatic vegetation may result in acceleraded growth of blue-green algal blooms and thus removal of nuisance natives should be highly selective.

Recommendations for 2023 and future lake improvements are provided in Section 5.0 at the end of this report.

2.0 AQUATIC PLANT SURVEY METHODS

The aquatic plant sampling methods used for lake surveys of macrophyte communities commonly consist of shoreline surveys, visual abundance surveys, transect surveys, AVAS surveys, and Point-Intercept Grid surveys. The Michigan Department of Environment, Great Lakes, and Energy (EGLE) prefers that an Aquatic Vegetation Assessment Site (AVAS) Survey, or a GPS Point-Intercept survey (or both) be conducted on most inland lakes following large-scale aquatic herbicide treatments to assess the changes in aquatic vegetation structure and to record the relative abundance and locations of native aquatic plant species. Due to the large size of Long Lake, a bi-seasonal GPS Point-Intercept grid matrix/AVAS survey is conducted to assess all aquatic species, including submersed, floating-leaved species, and emergent aquatic plants.

2.1 The GPS Point-Intercept Survey Method

While the EGLE AVAS protocol considers sampling vegetation using visual observations in areas around the littoral zone, the Point-Intercept Grid Survey method is meant to assess vegetation throughout the entire surface area of a lake (Madsen et *al*. 1994; 1996).

The points should be placed together as closely and feasibly as possible to obtain adequate information of the aquatic vegetation communities throughout the entire lake. At each GPS Point location the aquatic vegetation species presence and abundance are estimated. In between the GPS points, any additional species and their relative abundance are also recorded using sampling and other visual techniques. Once the aquatic vegetation communities throughout the lake have been recorded using the GPS points, the data can be placed into a Geographic Information System (GIS) software package to create maps showing the distribution and relative abundance of particular species. The GPS Point-Intercept method is particularly useful for monitoring aquatic vegetation communities through time and for identification of nuisance species that could potentially spread to other previously uninhabited areas of the lake.

The GPS Point-Intercept method survey conducted on June 2, 2022 consisted of a whole-lake survey and scan (Figure 1) with 268 equidistantly-spaced grid points on Long Lake, using a Lowrance® 50-satellite GPS WAAS-enabled side-scanning unit (accuracy within 2 feet). A combination of rake tosses and visual data accounted for the observations in the survey. Areas that were deeper than 20 feet and not vegetated or that consisted of barren sand were not included in the data analysis.

When the bottom was visible, visual data was collected. When no bottom was visible, the plants were confirmed using two rake tosses at each site.

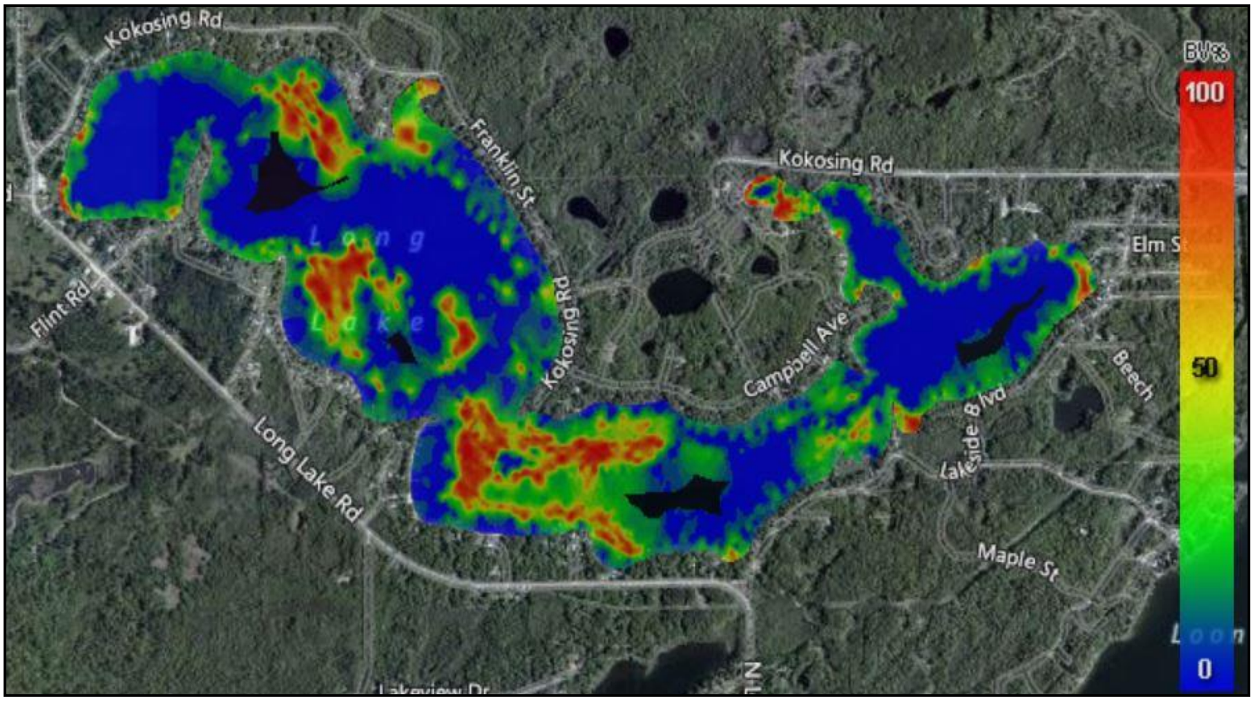

Figure 1. 2022 Aquatic vegetation biovolume map of Long Lake. Note: Blue denotes no vegetation; Green denotes low-growing vegetation; Red denotes high-growing vegetation.

3.0 AQUATIC PLANT SURVEY RESULTS FOR 2022

A preliminary whole-lake aquatic vegetation survey of Long Lake was conducted on June 2, 2022 to determine the distribution and relative abundance of both invasive and native aquatic vegetation in and around Long Lake.

3.1 Long Lake Exotic Aquatic Plant Species (2022)

The June 2, 2022 survey determined that 3.4 acres of EWM (Figure 2) and 64.2 acres of Curly-leaf Pondweed (Figure 3) were present and required treatment. The initial treatment was conducted by PLM on June 7, 2022 and consisted of diquat and hydrothol to address the EWM and CLP. In addition, 1.7 acres of chelated copper was used for nuisance dense filamentous algae in the canals. The second survey occurred on July 7, 2022 and determined the need for a 8.7 acre algae treatment, along with 16.0 acres of nuisance native vegetation that was treated with diquat and flumioxazin. Additional surveys were conducted on September 2, 2022 to determine treatment efficacy. All treatments appeared to be successful with abundant non-nuisance natives remaining. Figures 4a-4c below show the treatment locations in 2022.

Table 1. Change in EWM and CLP acres before and after herbicide treatment.

Invasive Aquatic Macrophyte Species	***Common Name***	***Acres Pre-Treatment 2022***	***Acres Post-Treatment 2022***
Myriophyllum spicatum	Eurasian Watermilfoil	3.6	0.0
Potamogeton crispus	Curly-leaf Pondweed	64.2	0.0

Figure 2. Eurasian Watermilfoil
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Figure 3. Curly-leaf Pondweed
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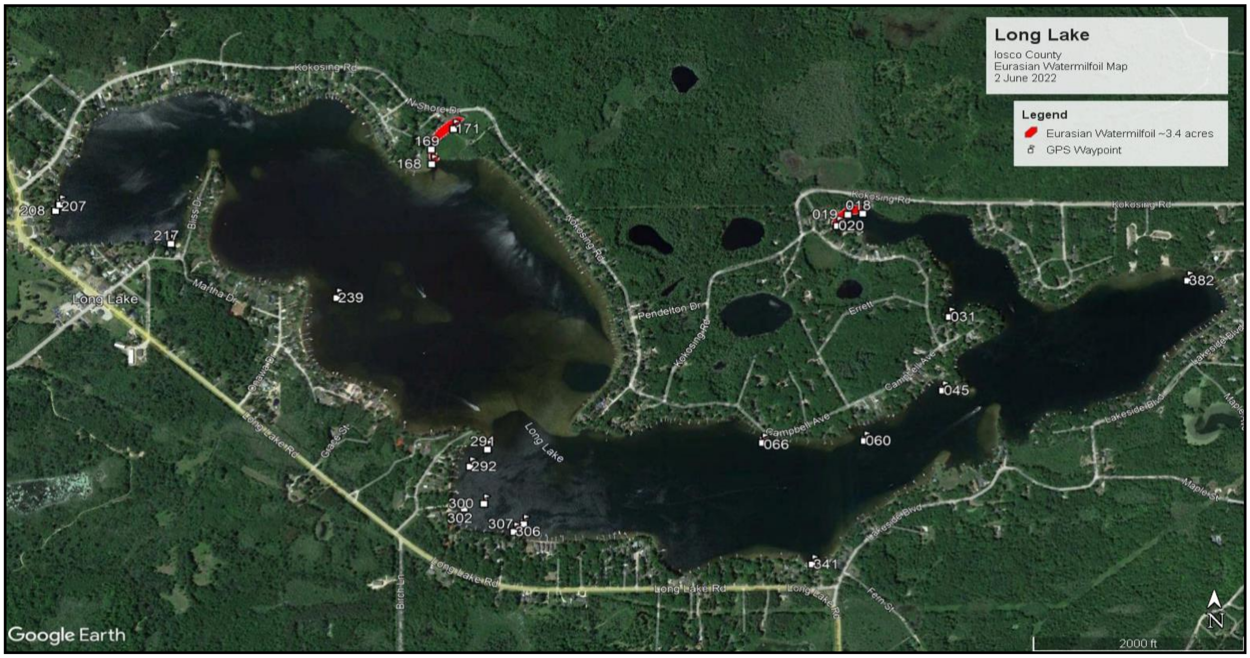


Figure 4a. Distribution of EWM in Long Lake (June 2, 2022).

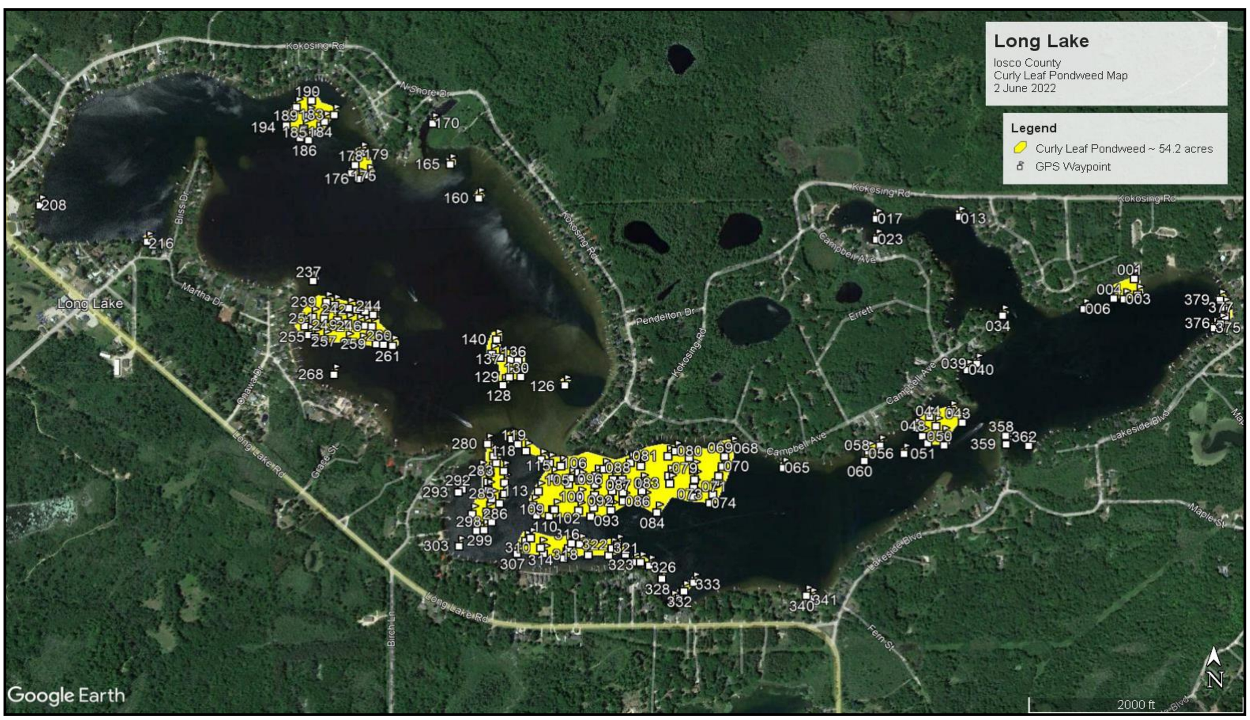


Figure 4b. Distribution of CLP in Long Lake (June 2, 2022).

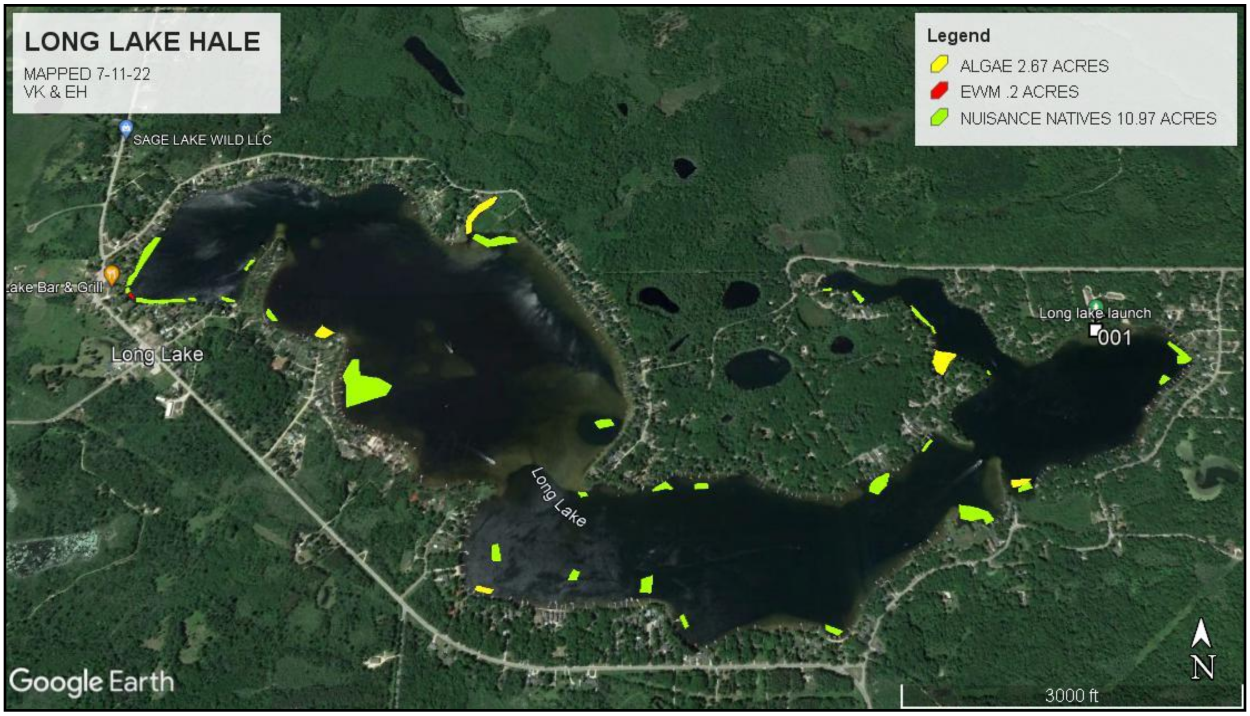


Figure 4c. Distribution of nuisance pondweeds, EWM, and algae in Long Lake (July 11, 2022).

3.2 Long Lake Native Aquatic Plant Species (2022)

During the June 2, 2022 survey, a total of 21 submersed, 4 floating-leaved, and 3 emergent aquatic plant species were found for a grand total of 28 species (Table 2). The table shows the relative abundance in percentage of littoral zone cover for each species. This indicates a high biodiversity of aquatic vegetation in Long Lake. The most common native aquatic plants included Chara, Fern-leaf Pondweed, and Whorled Watermilfoil.

Table 2. Percent cover of native aquatic plant species found in and around Long Lake during the June 2, 2022 survey.

Native Aquatic Plant Species	***Aquatic Plant Common Name***	***June 2022 % Cover***
Chara vulgaris	Muskgrass	25.1
Potamogeton illinoensis	Illinois Pondweed	8.0
Stuckenia pectinatus	Sago Pondweed	7.1
Potamogeton amplifolius	Large-leaf Pondweed	9.6
Potamogeton praelongus	White-stemmed Pondweed	5.5
Potamogeton gramineus	Variable-leaf Pondweed	5.0
Potamogeton zosteriformis	Flat-stem Pondweed	3.6
Potamogeton richardsonii	Clasping-leaf Pondweed	12.0
Potamogeton robbinsii	Fern-leaf Pondweed	15.6
Potamogeton natans	Floating-leaf Pondweed	1.1
Potamogeton pusillus	Small-leaf Pondweed	0.7
Potamogeton epihydrus	Ribbon-leaf Pondweed	0.1
Vallisneria americana	Wild Celery	6.3
Zosterella dubia	Water Stargrass	5.7
Myriophyllum sibiricum	Northern Watermilfoil	2.1
Myriophyllum verticillatum	Whorled Watermilfoil	15.2
Myriophyllum tenellum	Leafless Watermilfoil	11.3
Najas guadalupensis	Southern Naiad	2.0
Elodea canadensis	Common Elodea	14.7
Ceratophyllum demersum	Coontail	0.1
Utricularia vulgaris	Bladderwort	3.6
Lemna minor	Duckweed	0.4
Nymphaea odorata	White Water lily	3.6
Nuphar advena	Yellow Water lily	3.2
Brasenia schreberi	Watershield	0.9
Typha latifolia	Cattails	1.0
Schoenoplectus acutus	Bulrushes	0.3
Iris sp.	Iris	0.4

4.0 LONG LAKE 2022 WATER QUALITY RESULTS

The quality of water is highly variable among Michigan inland lakes, although some characteristics are common among particular lake classification types. The water quality of Long Lake is affected by both land use practices and climatic events. Climatic factors (i.e., spring runoff, heavy rainfall) may alter water quality in the short term; whereas, anthropogenic (man-induced) factors (i.e. shoreline development, lawn fertilizer use) alter water quality over longer time periods. Furthermore, lake water quality helps to determine the classification of particular lakes (Table 3). Lakes that are high in nutrients (such as phosphorus and nitrogen) and chlorophyll-*a*, and low in transparency are classified as eutrophic; whereas those that are low in nutrients and chlorophyll-*a*, and high in transparency are classified as oligotrophic. Lakes that fall in between these two categories are classified as mesotrophic. Long Lake is classified as meso-eutrophic based on its moderate transparency and moderate nutrient and chlorophyll-*a* concentrations. This means that the lake has a moderate quantity of nutrients and high water clarity that can exacerbate aquatic plant and algae growth. A map showing all water quality sampling locations is shown below in Figure 5.

Lake Trophic Status	***Total Phosphorus ($\mu g\ L^{-1}$)***	***Chlorophyll-a ($\mu g\ L^{-1}$)***	***Secchi Transparency (feet)***
Oligotrophic	< 10.0	< 2.2	> 15.0
Mesotrophic	10.0 – 20.0	2.2 – 6.0	7.5 – 15.0
Eutrophic	> 20.0	> 6.0	< 7.5

Table 3. Lake Trophic Status Classification Table.

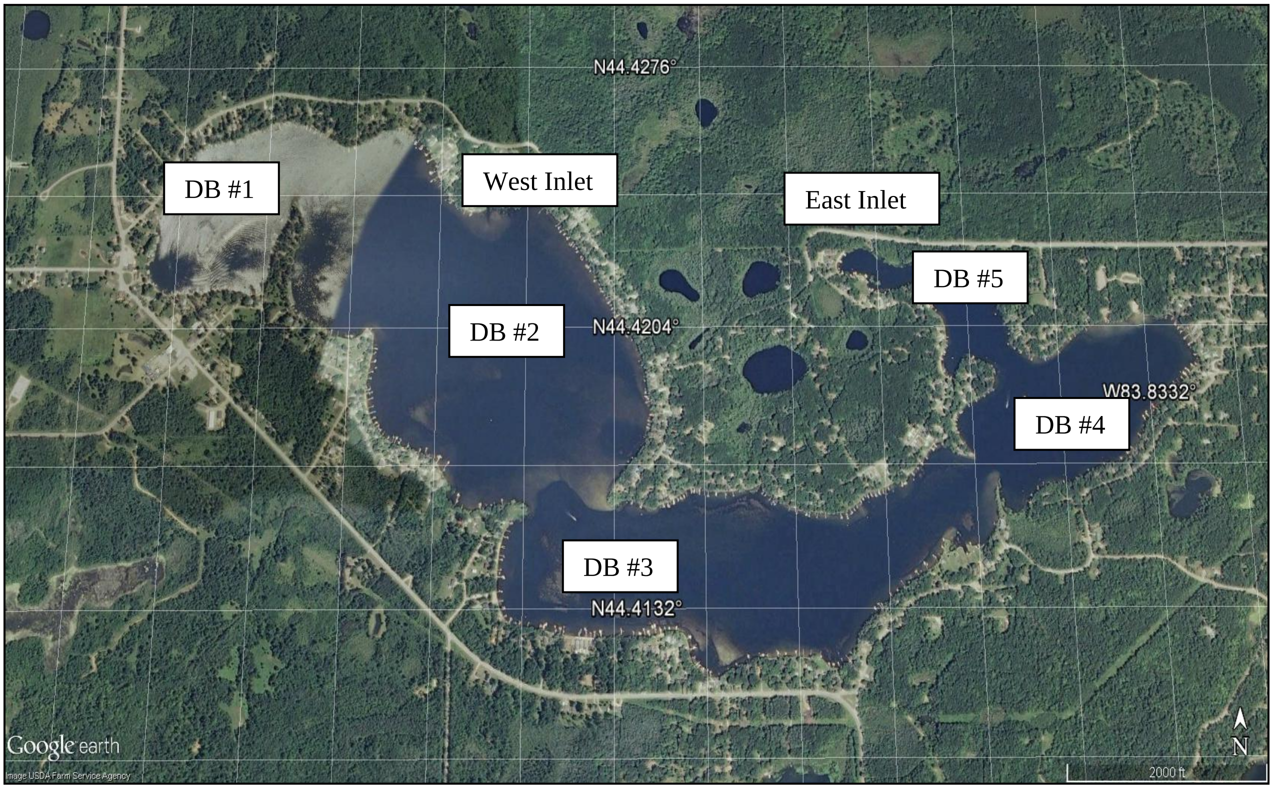


Figure 5. Water quality sampling locations (n=5 deep basins) in Long Lake, Iosco County, Michigan.

4.1 Long Lake Deep Basin Water Quality Data

Water quality parameters such as dissolved oxygen, water temperature, conductivity, turbidity, total dissolved solids, pH, total alkalinity, total phosphorus, total Kjeldahl nitrogen, Secchi transparency, chlorophyll-*a*, among others, all respond to changes in water quality and consequently serve as indicators of water quality change. These parameters were collected at the 5 deep basins and 2 inlets of Long Lake on September 2, 2022. Water quality data collected in these locations are shown below in Tables 4-9.

Dissolved Oxygen

Dissolved oxygen (DO) is a measure of the amount of oxygen that exists in the water column. In general, dissolved oxygen levels should be greater than 5 mg L^{-1} to sustain a healthy warm-water fishery. DO concentrations in Long Lake may decline if there is a high biochemical oxygen demand (BOD) where organismal consumption of oxygen is high due to respiration.

DO is generally higher in colder waters and is measured in milligrams per liter (mg L^{-1}) with the use of a special meter and/or through the use of Winkler titration methods. A decline in DO may cause increased release rates of phosphorus (P) from Long Lake bottom sediments if DO concentrations drop to near zero milligrams per liter. The September 2, 2022 DO levels ranged from a high of 8.7 mg L^{-1} at the surface to a low of 0.9 mg L^{-1} at the bottom. This means that the phosphorus locked in the sediments at the lake bottom is prone to release under these low DO conditions. This phosphorus release is what fuels the algae and aquatic plant growth.

Water Temperature

The water temperature of lakes varies within and among seasons and is nearly uniform with depth under winter ice cover because lake mixing is reduced when waters are not exposed to wind. When the upper layers of water begin to warm in the spring after ice-off, the colder, dense layers remain at the bottom. This process results in a “thermocline” that acts as a transition layer between warmer and colder water layers. During the fall season, the upper layers begin to cool and become denser than the warmer layers, causing an inversion known as “fall turnover”. In general, lakes with deep basins will stratify and experience turnover cycles. Water temperature is measured in degrees Celsius (ºC) or degrees Fahrenheit (ºF) with the use of a submersible thermometer. The September 2, 2022 water temperatures ranged from 78.1°F at the surface to 51.2°F at the bottom and thus differed by nearly 26.9°F from top to bottom. Water temperatures for the inlets were 73.0°F for the West Inlet and 67.2°F for the East Inlet. Long Lake likely mixes shortly after ice off when the lake begins to set up a thermocline and the surface waters warm.

Conductivity

Conductivity is a measure of the amount of mineral ions present in the water, especially those of salts and other dissolved inorganic substances. Conductivity generally increases as the amount of dissolved minerals and salts in a lake increases, and also increases as water temperature increases. Conductivity is measured in microsiemens per centimeter (µS cm^{-1}) with the use of a conductivity probe and meter. Conductivity values for Long Lake were moderate and ranged from 230-250 µS cm^{-1} on September 2, 2022, which is favorable for an inland lake. Values for the inlets were similar with 207 µS cm^{-1} observed at the West Inlet and 358 µS cm^{-1} observed at the East Inlet.

Turbidity

Turbidity is a measure of the loss of water transparency due to the presence of suspended particles. The turbidity of water increases as the number of total suspended particles increases. Turbidity may be caused from erosion inputs, phytoplankton blooms, stormwater discharge, urban runoff, re-suspension of bottom sediments, and by large bottom-feeding fish such as carp. Particles suspended in the water column absorb heat from the sun and raise the water temperature. Since higher water temperatures generally hold less oxygen, shallow turbid waters are usually lower in dissolved oxygen. Turbidity is measured in Nephelometric Turbidity Units (NTU's) with the use of a turbidimeter. The World Health Organization (WHO) requires that drinking water be less than 5 NTU's; however, recreational waters may be significantly higher than that. Turbidity ranged from 0.4-3.6 NTU's on September 2, 2022 and was highest near the lake bottom due to increased suspension of sediments into the water column that increase turbidity. Turbidity was favorable in the inlets and ranged from 1.0-2.3 NTU's. The lake bottom is predominately sandy substrate with some marl and silt, which increases the turbidity values near the lake bottom.

pH

pH is the measure of acidity or basicity of water. The standard pH scale ranges from 0 (acidic) to 14 (alkaline), with neutral values around 7. Most Michigan lakes have pH values that range from 6.5 to 9.5. Acidic lakes (pH < 7) are rare in Michigan and are most sensitive to inputs of acidic substances due to a low acid neutralizing capacity (ANC). pH is measured with a pH electrode and pH-meter in Standard Units (S.U). The pH of Long Lake water ranged from 8.4-8.5 S.U. and the pH of inlet water ranged from 7.5-7.9 S.U. on September 2, 2022. From a limnological perspective, Long Lake is considered "slightly basic" on the pH scale.

Total Alkalinity

Total alkalinity is the measure of the pH-buffering capacity of lake water. Lakes with high alkalinity (> 150 mg L^{-1} of $CaCO_3$) are able to tolerate larger acid inputs with less change in water column pH. Many Michigan lakes contain high concentrations of $CaCO_3$ and are categorized as having "hard" water. Total alkalinity is measured in milligrams per liter of $CaCO_3$ through an acid titration method. The total alkalinity of Long Lake is considered "low" (< 150 mg L^{-1} of $CaCO_3$), and indicates that the water is not hard or highly alkaline. Total alkalinity ranged from 93-97 mg L^{-1} of $CaCO_3$ on September 2, 2022 among all deep basins. Total alkalinity may change on a daily basis due to the re-suspension of sedimentary deposits in the water and respond to seasonal changes due to the cyclic turnover of the lake water.

Total Phosphorus

Total phosphorus (TP) is a measure of the amount of phosphorus (P) present in the water column. Phosphorus is the primary nutrient necessary for abundant algae and aquatic plant growth. Lakes which contain greater than 20 µg L^{-1} of TP are defined as eutrophic or nutrient-enriched. TP concentrations are usually higher at increased depths due to higher release rates of P from lake sediments under low oxygen (anoxic) conditions. Phosphorus may also be released from sediments as pH increases. Total phosphorus is measured in micrograms per liter (µg L^{-1}) or in milligrams per liter (mg L^{-1}) with the use of a chemical autoanalyzer. The range of TP was <0.010-0.300 mg L^{-1}, with the highest values at the bottom of the deepest basin and the lowest values at the surface of all basins. These concentrations are within a normal range but would likely increase during periods of heavy rainfall and associated runoff. The inlets were significantly moderate in TP with a value of 0.100 mg L^{-1} in the West Inlet and <0.030 mg L^{-1} in the East Inlet. The West Inlet was the biggest contributor of phosphorus in 2022.

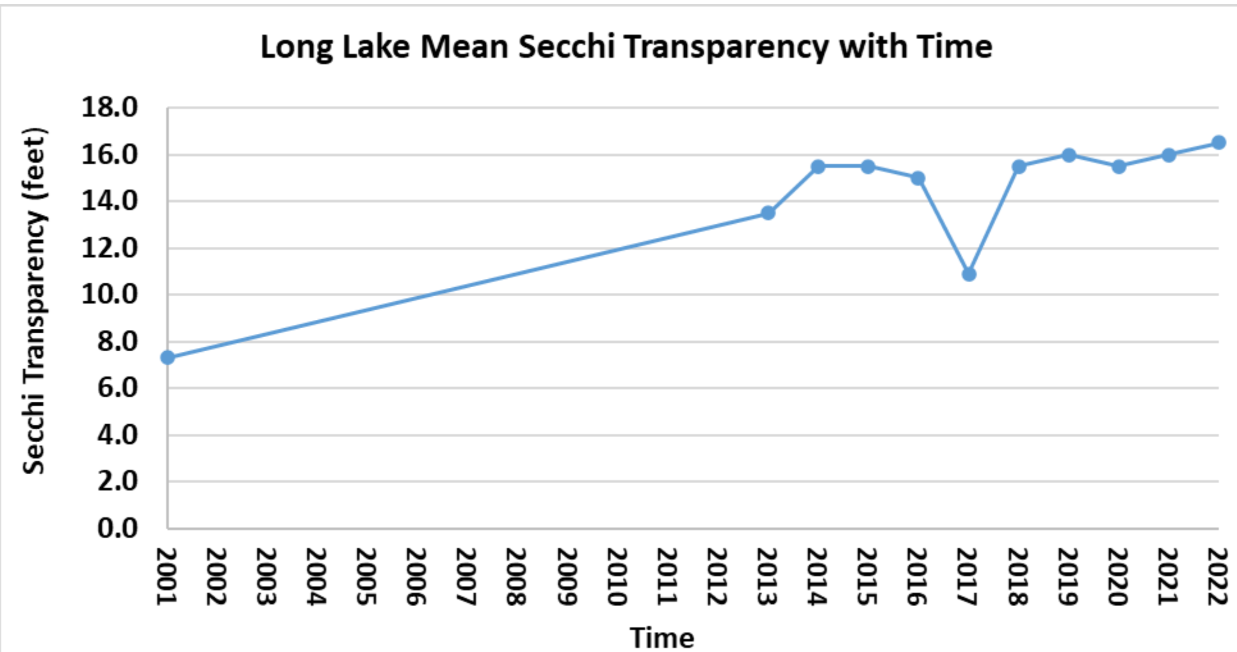
Total Kjeldahl Nitrogen

Total Kjeldahl Nitrogen (TKN) is the sum of all nitrogen forms in freshwater systems. Much nitrogen (amino acids and proteins) also comprises the bulk of living organisms in an aquatic ecosystem. Nitrogen originates from atmospheric inputs (i.e., burning of fossil fuels), wastewater sources from developed areas (i.e. runoff from fertilized lawns), agricultural lands, septic systems, and from waterfowl droppings. It also enters lakes through groundwater or surface drainage, drainage from marshes and wetlands, or from precipitation (Wetzel, 2001). In lakes with an abundance of nitrogen (N: P > 15), phosphorus may be the limiting nutrient for phytoplankton and aquatic macrophyte growth. Alternatively, in lakes with low nitrogen concentrations (and relatively high phosphorus), the blue-green algae populations may increase due to the ability to fix nitrogen gas from atmospheric inputs. Lakes with a mean TKN value of 0.66 mg L^{-1} may be classified as oligotrophic, those with a mean TKN value of 0.75 mg L^{-1} may be classified as mesotrophic, and those with a mean TKN value greater than 1.88 mg L^{-1} may be classified as eutrophic. Long Lake contained highly variable values for TKN (<0.50-2.0 mg L^{-1}) on September 2, 2022. The inlets contained similar values at <0.5-2.0 mg L^{-1} for the West and East Inlets, respectively.

Secchi Transparency

Secchi transparency is a measure of the clarity or transparency of lake water, and is measured with the use of an 8-inch diameter standardized Secchi disk. Secchi disk transparency is measured in feet (ft) or meters (m) by lowering the disk over the shaded side of a boat around noon and taking the mean of the measurements of disappearance and reappearance of the disk.

Elevated Secchi transparency readings allow for more aquatic plant and algae growth. Eutrophic systems generally have Secchi disk transparency measurements less than 7.5 feet due to turbidity caused by excessive planktonic algae growth. The Secchi transparency of Long Lake on September 2, 2022 averaged 16.5 feet which is favorable. These Secchi transparency values are adequate to allow abundant growth of algae and aquatic plants in the majority of the littoral zone of the lake. Secchi transparency is variable and depends on the amount of suspended particles in the water (often due to windy conditions of lake water mixing) and the amount of sunlight present at the time of measurement.



Total Dissolved Solids

Total Dissolved Solids (TDS) is the measure of the amount of dissolved organic and inorganic particles in the water column. Particles dissolved in the water column absorb heat from the sun and raise the water temperature and increase conductivity. Total dissolved solids are often measured with the use of a calibrated meter in mg L^{-1}. Spring values are usually higher due to increased watershed inputs from spring runoff and/or increased planktonic algal communities. The concentration of TDS in Long Lake ranged from 111-124 mg L^{-1} in the lake water and from 116-149 mg L^{-1} in the inlets, with the highest value at the East Inlet. The inlet values indicate that solids are being transported to the lake from the land especially during intense rainfall events.

Oxidative Reduction Potential

The oxidation-reduction potential (E_h) of lake water describes the effectiveness of certain atoms to serve as potential oxidizers and indicates the degree of reductants present within the water. In general, the Eh level (measured in millivolts) decreases in anoxic (low oxygen) waters. Low E_h values are therefore indicative of reducing environments where sulfates (if present in the lake water) may be reduced to hydrogen sulfide (H_2S). Decomposition by microorganisms in the hypolimnion may also cause the E_h value to decline with depth during periods of thermal stratification. The E_h (ORP) values for Long Lake were variable with depth and location. The ORP values ranged from 135.2-62.0 mV from the surface to the bottom within the lake and indicated oxidized rather than reduced conditions except for at the bottom where abundant microbial activity was dominant and lowered the ORP in that region of the lake.

Chlorophyll-a and Phytoplankton Communities

Chlorophyll-*a* is a measure of the amount of green plant pigment present in the water, often in the form of planktonic algae. High chlorophyll-*concentrations* are indicative of nutrient-enriched lakes. Chlorophyll-*a* concentrations greater than 6.0 µg L^{-1} are found in eutrophic or nutrient-enriched aquatic systems, whereas chlorophyll-*a* concentrations less than 2.2 µg L^{-1} are found in nutrient-poor or oligotrophic lakes. Chlorophyll-*a* is measured in micrograms per liter (µg L^{-1}) with the use of an acetone extraction method and a spectrometer. The chlorophyll-*a* concentrations in Long Lake were determined by collecting a composite sample of the algae throughout the water column at each of the five deep basin sites from just above the lake bottom to the lake surface on September 2, 2022. The chlorophyll-*a* concentrations ranged from 1.3-2.6 µg L^{-1}, which was moderate and higher than in 2021 and likely due to increased water temperatures and prolonged sunlight.

Algal genera from a composite water sample collected over the deep basins of Long Lake on September 2, 2022 were analyzed under a compound bright field microscope. The genera present included the Chlorophyta (green algae): *Chlorella* sp., *Rhizoclonium* sp., *Mougeotia* sp., *Akinestrodesmus* sp., *Scenedesmus* sp., *Cosmarium* sp., and *Spirogyra* sp. The Cyanophyta (blue-green algae): *Oscillatoria* sp.; The Bascillariophyta (diatoms): *Synedra* sp*., Navicula* sp., *Fragillaria* sp., and *Cymbella* sp. The aforementioned species indicate a diverse algal flora and represent a relatively balanced freshwater ecosystem, capable of supporting a strong zooplankton community in favorable water quality conditions. The waters of Long Lake are rich in the diatoms and small green algae, which are indicators of good water quality and also support a robust fishery.

E. Coli Bacteria

Escherichia coli (*E. coli*) is a rod-shaped bacterium that constitutes fecal coliform, which is the dominant bacteria present in the feces of warm-blooded animals. *E. coli* bacteria are useful indicators of bacteriological contamination in aquatic ecosystems. *E. coli* may be contributed from fecal matter from warm-blooded animals directly, or from leaking septic seepage. The state of Michigan adopted *E. coli* concentration threshold limits for surface waters in May of 1994 to protect human health. If three or more samples are collected over a 30-day period and average over 130 *E. coli* Colony Forming Units (CFU's) per 100 ml, then local health officials are required to close public beaches. In addition, if any one sample detects an *E. coli* concentration of 300 CFU's per 100 milliliters, then the beaches will be closed as well. Other (non-body contact) activities (such as fishing and boating) will be halted if concentrations exceed 1,000 CFU's per 100 ml. *E. coli* was not sampled in 2022 because samples have to be processed within four hours and additional field work was conducted.

Table 4. September 2, 2022 Deep Basin #1 Water Quality Data

Depth ft	Water Temp ºF	DO mg L^{-1}	pH S.U.	Cond. µS cm^{-1}	Total Diss. Solids mg L^{-1}	Turb. NTU	ORP mV	Total Kjeldahl Nitrogen mg L^{-1}	Total Alk. mgL^{-1} $CaCO_3$	Total Phos. mg L^{-1}
0	76.5	8.4	8.5	240	118	0.5	126.4	<0.5	95	<0.010
21	67.2	6.9	8.4	240	118	1.0	119.2	<1.0	95	0.020
43	59.6	0.9	8.4	250	124	3.1	97.2	1.0	96	0.050

Table 5. September 2, 2022 Deep Basin #2 Water Quality Data

Depth ft	Water Temp ºF	DO mg L^{-1}	pH S.U.	Cond. µS cm^{-1}	Total Diss. Solids mg L^{-1}	Turb. NTU	ORP mV	Total Kjeldahl Nitrogen mg L^{-1}	Total Alk. mgL^{-1} $CaCO_3$	Total Phos. mg L^{-1}
0	77.9	8.7	8.5	240	114	0.5	135.2	<0.5	95	<0.010
30.0	67.6	7.1	8.5	240	114	1.5	139.2	1.0	93	<0.020
60.0	51.2	1.9	8.4	240	114	3.6	113.6	2.0	93	0.300

Table 6. September 2, 2022 Deep Basin #3 Water Quality Data

Depth ft	Water Temp ºF	DO mg L^{-1}	pH S.U.	Cond. µS cm^{-1}	Total Diss. Solids mg L^{-1}	Turb. NTU	ORP mV	Total Kjeldahl Nitrogen mg L^{-1}	Total Alk. mgL^{-1} $CaCO_3$	Total Phos. mg L^{-1}
0	78.1	8.1	8.5	230	111	0.4	125.8	< 0.5	96	<0.010
20	68.7	7.0	8.5	230	111	1.3	116.2	1.0	96	0.020
40	60.0	1.7	8.5	230	111	3.0	88.7	2.0	97	0.030

Table 7. September 2, 2022 Deep Basin #4 Water Quality Data.

Depth ft	*Water Temp ºF*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Total Diss. Solids mg L^{-1}*	*Turb. NTU*	*ORP mV*	*Total Kjeldahl Nitrogen mg L^{-1}*	*Total Alk. mgL^{-1} $CaCO_3$*	*Total Phos. mg L^{-1}*
0	**77.9**	**8.1**	**8.4**	**236**	**114**	**0.7**	**124.1**	**<0.5**	**95**	**<0.010**
27	**67.2**	**6.2**	**8.4**	**236**	**114**	**1.3**	**119.3**	**0.5**	**95**	**0.020**
54	**56.3**	**1.8**	**8.5**	**236**	**114**	**3.1**	**77.0**	**2.0**	**96**	**0.050**

Table 8. September 2, 2022 Deep Basin #5 Water Quality Data.

Depth ft	*Water Temp ºF*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Total Diss. Solids mg L^{-1}*	*Turb. NTU*	*ORP mV*	*Total Kjeldahl Nitrogen mg L^{-1}*	*Total Alk. mgL^{-1} $CaCO_3$*	*Total Phos. mg L^{-1}*
0	**77.9**	**8.2**	**8.5**	**232**	**112**	**0.4**	**124.3**	**<0.5**	**95**	**<0.010**
19	**69.9**	**7.5**	**8.5**	**232**	**112**	**1.9**	**117.2**	**1.0**	**95**	**0.020**
38	**59.2**	**2.3**	**8.4**	**232**	**112**	**2.1**	**62.0**	**2.0**	**96**	**0.030**

4.2 Long Lake Inlet Water Quality Data (2022)

The West and East Inlets on Long Lake have demonstrated that the nutrient concentrations originating from them is significantly higher than the concentrations that are ambient in the lake water. This means that the inlets are a threat to the water quality of the lake and prompt consideration of upstream BMP's should be implemented. Inlet water quality data collected on September 2, 2022 are shown below in Table 9.

Table 9. Long Lake inlet water quality data (September 2, 2022).

Location	*Water Temp ºF*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*Turb. NTU*	*ORP mV*	*Total Kjeldahl Nitrogen mg L^{-1}*	*Total Diss. Solids mg L^{-1}*	*Total Phos. mg L^{-1}*	*Total Susp. Solids mg L^{-1}*
West Inlet	**73.0**	**7.5**	**7.5**	**207**	**1.0**	**112.6**	**<0.5**	**116**	**0.100**	**<10**
East Inlet	**67.2**	**6.8**	**7.9**	**358**	**2.3**	**92.5**	**2.0**	**149**	**<0.030**	**<10**

5.0 LONG LAKE 2022 MANAGEMENT RECOMMENDATIONS

5.1 Long Lake Open Water Improvements

Aquatic vegetation surveys will be conducted in Late May or early June of 2023 with treatments to follow within a week or two of the survey. These surveys will prescribe treatments for EWM, CLP, and only nuisance native aquatic vegetation. It is critical to note that removal of too much aquatic vegetation can create a competitive advantage for algae which can proliferate throughout Long Lake.

An additional survey after the treatment(s) will determine the efficacy of the treatment and any follow-up treatment(s) that may be needed. EWM treatment may be treated with a combination of ProcellaCOR® and diquat as in 2023. CLP may be treated with Aquathol K® at a dose of 1-2 gal/acre. Diquat and/or Clipper® may be used on the nuisance native aquatic weeds. In recent years, algae became a concern on Long Lake and many other lakes due to intense rainfall and runoff and low wind conditions for an extended time period. Algae will be treated with chelated copper products if necessary and in localized near-shore conditions only as allowed by the EGLE permit. Algal blooms usually dissipate on their own and thus only very dense filamentous blooms should be addressed. Blue-green algae should never be treated with algacides and it can exacerbate the blooms.

Water quality will be monitored in the lake in 2023 and graphed with historic data to determine any trends over time for Secchi transparency.

In conclusion, water quality in Long Lake remains high but there is some concern about possible internal loading of phosphorus at the deepest basin which may be present during late summer due to a combination of runoff, decaying aquatic vegetation, and septic tank contributions. Water clarity is moderately high allowing light penetration to deeper water that helps support an abundant aquatic plant growth throughout many areas of the lake. Levels of nutrients such as phosphorus and nitrogen are moderate, but sufficient to support aquatic plant growth. Inlet nutrient concentrations often exceed in-lake nutrients levels and contribute to long-term eutrophication and potential algal growth.

Table 10. Proposed* 2023 budget for the continuation of the Long Lake Improvement Program.

Long Lake Improvement Strategy	***Estimated 2023 Annual Cost***
Herbicides for control of invasive aquatic EWM (approx. 15 acres)@ $693 per acre and CLP (approx. 70 acres)@ $183 per acre	$23,205
Herbicides for control of nuisance native aquatic vegetation (approx. 28 acres @$500 per acre)	$14,000
Professional Management Services[3] (water sampling, oversight of treatments, mapping, management)	$12,500
Contingency Funds (necessary for additional costs that may arise due to unpredictable circumstances)	$4,971
TOTAL ANNUAL ESTIMATED COST	$54,676

***Proposed lake management budget for Long Lake in 2023. Note: If EWM returns then additional cost may be needed. Use of reserve or roll-over funds from previous years may then be necessary. Budget for nuisance native aquatic plant growth may also be increased if necessary due to unexpected growth in shallow areas. This proposed budget may also be an over-estimate and is only a recommendation and may be altered by the LLPOA and the Township.**

6.0 LITERATURE CITED

Madsen, J.D., J.A. Bloomfield, J.W. Sutherland, L.W. Eichler, and C.W. Boylen. 1996. The aquatic macrophyte community of Onondaga Lake: Field survey and plant growth bioassays of lake sediments, *Lake and Reservoir Management* 12:73-79.

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