Otsego Lake 2024 Annual Lake Evaluation & 2025 Management Recommendations

Provided for: Otsego Lake Association (OLA) Board

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TABLE OF CONTENTS

SECTION **PAGE**

LIST OF FIGURES

LIST OF TABLES

Otsego Lake 2024 Lake Evaluation & 2025 Management Recommendations

December, 2024

1.0 2024 EXECUTIVE SUMMARY

In 2024, the water quality of Otsego was excellent relative to dissolved oxygen, conductivity, total dissolved solids and low nutrient concentrations. The clarity of Otsego Lake during the 2024 sampling averaged 8.6 feet which is favorable. Erosion and sediment inputs will continue to be monitored as sediments can be a major source of nutrient loading and lead to reduced water clarity. RLS took new sediment samples across the North Bay to see if there were other areas that could benefit from muck pellets. Many came back high enough for potential treatment, however, it was decided that the cost outweighed the potential benefit. RLS, will continue to monitor the sediment composition within Otsego Lake. During the 2024 lake evaluations, Otsego Lake contained one invasive submersed aquatic plant species, Eurasian Watermilfoil (*Myriophyllum spicatum*). Approximately 5.0 acres were found between the two surveys. Recommendations for prevention and treatment of invasives are offered later in this management plan report. The milfoil was treated by PLM with oversight by RLS on June 20th, 2024 and August 5th, 2024 with the use of the systemic herbicide ProcellaCOR® at a dose of 6.0 PDU along with the contact herbicide diquat at a dose of 1 gallon per acre. The treatment will be evaluated in spring of 2025 for efficacy given the late season application.

Otsego Lake contained 18 native submersed, 4 floating-leaved, and 3 emergent aquatic plant species, for a total of 25 native aquatic macrophyte species during the lake survey on July 25, 2024. This represents a slight increase in two native species relative to 2023. Although this biodiversity is favorable, the relative abundance of each plant genus was sparse to moderate overall and thus protection of native biodiversity is critical.

A detailed, Early Detection- Rapid Response Protocol for future invasives that may enter the lake was initiated in 2021 by RLS for the lake community and will be revised annually when new information becomes available as is expected in 2025.

A professional limnologist/lake manager from RLS will continue to perform regular GPS-guided whole-lake surveys each summer/early fall to monitor the growth and distribution of all invasives prior to and after treatments to determine treatment efficacy.

Continuous monitoring of the lake for potential influxes of other exotic aquatic plant genera (i.e., *Hydrilla*) that could also significantly disrupt the ecological stability of Otsego Lake is critical. In 2025, the lake manager will oversee all management activities and would be responsible for the creation of aquatic plant management survey maps, direction of the herbicide applicator to target-specific areas of aquatic vegetation for removal, and other relevant management activities.

In 2025, lake weed treatments should consist only of systemic herbicides for Eurasian Watermilfoil (EWM) when needed or for the treatment of other invasives as desired.

In 2025, RLS will continue to work with the OLA on formation of a Special Assessment District (SAD) to fund critical future improvements. These include aquatic vegetation surveys and necessary invasive weed treatments, improvements in water quality, reduction of erosion, and reduction of transfer of invasive species to the lake. Additionally, RLS will work with the OLA to consider evaluation of muck reduction in the north region of the lake.

A bottom sediment hardness scan with 72,367 GPS soundings was conducted of the entire lake bottom on July 23- 24, 2024. The bottom hardness map shows (Figure 1) that most of the lake bottom consists of fairly sandy sediments throughout the shallow areas of the lake with larger areas of soft organic deposits in the deeper waters. Table 1 below shows the categories of relative bottom hardness with 0.0-0.1 referring to the softest and least consolidated bottom and >0.4 referring to the hardest, most consolidated bottom. This scale does not mean that any of the lake contains a truly “hard” bottom but rather a bottom that is more cohesive and not flocculent. The lake was used for logging in the late 1800s and early 1900s with 4 sawmills once operating on the lake. It has been estimated that up to 23 feet of organic sediments were deposited in the south basin from these activities (MDNR, 2009).

Lastly, RLS encourages all residents with septic systems to practice sound septic system and drain field management practices with annual pumping and bi-annual drain field inspections. In situ aerobic digesters such as the SludgeHammer® can reduce nitrogen and phosphorus in the drain field before it can enter the lake water table. It is highly recommended that all riparians invest in this technology which if very affordable given the long-term benefits.

Table 1. Otsego Lake relative hardness of the lake bottom by category or hardness and percent cover of each category (relative cover) in 2021-2024.

Lake Bottom Relative Hardness Category	**% Relative Cover of Bottom by Category 2021**	**% Relative Cover of Bottom by Category 2022**	**% Relative Cover of Bottom by Category 2023**	**% Relative Cover of Bottom by Category 2024**
0.0-0.1	0.1	0.3	0.02	0
0.1-0.2	4.9	5.0	1.17	0.6
0.2-0.3	47.0	40.5	78.5	81
0.3-0.4	47.9	30.5	20.3	18.4
>0.4	0.1	23.7	0.02	0

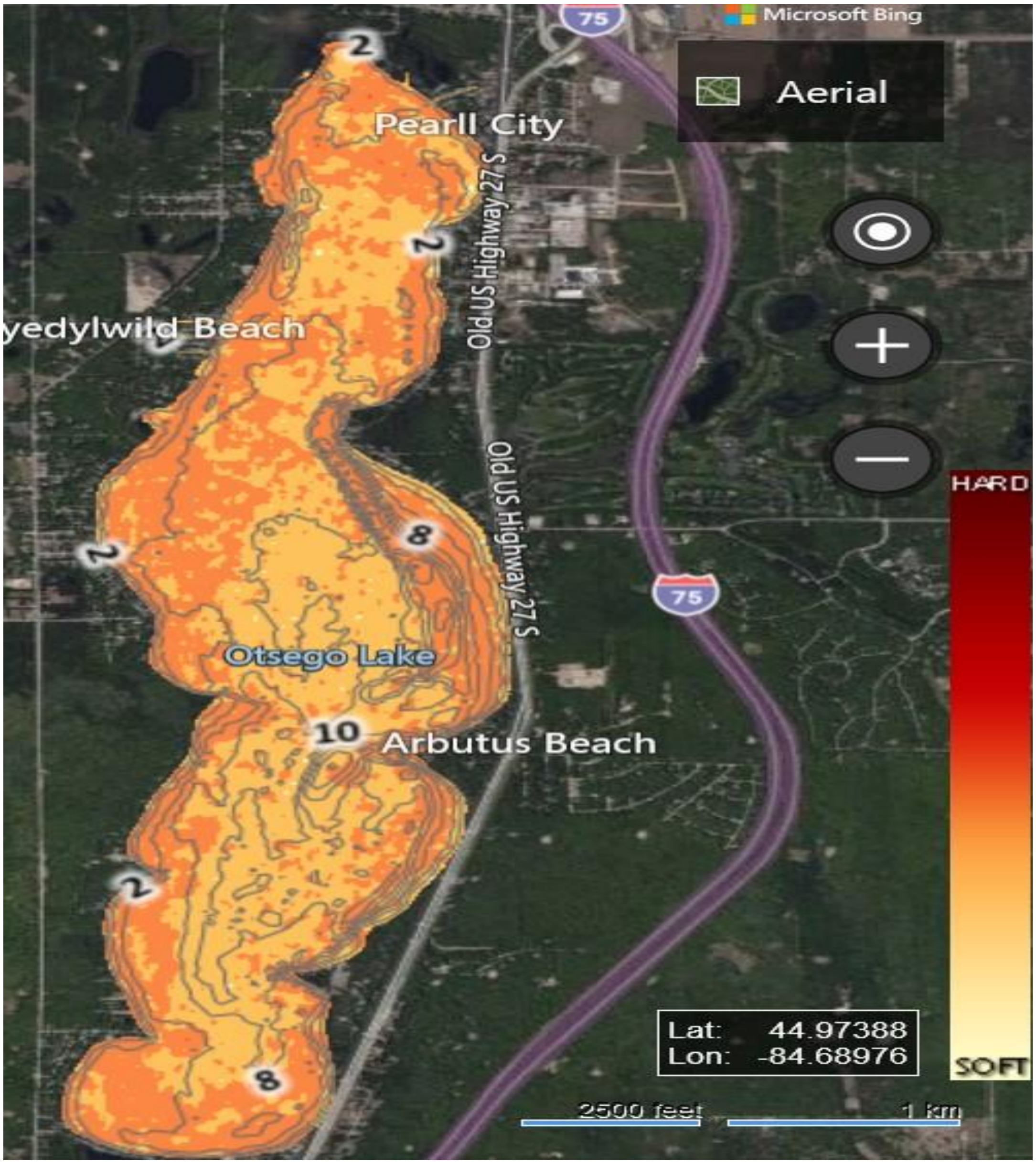


Figure 1. Otsego Lake 2024 sediment relative bottom hardness Map.

2.0 2024 OTSEGO LAKE WATER QUALITY

Water quality is highly variable among Michigan's inland lakes, although some characteristics are common among particular lake classification types. The water quality of Otsego 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. Since many lakes have a fairly long hydraulic residence time, the water may remain in the lake for years and is therefore sensitive to nutrient loading and pollutants. Furthermore, lake water quality helps to determine the classification of particular lakes (Table 2). 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. **Otsego Lake is classified as a mesotrophic (moderately nutrient-rich) lake due to the low to moderate nutrients, moderate Secchi transparency, and low to moderate chlorophyll-a concentrations.**

Table 2. General Lake Trophic Status Classification.

Lake Trophic Status	*Total Phosphorus (mg L^{-1})*	*Chlorophyll-a (µg L^{-1})*	*Secchi Transparency (feet)*
Oligotrophic	< 0.010	< 2.2	> 15.0
Mesotrophic	0.010-0.025	2.2 – 6.0	7.5 – 15.0
Eutrophic	> 0.025	> 6.0	< 7.5

2.1 Water Quality Parameters

Water quality parameters were measured on July 25, 2024 and included dissolved oxygen (in mg/L), water temperature (in °C), specific conductivity (mS/cm), turbidity (NTU's), total suspended solids (mg/L), total dissolved solids (mg/L), pH (S.U.), total alkalinity (mg $CaCO_3$/L), total phosphorus (in mg/L), total Kjeldahl nitrogen (in mg/L), chlorophyll-a (in µg/L), and Secchi transparency (in feet). All of these parameters respond to changes in water quality and consequently serve as indicators of change. The deep basin results are discussed below and are presented in Tables 3-8. A map showing the sampling locations for all water quality samples is shown below in Figure 2.

All water samples and readings were collected at the three deepest basins on July 25, 2024 with the use of a Van Dorn horizontal water sampler and calibrated Eureka Manta II® multi-meter probe with parameter electrodes, respectively. All samples were collected with new bottles, placed on ice, and taken to a NELAC (EPA)-certified laboratory for analysis. Turbidity was measured with a calibrated Lutron® turbidity meter and chlorophyll-a was measured in situ with a calibrated Turner Designs® fluorimeter. Whenever possible, historical data comparisons were made for certain parameters that utilized similar periods and methods as those used in this study. Water quality data in the same deep basins and using the same EPA methods was scarce but comparisons were made when possible.

For information on Otsego Lake water levels, daily water level data can be found online at the following USGS website:
https://waterdata.usgs.gov/mi/nwis/uv/?site_no=445512084415301&PARAmeter_cd=00065,62615

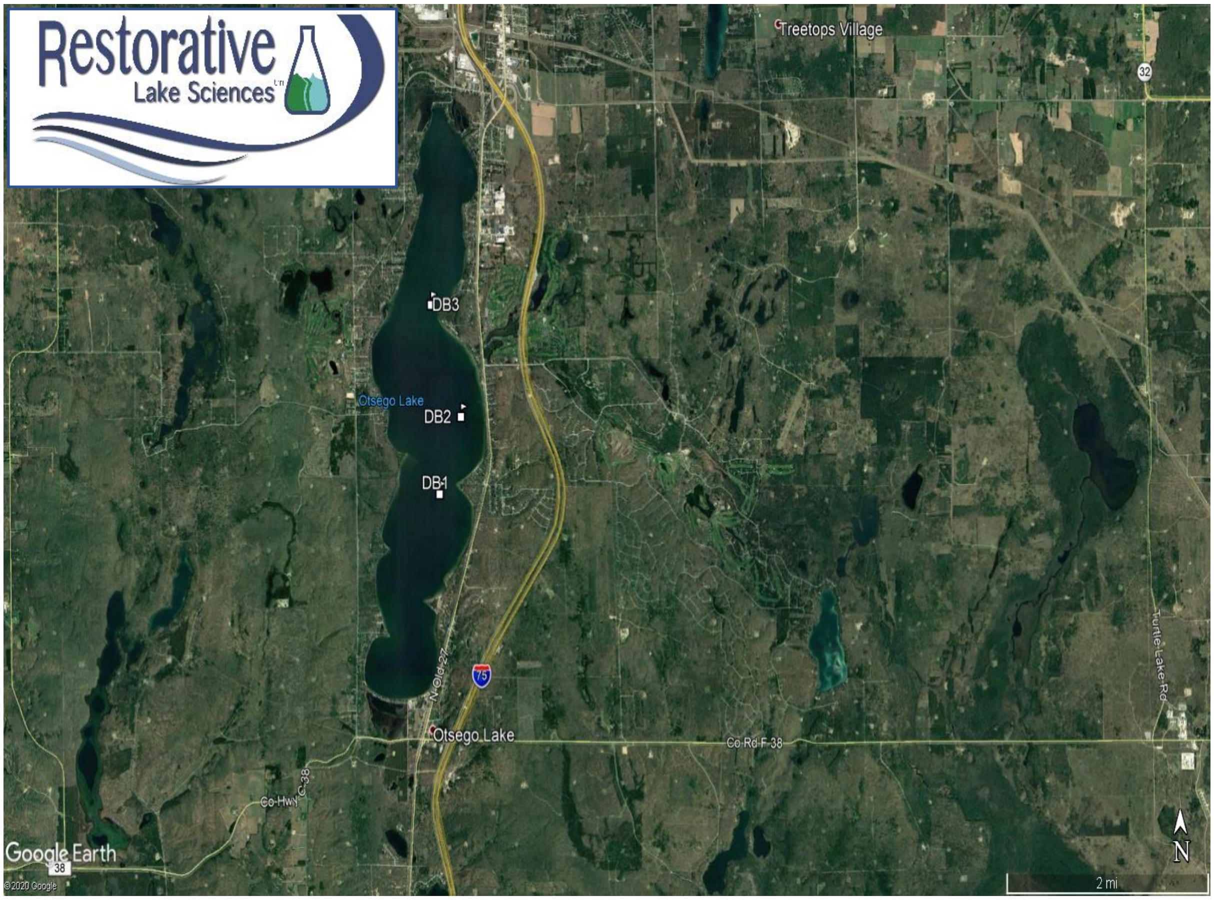
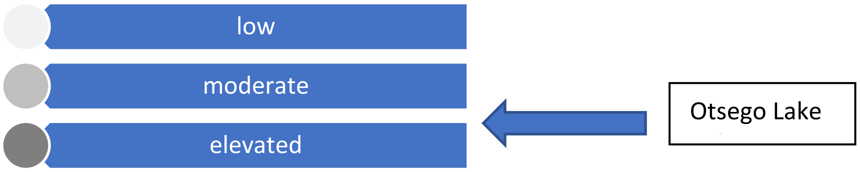


Figure 2. Locations for deep basin water quality sampling in Otsego Lake (July 25, 2024).

2.1.1 Dissolved Oxygen

Dissolved oxygen 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 to sustain a healthy warm-water fishery and even higher around 6 mg/L for trout. Dissolved oxygen concentrations may decline if there is a high biochemical oxygen demand (BOD) where organismal consumption of oxygen is high due to respiration. Dissolved oxygen is generally higher in colder waters. Dissolved oxygen was measured in milligrams per liter (mg/L) with the use of a calibrated Eureka Manta II® dissolved oxygen meter. **Dissolved oxygen (DO) concentrations in the deep basins ranged from 7.11-8.52 mg/L on July 25, 2024, with the highest values measured at the surface and lowest values near the lake bottom.** The bottom of the lake produces a biochemical oxygen demand (BOD) due to microbial activity attempting to break down high quantities of organic plant matter, which reduces dissolved oxygen in the water column at depth. Furthermore, the lake bottom is distant from the atmosphere where the exchange of oxygen occurs. A decline in the dissolved oxygen concentrations to near zero may result in an increase in the release rates of phosphorus (P) from lake bottom sediments. A previous study by the MDNR (2008) determined the surface to bottom DO concentrations to range from 9.8-6.2 mg/L, which are similar to the concentrations measured during this evaluation.



2.1.2 Water Temperature

A lake's water temperature varies within and among seasons and is nearly uniform with depth under the winter ice cover because lake mixing is reduced when waters are not exposed to the 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" (Figure 3). In general, shallow lakes will not stratify and deeper lakes may experience single or multiple turnover cycles. Water temperature was measured in degrees Celsius (ºC) with the use of a calibrated Eureka Manta II® submersible thermometer. **The July 25, 2024 water temperatures of Otsego Lake demonstrated a lack of thermoclines which are indicative of a continually mixed (polymictic) lake that mixes multiple times per year due to the overall shallow depths.**

On the day of sampling, water temperatures ranged from 23.13°C at the surface to 22.47°C at the bottom of the three deep basins. The MDNR (2008) study also reported the lack of a thermocline.

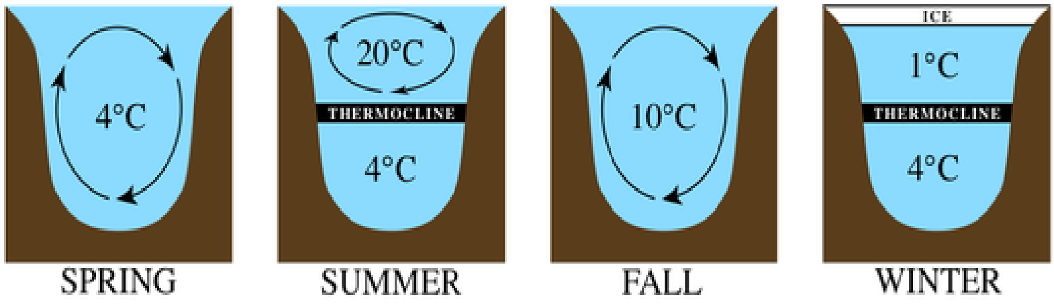
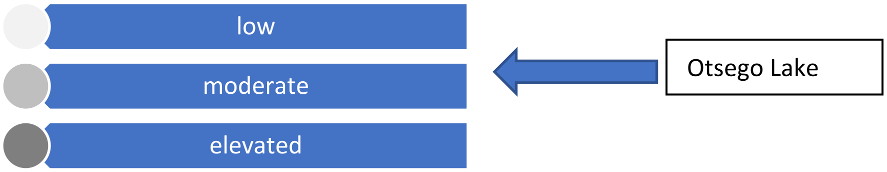


Figure 3. The lake thermal stratification process.

2.1.3 Specific Conductivity

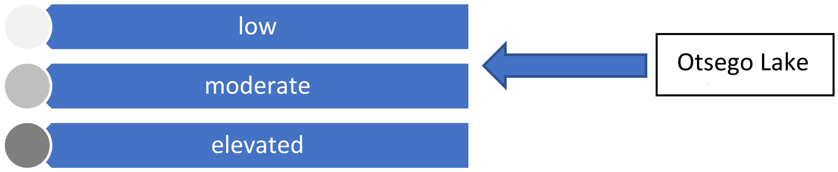
Specific conductivity is a measure of the number of mineral ions present in the water, especially those of salts and other dissolved inorganic substances that can conduct an electrical current. Specific conductivity generally increases with water temperature and the amount of dissolved minerals and salts in a lake. Specific conductivity was measured in micro Siemens per centimeter (µS/cm) with the use of a calibrated Eureka Manta II® specific conductivity probe and meter. **Specific conductivity values for Otsego Lake were variable among depths at the deep basins on July 25, 2024 and ranged from 237.9-242 mS/cm which are moderate and favorable values.** Since these values are moderate for an inland lake, the lake water contains ample dissolved metals and ions such as calcium, potassium, sodium, chlorides, sulfates, and carbonates. Baseline parameter data such as specific conductivity are important to measure the possible influences of land use activities (i.e. road salt influences) on Otsego Lake over a long period of time, or to trace the origin of a substance to the lake in an effort to reduce pollutant loading. Elevated conductivity values over 800 mS/cm can negatively impact aquatic life.



2.1.4 Turbidity, Total Dissolved Solids, and Total Suspended Solids

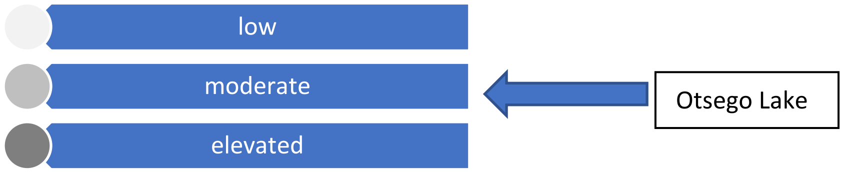
Turbidity

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 by erosion inputs, phytoplankton blooms, storm water 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 water temperatures. Since higher water temperatures generally hold less oxygen, shallow turbid waters are usually lower in dissolved oxygen. Turbidity was measured in Nephelometric Turbidity Units (NTU's) with the use of a calibrated Lutron® turbidity meter. The World Health Organization (WHO) requires that drinking water be less than 5 NTU's; however, recreational waters may be significantly higher than that. **The turbidity of Otsego Lake was moderate and ranged from 2.0-5.0 NTU's during the July 25, 2024 sampling event.** On the day of sampling, the winds were calm in the morning, and turbidity was not likely influenced by much re-suspension of sediments although bottom samples are usually higher in turbidity due to fine particle re-suspension



Total Dissolved Solids

Total dissolved solids (TDS) is a 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 were measured with the use of a calibrated Eureka Manta II® meter in mg/L. Spring values are usually higher due to increased watershed inputs from spring runoff and/or increased planktonic algal communities. **The TDS in Otsego Lake on July 25, 2024 ranged from 153.5-175.3 mg/L for the deep basins which is moderate for an inland lake and correlates with the measured moderate conductivity.**



2.1.5 pH

pH is a measure of acidity or basicity of water. pH was measured with a calibrated Eureka Manta II® pH electrode and pH-meter in Standard Units (S.U). 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 7.0 to 9.5 S.U. 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). **The pH of Otsego Lake water ranged from 7.11-8.40 S.U. during the July 25, 2024 sampling event.** This range of pH is neutral to slightly alkaline on the pH scale and is ideal for an inland lake and is similar to the value of 8.4 S.U. recorded by the MDNR in 2007. pH tends to rise when abundant aquatic plants are actively growing through photosynthesis or when abundant marl deposits are present.

2.1.6 Total Alkalinity

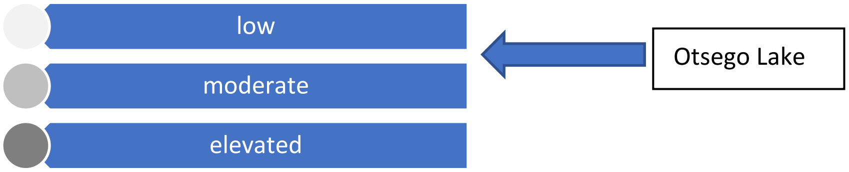
Total alkalinity is a measure of the pH-buffering capacity of lake water. Lakes with high alkalinity (> 150 mg/L of $CaCO_3$) are able to tolerate larger acid inputs with less change in water column pH. Many Michigan lakes contain high concentrations of $CaCO_3$ and are categorized as having "hard" water. Total alkalinity was measured in milligrams per liter of $CaCO_3$ through the acid titration Method SM 2320 B-11.

Total alkalinity in the deep basins ranged from 66-77 mg/L of $CaCO_3$ during the July 25, 2024 sampling event, which represents a moderately low alkalinity (slightly soft water) and may be a characteristic of the lake sediments and geology. 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. This range of total alkalinity was similar to those previously measured by the MDNR (2009) and U of M (1980).

2.1.7 Total Phosphorus

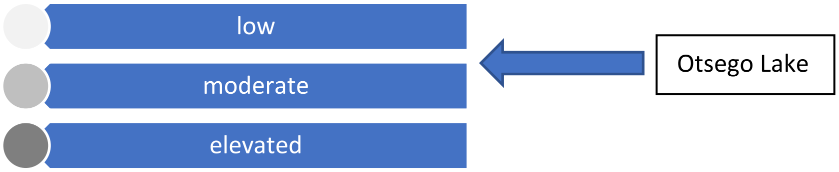
Total Phosphorus

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 0.020 mg/L (or 20 µg/L) of TP are defined as eutrophic or nutrient-enriched. TP concentrations are usually higher at increased depths due to the 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 was measured in milligrams per liter (mg/L) with the use of Method EPA 200.7 (Rev. 4.4). **The total phosphorus (TP) concentrations in the lake deep basins were <0.010 – 0.016 mg/L during the July 25, 2024 sampling event.** These values are considered below the eutrophic threshold.



2.1.8 *Total Kjeldahl Nitrogen*

Total Kjeldahl nitrogen is the sum of organic nitrogen and ammonia (NH_3^+), nitrogen forms in freshwater systems. TKN was measured with Method EPA 351.2 (Rev. 2.0). 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, which is correct for Otsego Lake. 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. **Otsego Lake contained low concentrations of TKN at all depths (0.9-1.1 mg/L), which is normal for an inland lake of similar size and favorable.** In the absence of dissolved oxygen, nitrogen is usually in the ammonia form and will contribute to rigorous submersed aquatic plant growth if adequate water transparency is present.

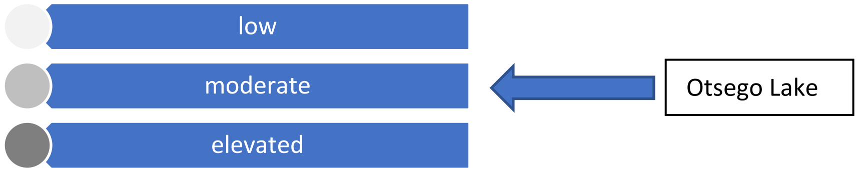


2.1.9 *Chlorophyll-a and Algal Communities*

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-a concentrations are indicative of nutrient-enriched lakes. Chlorophyll-*a* concentrations greater than 6 µg/L are found in eutrophic or nutrient-enriched aquatic systems, whereas chlorophyll-*a* concentrations less than 2.2 µg/L are found in nutrient-poor or oligotrophic lakes. Chlorophyll-*a* was measured in micrograms per liter (µg/L) with Method SM 10200H.

The chlorophyll-*a* concentrations in Otsego Lake were determined by collecting a composite sample of the algae throughout the water column at the deep basin sites from just above the lake bottom to the lake surface. **The chlorophyll-*a* concentrations in the deep basins ranged from 2.0-4.0 µg/L during the July 25, 2024 sampling event.** These concentrations are moderate and favorable and are within the previously reported ranges from MDNR (2009) and U of M (1980). Chlorophyll-a concentrations may significantly fluctuate with changes in air and water temperatures and with storm-driven runoff.

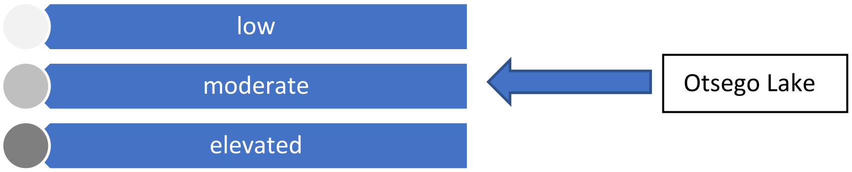
Algal genera from a composite water sample collected from the deep basins of Otsego Lake were analyzed under a Zeiss® compound brightfield microscope. The genera present included the Chlorophyta (green algae): *Chlorella* sp., *Scenedesmus* sp., *Pediastrum* sp., *Cosmarium* sp., *Mougeotia* sp., and *Akinestrodesmus* sp.; the Cyanophyta (blue-green algae): *Microcystis* sp., and *Oscillatoria* sp; the Bascillariophyta (diatoms): *Navicula* sp., *Synedra* sp., *Tabellaria* sp., *Fragilaria* sp., and *Cymbella* sp. The aforementioned species indicate a moderately diverse algal flora and represent a relatively balanced freshwater ecosystem, capable of supporting a strong zooplankton community in favorable water quality conditions. The green algae and diatoms were the most abundant, followed by the blue-green algae. Algal blooms, including blue-green algae have been historically reported on Otsego Lake with time (U of M study, 1980; MDNR, 2009).



2.1.10 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 (Figure 4). 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 Otsego Lake was measured on July 25, 2024 and ranged from 8.3-9.2 feet over the deep basins which are good measurements. Measurements were collected during calm conditions.** This transparency indicates a moderate quantity of suspended particles and algae throughout the water column which would result in reduced water clarity. 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.

Secchi transparency has fluctuated throughout time and ranged from 9.0-14.8 feet (U of M study 1980; MDNR, 2008) and is likely correlated with lake use and wind and storm events as well as the concentrations of algae and solids.



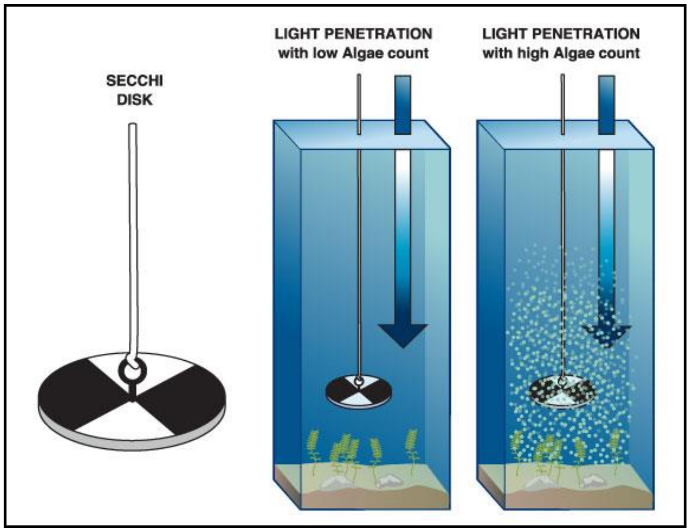


Figure 4. Measurement of water transparency with a Secchi disk.

Table 3. Otsego Lake physical water quality parameter data collected in deep basin #1 (July 25, 2024).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Turb. (NTU)	Secchi Depth (ft)
0	23.1	7.8	8.1	239.9	153.5	2.0	8.3
1.0	23.1	7.8	8.2	239.9	153.6	2.0	
2.0	23.0	7.8	8.1	240.1	153.7	2.0	
3.0	23.0	6.5	7.1	273.3	175.3	5.0	

Table 4. Otsego Lake chemical water quality parameter data collected in deep basin #1 (July 25, 2024).

Depth (m)	TKN (mg/L)	TP (mg/L)	Chl-a (µg/L)	Talk (mg/L)
0	1.2	0.014	2.0	66
2.0	1.0	0.010	--	66
3.0	1.0	0.010	--	66

Table 5. Otsego Lake physical water quality parameter data collected in deep basin #2 (July 25, 2024).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Turb. (NTU)	Secchi Depth (ft)
0	23.1	7.9	8.2	242	154.9	2.0	9.2
1	23.1	7.9	8.2	242	154.9	2.0	
2	22.9	7.9	8.2	242	154.7	2.0	
3	22.9	7.8	8.1	242	154.7	2.0	
4	22.8	7.7	8.1	242	154.7	3.0	
5	22.7	7.7	8.1	242	154.5	5.0	
6	22.7	7.7	8.1	242	154.6	5.0	

Table 6. Otsego Lake chemical water quality parameter data collected in deep basin #2 (July 25, 2024).

Depth (m)	TKN (mg/L)	TP (mg/L)	Chl-a (µg/L)	Talk (mg/L)
0	0.9	0.014	4.0	67
1.5	1.1	0.016	--	70
3.0	1.1	0.010	--	77

Table 7. Otsego Lake physical water quality parameter data collected in deep basin #3 (July 25, 2024).

Depth (m)	Water Temp (°C)	DO (mg/L)	pH (S.U.)	Conduc. (mS/cm)	TDS (mg/L)	Turb. (NTU)	Secchi Depth (ft)
0	22.9	8.4	8.4	241	154	2.0	8.5
1.0	22.9	8.4	8.3	241	154	2.0	
2.0	22.5	8.4	8.4	240	154	3.0	
3.0	22.5	8.5	8.4	240	154	4.0	

Table 8. Otsego Lake chemical water quality parameter data collected in deep basin #3 (July 24, 2025).

Depth (m)	TKN (mg/L)	TP (mg/L)	Chl-a (µg/L)	Talk (mg/L)
0	1	0.016	3.0	68
2.0	1.0	0.010	--	70
4.0	1.0	0.010	--	71

3.0 2024 OTSEGO LAKE AQUATIC VEGETATION

3.1 2024 Otsego Lake Aquatic Vegetation Communities

Aquatic plants (macrophytes) are an essential component in the littoral zones of most lakes in that they serve as suitable habitat and food for macroinvertebrates, contribute oxygen to the surrounding waters through photosynthesis, stabilize bottom sediments (if in the rooted growth form), and contribute to the cycling of nutrients such as phosphorus and nitrogen upon decay. In addition, decaying aquatic plants contribute organic matter to lake sediments which further supports healthy growth of successive aquatic plant communities that are necessary for a balanced aquatic ecosystem. An overabundance of aquatic vegetation may cause organic matter to accumulate on the lake bottom faster than it can break down. Aquatic plants generally consist of rooted submersed, free-floating submersed, floating-leaved, and emergent growth forms. The emergent growth form (i.e., Cattails, Native Loosestrife) is critical for the diversity of insects onshore and for the health of nearby wetlands. Submersed aquatic plants can be rooted in the lake sediment (i.e., Milfoils, Pondweeds), or free-floating in the water column (i.e., Coontail). Nonetheless, there is evidence that the diversity of submersed aquatic macrophytes can greatly influence the diversity of macroinvertebrates associated with aquatic plants of different structural morphologies (Parsons and Matthews, 1995). Therefore, it is possible that declines in the biodiversity and abundance of submersed aquatic plant species and associated macroinvertebrates, could negatively impact the fisheries of inland lakes. Alternatively, the overabundance of aquatic vegetation can compromise recreational activities, aesthetics, and property values. Otsego Lake currently has a favorable quantity of submersed aquatic vegetation but there are still many areas of the lake that lack aquatic vegetation and thus preservation of native aquatic plants is important.

A whole-lake scan of the aquatic vegetation biovolume in Otsego Lake was conducted on July 23rd – 24th, 2024 with a WAAS-enabled Lowrance HDS 7® GPS with variable frequency transducer. This data included 63,602 GPS data sounding points which were uploaded to a cloud software program to reveal maps that displayed depth contours, sediment hardness, and aquatic vegetation biovolume (Figure 5). On the biovolume scan map, the color blue refers to areas that lack vegetation. The color green refers to low-lying vegetation. The colors red/orange refer to tall-growing vegetation. There are many areas around the littoral (shallow) zone of the lake that contain low-growing plants like Chara or Naiad. For this reason, the scans are conducted in conjunction with a whole lake GPS Point Intercept survey to account for individual species identification of all aquatic plants in the lake. Table 9 shows the biovolume categories by plant cover on July 23rd-24th, 2024.

The GPS Point Intercept survey is sometimes used with an Aquatic Vegetation Assessment Site (AVAS) Survey method to assess the relative abundance of submersed, floating-leaved, and emergent aquatic vegetation within and around the littoral zones of inland lakes.

With this survey method, the littoral zone areas of the lakes are divided into lakeshore sections approximately 100 - 300 feet in length. Each AVAS segment is sampled using visual observation, dependent on water clarity, and weighted rake tows to verify species identification. The species of aquatic macrophytes present and density of each macrophyte are recorded onto an AVAS data sheet. Each separate plant species found in each AVAS segment is recorded along with an estimate of each plant density. Each macrophyte species corresponds to an assigned number. There are designated density codes for the aquatic vegetation surveys, where a = found (occupying < 2% of the surface area of the lake), b = sparse (occupying 2-20% of the surface area of the lake), c = common, (occupying 21-60% of the surface area of the lake), and d = dense (occupying > 60% of the surface area of the lake). In addition to the particular species observed (via assigned numbers), density information above was used to estimate the percent cumulative coverage of each species within the AVAS site. Where shallow areas were present in the open waters of the lake, individual AVAS segments were sampled at those locations to assess the macrophyte communities in offshore locations. This is particularly important since exotics often expand in shallow island areas located offshore in many lakes.

The GPS Point-Intercept/AVAS survey of Otsego Lake was conducted on July 23rd-24th, 2024 and consisted of 1,213 sampling locations around the littoral zone (Figure 6). Data were placed in a table showing the relative abundance of each aquatic plant species found and a resultant calculation showing the frequency of each plant. **About half of the lake contained low-growing aquatic plants that were within the 0-20% cover category (a total of 91.3% of the lake area).**

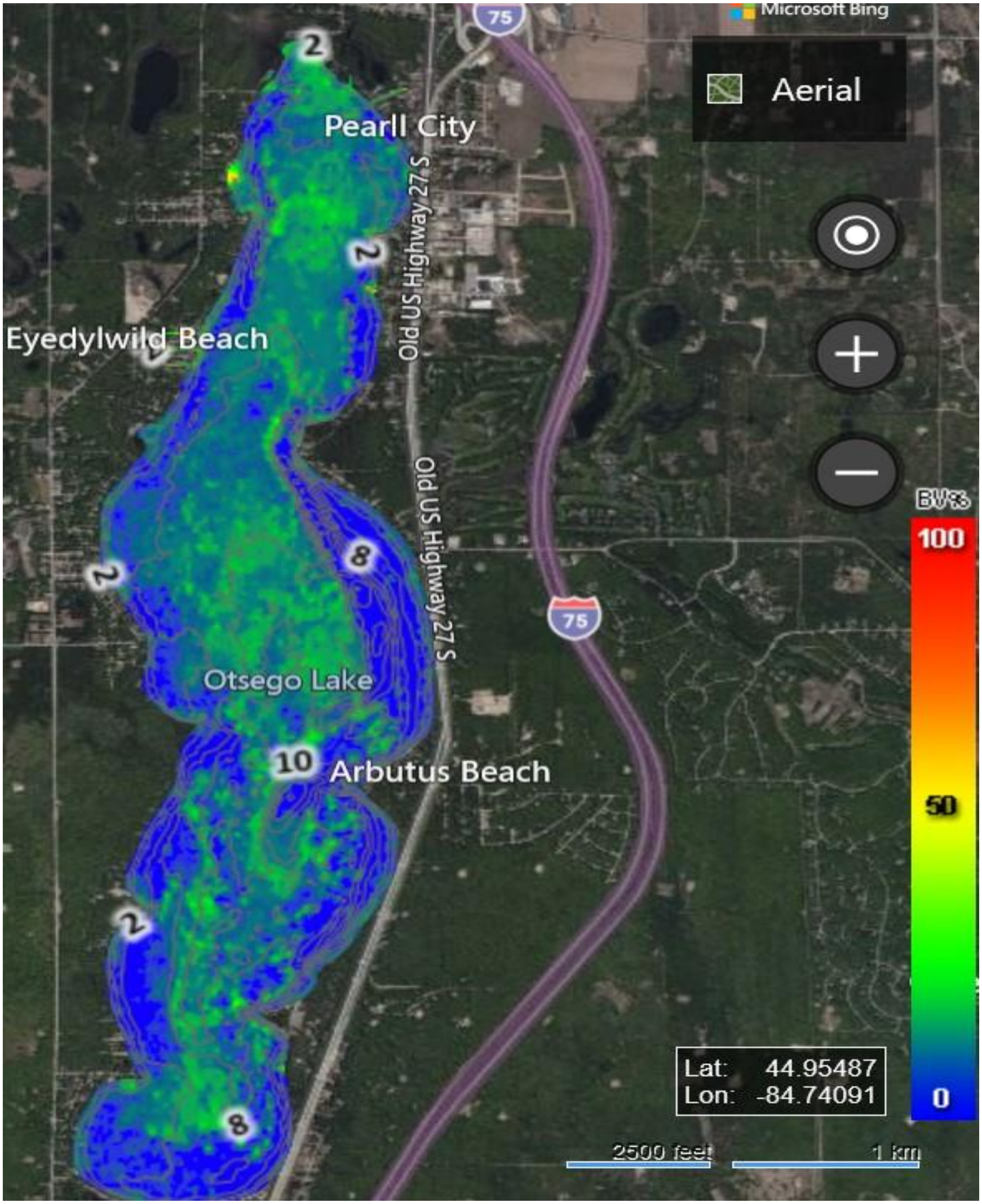


Figure 5. Aquatic plant biovolume of all aquatic plants in Otsego Lake, Otsego County, Michigan (July 24th, 2024). Note: Red color denotes high-growing aquatic plants, green color denotes low-growing aquatic plants, and blue color represents a lack of aquatic vegetation.

Table 9. Otsego Lake aquatic vegetation biovolume by bottom cover category (relative cover on July 25, 2024).

Aquatic Vegetation Biovolume Cover Category	% Relative Cover of Bottom by Category 2022	% Relative Cover of Bottom by Category 2023	% Relative Cover of Bottom by Category 2024
0-20%	94.3	91.5	91.3
20-40%	3.7	7.0	7.9
40-60%	0.7	1.3	0.5
60-80%	0.2	0.1	0
>80%	1.0	0.1	0.3

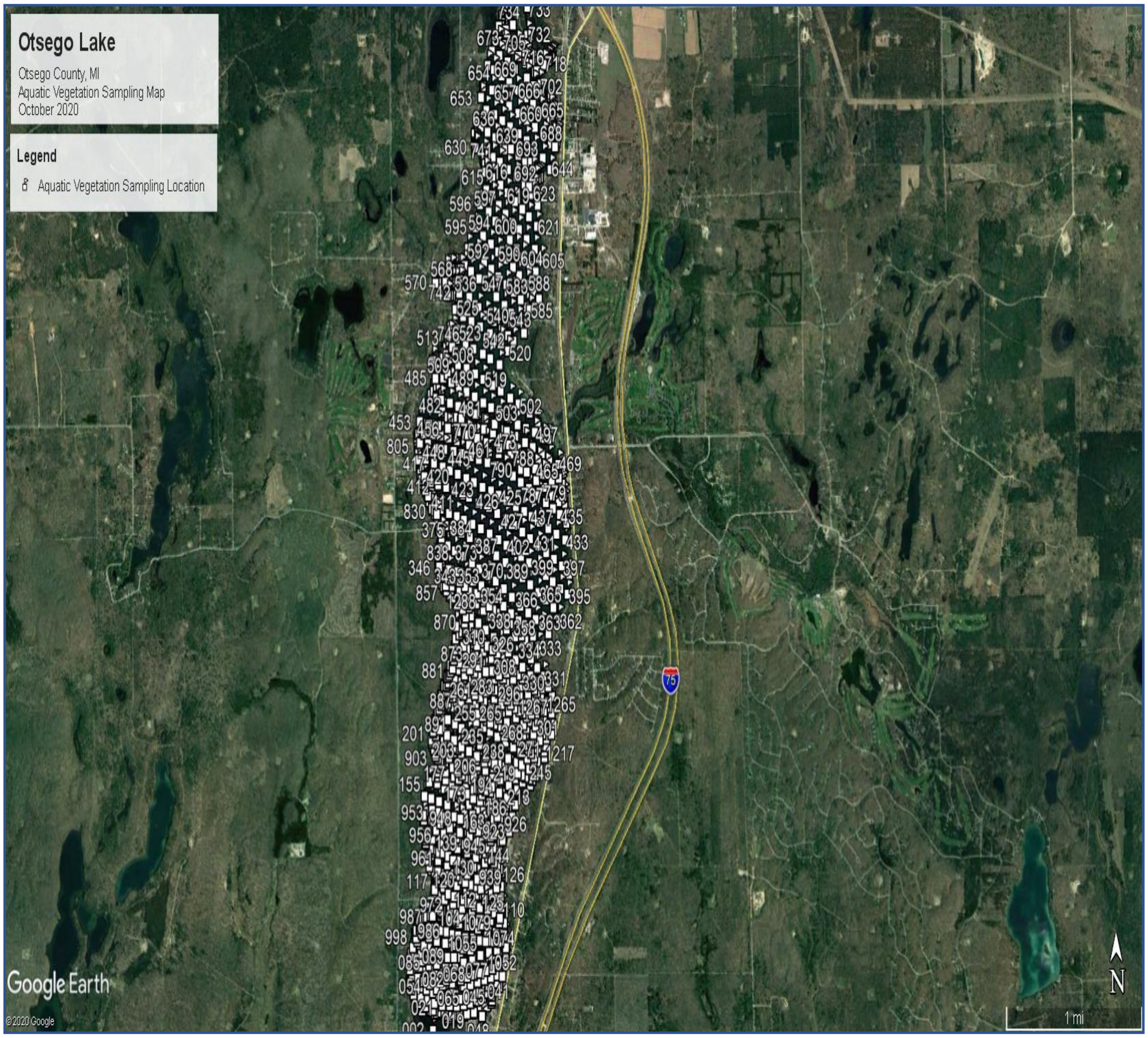


Figure 6. Aquatic vegetation sampling locations in Otsego Lake (2020-2024).

3.1.1 2024 Otsego Lake Native Aquatic Macrophytes

There are hundreds of native aquatic plant species in the waters of the United States. The most diverse native genera include the Potamogetonaceae (Pondweeds) and the Haloragaceae (Milfoils). Native aquatic plants may grow to nuisance levels in lakes with abundant nutrients (both water column and sediment) such as phosphorus, and in sites with high water transparency. The diversity of native aquatic plants is essential for the balance of aquatic ecosystems because each plant harbors different macroinvertebrate communities and varies in fish habitat structure.

Otsego Lake contained 18 native submersed, 4 floating-leaved, and 3 emergent aquatic plant species, for a total of 25 native aquatic macrophyte species (Table 10). Photos of all native aquatic plants are shown below in Figures 7-27. The emergent macrophytes were found along the shoreline areas of the lake. Additionally, the lower-growing species were found throughout the littoral zone and the higher-growing pondweeds were present in the deeper waters of the littoral zone where they were protected from wave action.

The dominant aquatic plants in the main part of the lake included the White-stem Pondweed (35.0% of the sampling locations), the macro alga Chara (17.3 % of the sampling locations), and slender naiad (14.5 % of the sampling locations). The pondweeds grow tall in the water column and serve as excellent fish cover. Chara and Slender Naiad provide bottom cover and help with sediment stabilization as well as colonizing areas reducing the chance for EWM to take over. Protection of all native aquatic plant species is critical for the lake ecosystem especially since the relative abundance is overall low for most native aquatic plant species.

The relative abundance of rooted aquatic plants (relative to non-rooted plants) in the lake suggests that the sediments are the primary source of nutrients (relative to the water column) since these plants obtain most of their nutrition from the sediments.

Table 10. Otsego Lake native aquatic vascular plants and frequency (July 24, 2024).

Native Aquatic Plant Species Name	*Native Aquatic Plant Common Name*	*Growth Form*	*% Frequency*
Chara vulgaris	Muskgrass	Submersed	17.3
Stuckenia pectinatus	Sago Pondweed	Submersed	0.4
Potamogeton zosteriformis	Flat-stem Pondweed	Submersed	0.4
Potamogeton robbinsii	Fern-leaf Pondweed	Submersed	0.3
Potamogeton illinoensis	Illinois Pondweed	Submersed	1.5
Potamogeton richardsonii	Clasping-leaf Pondweed	Submersed	1.1
Potamogeton nodosus	American Pondweed	Submersed	0.08
Potamogeton praelongus	White-stem Pondweed	Submersed	35.0
Potamogeton amplifolius	Large-leaf Pondweed	Submersed	8.9
Potamogeton foliosus	Thin-leaf Pondweed	Submersed	0.4
Potamogeton pusillus	Small-Pondweed	Submersed	0.9
Potamogeton gramineus	Variable-leaf Pondweed	Submersed	4.0
Nitella mucronata	Nitella	Submersed	0.08
Schoenoplectus subterminalis	Submersed Bullrush	Submersed	0.08
Elodea canadensis	Common Waterweed	Submersed	3.8
Utricularia vulgaris	Bladderwort	Submersed	0.8
Utricularia minor	Northern Watermilfoil	Submersed	2.7
Ceratophyllum demersum	Coontail	Submersed	0.08
Najas flexilis	Slender Naiad	Submersed	14.5
Potamogeton natans	Floating-leaf Pondweed	Floating-Leaved	1.4
Nymphaea odorata	White Waterlily	Floating-Leaved	3.8
Nuphar advena	Yellow Waterlily	Floating-Leaved	1.4
Brasenia schreberi	Watershield	Floating-Leaved	1.5
Schoenoplectus acutus	Bulrushes	Emergent	2.2
Typha latifolia	Cattails	Emergent	0.9
Sparganium sp.	Burr Reed	Emergent	0.5

Figure 7. Chara (Muskgrass)

Figure 8. Sago Pondweed

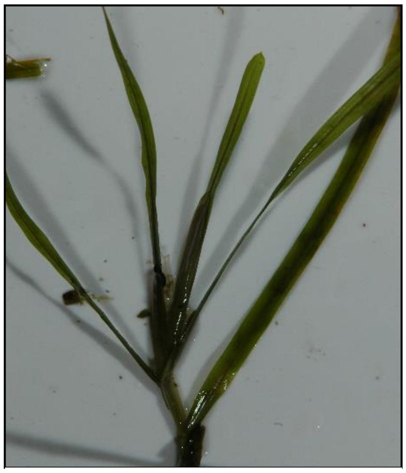


Figure 9. Flat-stem Pondweed

Figure 10. Fern-leaf Pondweed

Figure 11. Illinois Pondweed

Figure 12. Clasping-Leaf Pondweed

Figure 13. Variable Pondweed

Figure 14. White-stem Pondweed

Figure 15. Large-leaf Pondweed

Figure 16. American-Pondweed

Figure 17. Small-Leaf Pondweed

Figure 18. Common Bladderwort

Figure 19. Common Waterweed (Elodea)

Figure 20. Southern Naiad

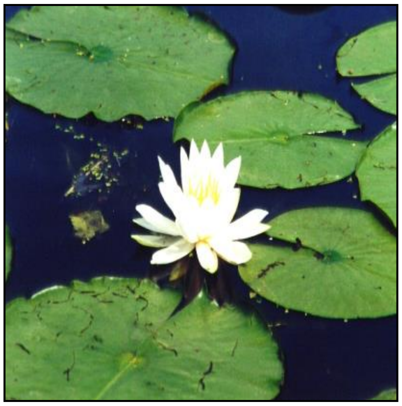


Figure 21. White Waterlily

Figure 22. Cattails

Figure 23. Burr Reed

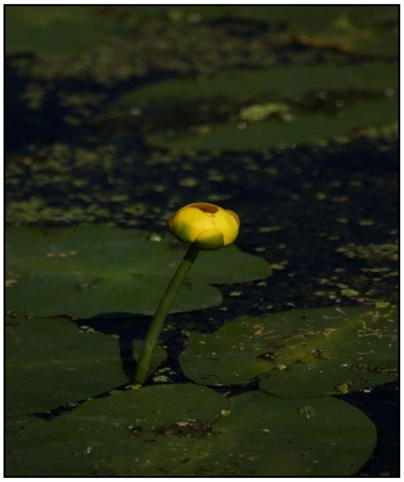


Figure 24. Yellow Waterlily

Figure 25. Bulrushes

Figure 26. Nitella

Figure 27. Northern Watermilfoil

3.1.2 2024 Otsego Lake Exotic Aquatic Macrophytes

Exotic aquatic plants (macrophytes) are not native to a particular site and are introduced by some biotic (living) or abiotic (non-living) vector. Such vectors include the transfer of aquatic plant seeds and fragments by boats and trailers (especially if the lake has public access sites), waterfowl, or by wind dispersal. In addition, exotic species may be introduced into aquatic systems through the release of aquarium or water garden plants into a water body. An aquatic exotic species may have profound impacts on the aquatic ecosystem. Eurasian Watermilfoil (*Myriophyllum spicatum*; Figure 28) is an exotic aquatic macrophyte first documented in the United States in the 1880's (Reed 1997), although other reports (Couch and Nelson 1985) suggest it was first found in the 1940's.

In recent years, this species has hybridized with native milfoil species to form hybrid species. Eurasian Watermilfoil has since spread to thousands of inland lakes in various states through the use of boats and trailers, waterfowl, seed dispersal, and intentional introduction for fish habitat. Eurasian Watermilfoil is a major threat to the ecological balance of an aquatic ecosystem through causation of significant declines in favorable native vegetation within lakes (Madsen et *al*. 1991), in that it forms dense canopies and may limit light from reaching native aquatic plant species (Newroth 1985; Aiken et *al*. 1979). Additionally, Eurasian Watermilfoil can alter the macroinvertebrate populations associated with particular native plants of certain structural architecture (Newroth 1985).

Approximately 3.8 acres of Eurasian Watermilfoil were found in Otsego Lake during the May 23, 2024 survey (Figure 29). The milfoil was treated by PLM with oversight by RLS on June 20, 2024 with the use of the systemic herbicide ProcellaCOR® at a dose of 6.0 PDU along with the contact herbicide diquat at a dose of 1 gallon per acre. During the second survey on June 23, 2024 another 1.0 acre of EWM was identified in the North East channel and this was treated on August 5th, 2024 with the same systemic as the first treatment. The treatment will be evaluated in spring of 2024 for efficacy given the late season application. Eurasian Watermilfoil growth in Otsego Lake is capable of producing dense surface canopies in shallow areas as well as in deeper waters due to the sometimes high light penetration. In addition, it could hybridize with the native northern watermilfoil and create a highly herbicide-resistant strain.

There was no viable invasive Curly-leaf Pondweed found in the lake during the 2024 survey, but it was noted in a few previous years and RLS will continue to monitor its presence. Curly-leaf Pondweed (*Potamogeton crispus*) is an exotic, submersed, rooted aquatic plant that was introduced into the United States in 1807 but was abundant by the early 1900's. It is easily distinguished from other native pondweeds by its wavy leaf margins. It grows early in the spring and as a result may prevent other favorable native aquatic species from germinating. The plant reproduces by the formation of fruiting structures called turions. It does not reproduce by fragmentation as invasive watermilfoil does; however, the turions may be deposited in the lake sediment and germinate in following seasons.

Curly-leaf Pondweed is a pioneering aquatic plant species and specializes in colonizing disturbed habitats. It is highly invasive in aquatic ecosystems with low biodiversity and unique sediment characteristics.

Lastly, Starry Stonewort was found in previous years but not in 2024. Starry Stonewort (*Nitellopsis obtusa*) is an invasive macro alga that has invaded many inland lakes and was originally discovered in the St. Lawrence River. The "leaves" appear as long, smooth, angular branches of differing lengths. The alga has been observed in dense beds at depths beyond several meters in clear inland lakes and can grow to heights in excess of a few meters. It prefers clear alkaline waters and has been shown to cause significant declines in water quality and fishery spawning habitat Individual fragments can be transported to the lake via waterfowl or boats. Although it prefers alkaline waters, it can thrive in most clear waters and especially in shallow canals.

The species of invasive aquatic plants present, and relative abundance of each plant were recorded and then the amount of cover in the littoral zone was calculated. **Exotic aquatic plant species that were found in Otsego Lake during the two surveys are shown in Table 11 below and discussions of key invasives also follow below.** Figures 29-30 display the locations where each invasive aquatic plant was located during the survey.

Figure 28. Hybrid Eurasian Watermilfoil plant with seed head and fragments.

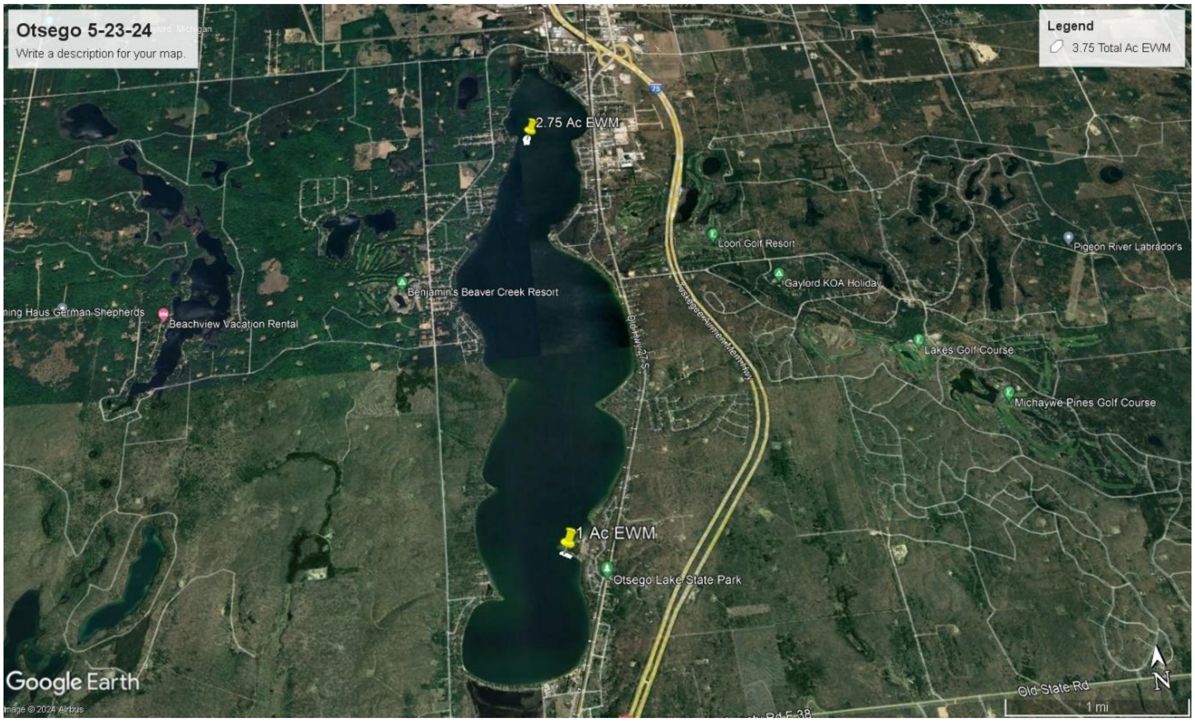


Figure 29. EWM distribution in Otsego Lake (May 23, 2024).

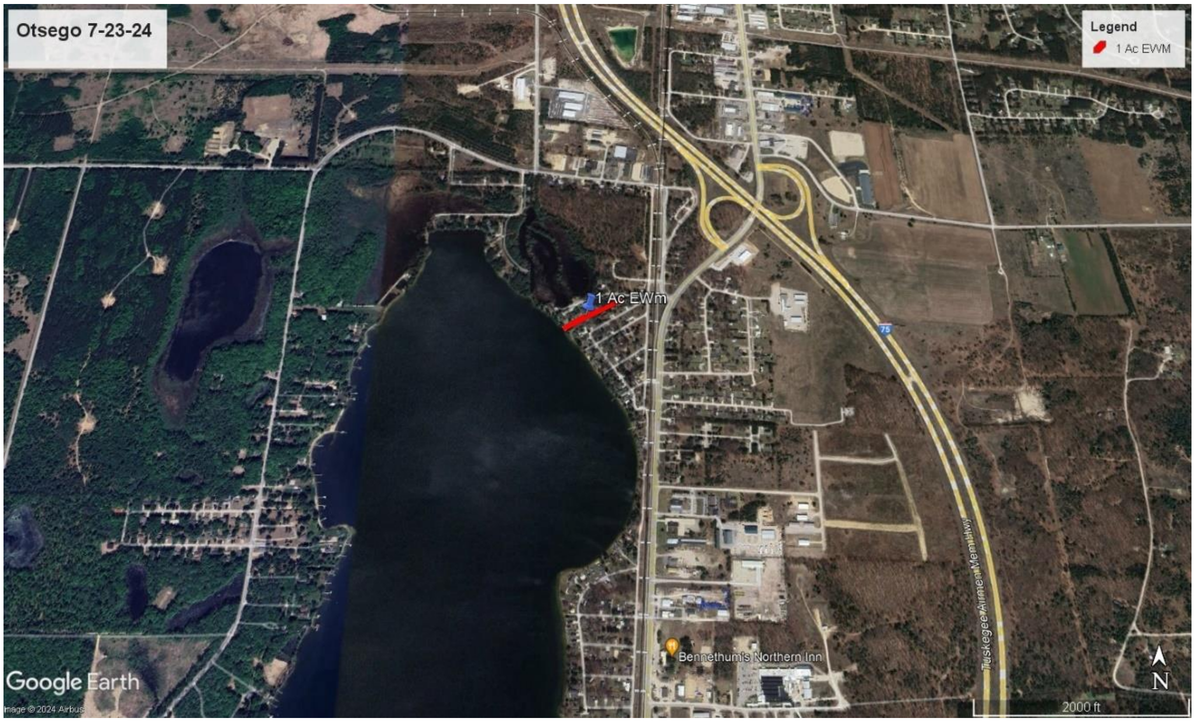


Figure 30. EWM distribution in Otsego Lake canal (July 23,2024).

Table 11. Otsego Lake exotic aquatic plant species (May and July combined) prior to treatment.

Exotic Aquatic Plant Species	***Exotic Aquatic Plant Common Name***	***Exotic Aquatic Plant Growth Habit***	***Abundance in Otsego Lake***
Myriophyllum spicatum	Eurasian Watermilfoil	Rooted, Submersed	~4.75 acres
Potamogeton crispus	Curly-leaf Pondweed	Rooted, Submersed	~0 acres
Nitellopsis obtusa	Starry Stonewort	Rooted, Submersed	~0 acres

4.0 2023 OTSEGO LAKE ZOOPLANKTON

A zooplankton tow using a Wildco® pelagic plankton net (63 micrometer) with collection jar (Figure 31) was conducted by RLS scientists August 29, 2024 in the 3 deep basins of Otsego Lake. The plankton net was left at depth for 30 seconds and then raised slowly to the surface at an approximate rate of 4 feet/second. The net was then raised above the lake surface and water was splashed on the outside of the net to dislodge any zooplankton from the net into the jar. The jar was then drained into a 125-mL bottle with a CO_2 tablet to anesthetize the zooplankton. The sample was then preserved with a 70% ethyl alcohol solution. Plankton sub-samples (in 1 ml aliquots) were analyzed under a Zeiss® dissection scope with the use of a Bogorov counting chamber. Taxa were keyed to genus and are shown in Tables 12-14 below.

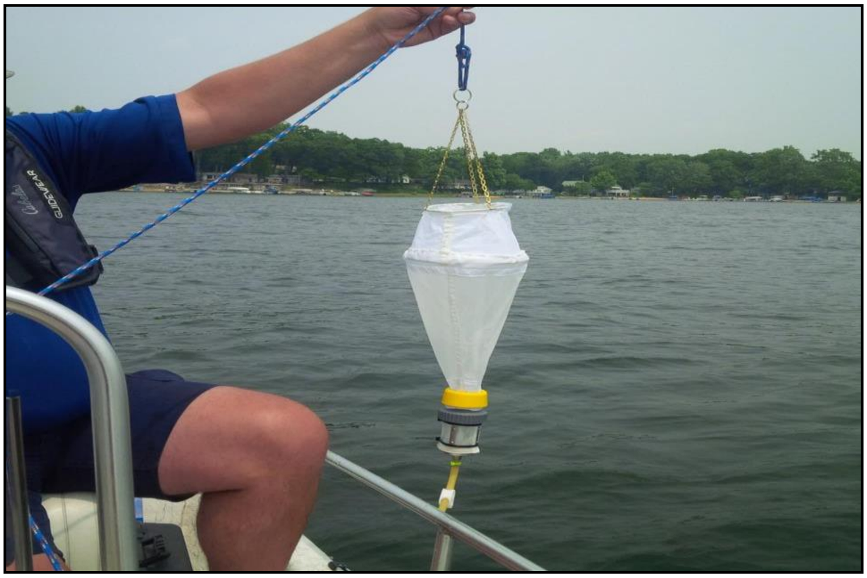


Figure 31. A zooplankton collection tow net.

Table 12. Zooplankton taxa and count data from Otsego Lake Deep Basin #1 (August 29, 2024).

Cladocerans	Count	Copepods	Count	Rotifers	Count
***Daphnia* sp.**	32	***Cyclops* sp.**	6	***Keratella* sp.**	9
***Chydorus* sp.**	5	***Nauplius* sp.**	7		
***Bosmina* sp.**	3				

Table 13. Zooplankton taxa and count data from Otsego Lake Deep Basin #2 (August 29, 2024).

Cladocerans	Count	Copepods	Count	Rotifers	Count
***Daphnia* sp.**	49	***Cyclops* sp.**	1	***Keratella* sp.**	13
***Chydorus* sp.**	3	***Diaptomus* sp.**	8	***Asplanchna* sp.**	1
***Bosmina* sp.**	11				

Table 14. Zooplankton taxa and count data from Otsego Lake Area #3 (August 29, 2024).

Cladocerans	Count	Copepods	Count	Rotifers	Count
***Daphnia* sp.**	35	***Cyclops* sp.**	1	***Keratella* sp.**	6
***Bosmina* sp.**	9	***Nauplius* sp.**	5		
***Diaphanasoma* sp.**	3				

5.0 2024 OTSEGO LAKE AIS DETECTION & RAPID RESPONSE PROTOCOL

An exotic species is a non-native species that does not originate from a particular location. When international commerce and travel became prevalent, many of these species were transported to areas of the world where they did not originate. Due to their small size, insects, plants, animals, and aquatic organisms may escape detection and be unknowingly transferred to unintended habitats.

The first ingredient to successful prevention of unwanted transfers of exotic species to Otsego Lake is awareness and education. In the 2020 Otsego Lake Management Plan, RLS recommended boat washing stations and other prevention techniques. In 2021, RLS created the first draft of an aquatic invasive species (AIS) prevention and rapid response protocol. This is explained below in Section 5.2. **This plan will be revised only when a new invasive is on the move locally and a mitigation plan should be in place.**

I. **OVERVIEW**: **Otsego Lake** is located in northwest Michigan at 44°57’20”N 84°41’32”W,[1] south of the city of Gaylord in Otsego County. The lake spans the boundary between Otsego Lake Township to the south and Bagley Township to the north. Otsego Lake State Park is located on the southeast shore of the lake and Otsego County Park is on the northwest shore. The lake has many private cottages and homes with direct access to the lake and parks.

Otsego Lake is 1,972 acres (7.98 km^2), and 5 miles (8.0 km) long and 1 mile (1.6 km) at its widest. In general, it is a shallow lake averaging about 6–8 feet in most places, with a maximum depth of approximately 23 feet (7.0 m) in a few spots. The bottom shoal composed of sand and light gravel forms many "drop-offs" and holes. The lake is full of vegetation which is submerged at the bottom of the lake with very little floating vegetation.

Otsego Lake is within the Au Sable Watershed which drains 1,932 square miles and covers parts of eight counties (Otsego, Crawford, Montmorency, Roscommon, Ogemaw, Oscoda, Iosco and Alcona). The Au Sable River begins at the confluence of Kolke and Bradford creeks, about 2 miles north of Frederic in northwest Crawford County, and eventually empties into Lake Huron near the town of Oscoda. Major Tributaries of the Au Sable Watershed are East Branch Au Sable River, North Branch Au Sable River, South Branch Au Sable River, East Branch Big Creek, Middle Branch Big Creek, West Branch Big Creek, Pine River, East Branch Pine River, West Branch Pine River, South Branch Pine River, and the South Branch River.

II. SPECIES AT RISK

Native Aquatic Plants

Otsego Lake hosts at least 25 valuable native aquatic plant species including all of the aquatic plants listed in the 2020 lake management plan. Rare species such as Wild Rice are also present and should be preserved.

Lake Fishery

Otsego Lake is home to a diverse population of cool and warm water fish including Muskellunge, Lake Sturgeon, Northern Pike, Largemouth, Smallmouth Bass, Walleye, Pumpkin Seed (Sunfish), Bluegill, Rock Bass, Smallmouth Bass. Continued shoreline development and loss of natural habitat have challenged the fishery and natural populations of some native fish are sustained, however larger game fish populations like Walleye, Northern Pike, Lake Sturgeon, and Muskellunge have been periodically stocked by the MDNR to sustain their populations which do vary naturally at times with the lake water level and access to suitable breeding areas.

Birds

Otsego Lake shows large stands of wooded areas that include tree species such as Oak, Pine, and Maples which make it a highly desired habitat for native bird species such as Northern Bald Eagles, Common Loon, Belted Kingfisher, SandHill Crane, and numerous other migratory birds. Rare bird species recently spotted on Otsego Lake are the Golden Eagle and the Rose Breasted Grosbeak.

III. GOALS: The goal of this management plan is to achieve sustainable results in the control of invasive species and help facilitate the maintenance of valuable native plant and animal species within Otsego Lake. Elimination and control of invasive species in Otsego Lake will help to conserve the balance of this unique ecosystem and allow long term sustainability of the Au Sable Watershed as a whole.

IV. OUTLINE OF KEY AIS PROTOCOL COMPONENTS:

1. PREVENTION

- a. **Signage at launches and access sites**

- **b. Education sessions Q & A of riparians/stakeholders about AIS**
- **c. Visual education cards for distribution about AIS**
- **d. Boat wash at launch**

2. EARLY DETECTION AND RAPID RESPONSE (EDRR) PLAN

- **a. Regular surveys to map aquatic plants present**

  RLS recommended that a AVAS survey take place in early Spring and mid to late summer with periodic review as needed if treatment is required.

- **b. Invasive aquatic plants will be sampled and mapped**

  RLS does visual AVAS surveys as well as physical sampling of aquatic biomass. Other mapping techniques include GPS mapping and BioBase scanning for bottom hardness and sediment monitoring.

- **c. Lake Management will coordinate efforts with a licensed state** contractor/ applicato**r** to obtain permit.
- **d. Recommended chemical product and/or mechanical treatments**

3. CONTROL AND MANAGEMENT

- a**.** Conduct surveys beginning spring and into late fall
- b. Invasive species identified and assessed:
  - 1**.** Eurasian Water Milfoil
  - 2. Curly-leaf Pondweed
  - 3. Starry Stonewort
- c. Restoration Plan (see Otsego Lake Management Plan 2020)

4. COLLABORATION AND ENGAGEMENT

a. Board/riparian education

1. Educational presentation at board meetings
2. Board correspondence to stakeholders
3. Newsletters
4. Press release
5. Visual media, social media
6. Educational workshops

b. Continue with Lake Management Best Practices (see Otsego Lake Management Plan 2020)

6.0 2022 -2024 OTSEGO LAKE BIOAUGMENTATION MUCK REDUCTION

Restorative Lake Sciences (RLS) collected 20 sediment samples in the northernmost region of Otsego Lake on April 29, 2022. The samples were collected with an Ekman hand dredge and taken to an EPA-certified laboratory for analysis of organic matter. The percentage of organic matter was found to be very low ≤12% which indicates the presence of non-organic soft bottom (likely silt or clay). As a result of this finding, RLS recommended not applying the muck pellets to that region as they would have had little impact on reducing non-organic matter. RLS was present on the lake again on August 3, 2022 to sample a few other areas at the north and south regions of the lake (Figures 32 and 33). Since those areas demonstrated much higher concentrations of organic matter in the sediments, RLS recommended placement of the pellets in those areas. Aqua Weed control applied Muck Biotics to the approximate 50-acre total area (north and south) on September 5, 2022 with RLS present to oversee this unique treatment. Ideally, sediment organic matter percentages should be ≥40% to observe notable reductions. **RLS sampled 10 new locations in the North Bay to identify other potential areas for muck reduction treatments. Organic matter % are shown in Table 16. Seven out of the Ten samples came back ~40% or higher and could potentially benefit from treatment. However, these areas were in open zones of north bay so the cost effectiveness should be looked at closely. Sampling locations for 2024 are shown below in Figure 34.**

Table 15. Otsego Lake organic matter laboratory data
from sediment samples collected on August 3, 2022 and September 2023.

Sample #	% Organic Matter (carbon) August 2022 (Pre-bioaug)	% Organic Matter (carbon) September 2023 (Post-bioaug)
311N	14.0	0.93
312N	1.7	5.1
313N	61.0	60
314N	53.0	47
315N	75.0	72
316N	61.0	64
317S	65.0	77
318S	91.0	67

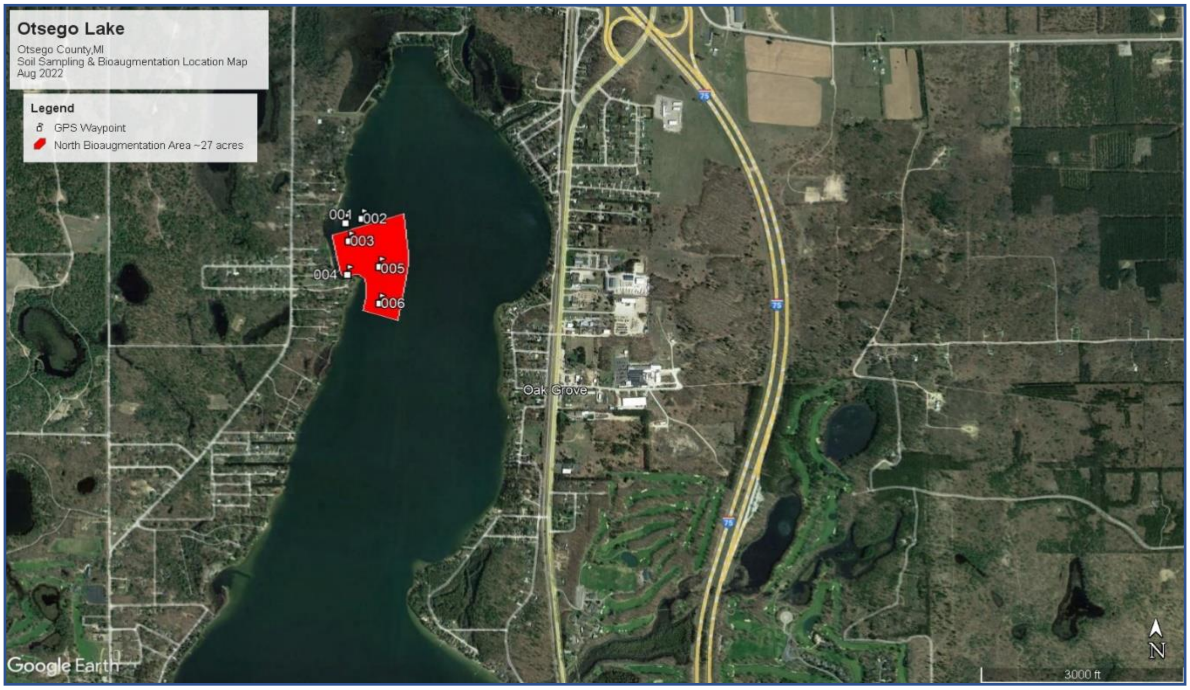


Figure 32. North Otsego Lake muck pellet application area as determined by sediment organic matter data (September, 2023).

Figure 33. South Otsego Lake muck pellet application areas as determined by sediment organic matter data (September, 2023).

Table 16: Organic matter sample values for North Bay samples taken May 23, 2024.

Sample ID	GPS Point	% By Weight
24-110	Sed 7	14
24-111	Sed 8	14
24-112	Sed 9	38
24-113	Sed 10	36
24-114	Sed 11	54
24-115	Sed 12	67
24-116	Sed 13	59
24-117	Sed 14	73
24-118	Sed 15	68
24-119	Sed 16	<0.010

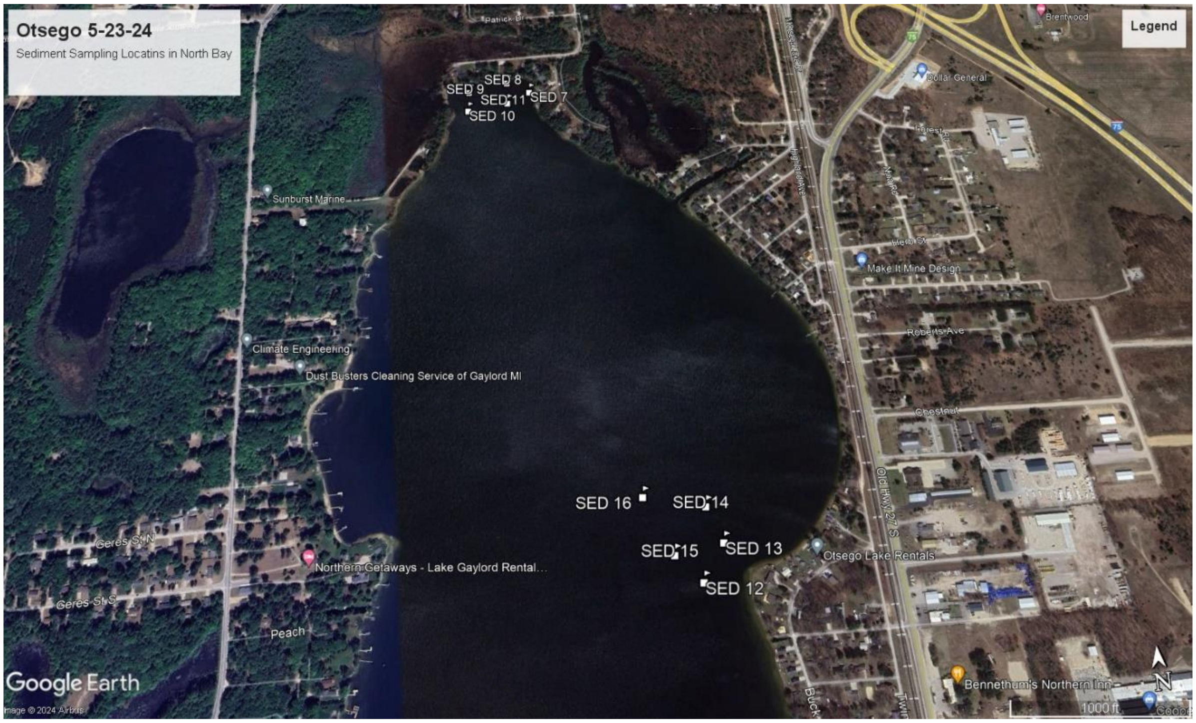


Figure 34: Sediment sampling locations in North Bay during the 2024 survey season. The 5 areas to the South East of North Bay could potentially benefit from treatment if desired.

7.0 OTSEGO LAKE 2023 CONCLUSIONS AND 2024 MANAGEMENT RECOMMENDATIONS

Otsego Lake is facing significant issues that degrade water quality, including inputs of nutrients from septic systems and significant shoreline erosion which leads to a decline in lake health over time. Additionally, invasive species such as Eurasian Watermilfoil (EWM), Curly-leaf Pondweed (CLP), and Starry Stonewort are located in the lake with the latter two previously present in the south region and canal region of the lake. These invasives pose a serious risk to the native aquatic plant biodiversity and recreational activities in the lake. Protection of the high biodiversity of native aquatic plants is essential for lake health, especially given the low relative abundance of most native aquatic plant species. **Here are the key conclusions and recommendations for successful management of Otsego Lake in 2025:**

1. Management of invasive species would be best achieved with aquatic herbicides but could be removed on a smaller scale with DASH technology. EGLE permits treatment of invasive EWM, CLP, and Starry Stonewort with aquatic herbicides**. In 2024, there were approximately 4.8 acres of EWM, 0 acres of CLP, and 0 acres of Starry Stonewort. RLS recommends spot-treating the EWM with the systemic herbicide ProcellaCOR® as this was used in 2024 with good results.** The product types and doses should rotate each year to lessen the occurrence of herbicide tolerance by EWM in Otsego Lake. **The 2025 spring survey will also confirm the efficacy of the ProcellaCOR® treatment if the milfoil does not overwinter.**

2. **Beginning in late spring 2025, an independent professional limnologist/aquatic botanist at RLS will perform regular GPS-guided whole-lake surveys to monitor the growth and distribution of all invasives prior to and after all treatments to determine treatment efficacy.** Continuous monitoring of the lake for potential influxes of other exotic aquatic plant genera (i.e., *Hydrilla*) that could also significantly disrupt the ecological stability of Otsego Lake is critical.

3. **In 2025, the lake manager should oversee all management activities and would be responsible for the creation of aquatic plant management survey maps, direction of the applicators to target-specific areas of aquatic vegetation for removal and reviewing all contractor invoices for accuracy.**

4. In 2025, water quality monitoring of the three deep basins will be conducted to evaluate long-term trends with trend analyses. The water quality parameters measured include physical parameters such as water temperature, dissolved oxygen, pH, conductivity, Secchi transparency, and total dissolved solids. In addition, chemical water quality parameters such as total phosphorus (TP), total Kjeldahl nitrogen (TKN), and chlorophyll-a. RLS will have enough data after 2025 to generate trend graphs for key water quality parameters. **The overall water quality of Otsego Lake is good with low nutrients and moderate clarity.**

5. **The determination of efficacy from the bioaugmentation treatment on Otsego muck reduction was evaluated in 2024 and preliminary lake sediment hardness scans are showing increased consolidation of sediments which is favorable.** There has also been a significant reduction in sediment organic carbon muck in the treatment area in 50% of the sampling locations, which is favorable. RLS recommends continued application of these microbes in that area or others where organic carbon is elevated but the cost to benefit should be considered relative to deeper areas that may not visibly show significant changes.

6. **In 2025, RLS will work with the OLA to form a Special Assessment District (SAD) for future improvements to improve water quality and reduce the presence and threats of invasive species.**

7. **RLS will continue to be involved with the education of riparians around Otsego Lake. This includes education on proper lakeside best management practices, septic system maintenance and innovative nutrient-reduction technologies such as the Sludge Hammer®, erosion control, and more.** During the lawn mowing phase, make sure to bag your clippings and return them to your local yard waste disposal site.

7.1 Proposed Cost Estimates for Otsego Lake Improvements

The proposed continued lake improvement and management program (Table 17) for Otsego Lake is discussed below along with a breakdown of estimated costs (Table 18) associated with the various proposed management items for Otsego Lake. It should be noted that proposed costs are estimates and may change in response to changes in environmental conditions (i.e., increases in aquatic plant growth or distribution, or changes in herbicide costs). Note that this table is adaptive and is likely to change. Any of these could be conducted during different years of a new or existing SAD program. However, it is highly recommended to perform all of these management methods as soon as possible. The annual cost will decline over time with the boat wash station, early detection rapid response protocol, and reductions in invasive aquatic plant species as well as shoreline erosion.

Table 17. Otsego Lake proposed improvement methods with primary and secondary goals and locations for implementation (2020-Present).

Proposed Improvement Method	**Primary Goal**	**Secondary Goal**	**Where to Implement**	**Current Action Status**
Maintenance program for septic systems	To reduce nutrients inputs from septic systems	To improve water quality parameters- especially lake bottom nutrients	Lake-wide	To be implemented in SAD
Spot-treatment with systemic herbicides for control of EWM and contacts for CLP and SS	Systemically reduce EWM throughout lake and reduce other invasives	Use less herbicide over time for all invasives	Entire lake where invasive EWM, CLP, SS are present	Ongoing; SAD
Bi-annual water quality monitoring of lake	Monitor lake health over time	Use long-term and current data to drive management decisions relative to BMP's	Lake deep basins (n=3)	Ongoing; SAD
Development of Early Detection Rapid Response Protocol for new invasives	Generate a clear strategy for dealing with new invasives that may be found in the lake	Allow for less long-term spread of any new invasives with early detection	Entire lake	Ongoing; SAD
Shoreline Erosion Control Assessment (site-specific)	To reduce erosion around the lake	To protect and improve water quality	Entire shoreline—impaired areas found	Ongoing; SAD

Boat launch washing stations	To reduce entry of invasives into Otsego Lake	To reduce exit of invasives from Otsego Lake	At public access site noted in this report.	SAD
Annual lake surveys pre- and post-treatment	To determine efficacy of all treatments on invasives and nuisance plants	To determine ability of native aquatic vegetation biodiversity to recover post-management implementation	Entire lake	Ongoing; SAD
Independent and objective oversight of lake treatments or other contractor work	To objectively evaluate treatments for optimum science and future costs	To work with applicators or contractors for optimum lake management solutions	Through treatment season	Ongoing; SAD
Riparian/Community Education	To raise awareness of lake issues and empower all to participate in lake protection	Long-term sustainability requires ongoing awareness and action	Entire lake community and those who frequent the lake; may also include other relevant stakeholders	Ongoing; SAD

Table 18. Otsego Lake proposed lake management program costs. Note: These items could be implemented over a period of years with professional services and treatment of invasives recommended on an annual basis.

Proposed Otsego Lake Improvement Item	Estimated Itemized Costs
[1]Treatments for EWM and CLP (Systemic herbicides used for EWM and contact herbicides for CLP and Starry Stonewort); NOTE: Future EWM or SS could be removed with DASH once acreage is reduced	$8,000
[2]Professional services (limnologist management of lake, aquatic vegetation surveys, deep basin water quality sampling, oversight of treatments, education, continued development of Rapid Response Protocol, annual professional report)	$18,000
[3]SAD formation and assistance with TWPs (includes RLS staff plus additional funds from TWP attorneys, admin, TWP staff)	~$30,500
[4]Boat washing station-solar	~$34,000
[5]Erosion Control site-specific recommendations/cost report for all problem areas (RLS)	$18,500
[6]Contingency	$10,900
Total Estimated Cost of all Items	$119,900

[1] This cost is based on an evaluation of previous and current treatments and possible need for higher systemic herbicide doses in the future to adequately control hybrid EWM and Starry Stonewort.

[2] This cost would include all annual professional consulting deliverables from RLS that would include aquatic plant surveys, follow-up surveys, treatment oversights, deep basin water quality sampling, riparian education, development of rapid response protocol, data analysis, professional annual report, and attendance at up to 2 lake Association meetings.

[3] This cost is an estimate to create the SAD and would include maps, working with RLS, the TWPs and the TWP attorneys.

[4] This cost includes signage and solar-powered boat washing stations (e.g., CD3 units)

[5] This cost would include site-specific recommendations and costs for erosion control of observed areas noted during the 2020 evaluation. This would produce a guidebook of the individual sites with recommendations for erosion control and approximate costs.

[6] Contingency is 10% of total project cost as required by PA 188.

8.0 SCIENTIFIC REFERENCES

Aiken, S.G., P.R. Newroth, and I. Wile. 1979. The biology of Canadian weeds. 34. *Myriophyllum spicatum* L. *Canadian Journal of Aquatic Plant Science* 59: 201-215.

Blackburn, R.D., L.W. Weldon, R.R. Yeo, and T.M. Taylor. 1969. Identification and distribution of certain similar-appearing submersed aquatic weeds in Florida. *Hyacinth Control Journal* 8:17-23.

Couch, R., and E. Nelson 1985. *Myriophyllum spicatum* in North America. Pp. 8-18. In: Proc. First Int. Symp. On Watermilfoil (*M. spicatum*) and related Haloragaceae species. July 23-24, 1985. Vancouver, BC, Canada. Aquatic Plant Management Society, Inc.

Eiswerth, M.E., S.G. Donaldson, and W.S. Johnson. 2000. Potential environmental impacts and economic damages of Eurasian Watermilfoil (*M. spicatum*) in Western Nevada and Northeastern California. *Weed Technology* 14(3):511-518.

Halstead, J.M., J. Michaud, and S, Hallas-Burt. 2003. Hedonic analysis of effects of a non-native invader (*Myriophyllum heterophyllum*) on New Hampshire (USA) lakefront properties. *Environmental Management* 30 (3): 391-398.

Henderson, C.L., C. Dindorf, and F. Rozumalski. 1998. Lakescaping for Wildlife and Water Quality. Minnesota Department of Natural Resources, 176 pgs.

Herrick, B.M., and Wolf, A.T. 2005. Invasive plant species in diked vs. undiked Great Lakes wetlands. *Journal of Great Lakes Research*., Internat. Assoc. Great. Lakes. Res. 31(3): 277-287.

Holland, R.E. 1993. Changes in planktonic diatoms and water transparency in Hatchery Bay, Bass Island Area, Western Lake Erie since the establishment of the zebra mussel, *Journal of Great Lakes Research* 19:617-624.

Lillie, R.A., and J. Budd. 1992. Habitat architecture of *Myriophyllum spicatum* L. as an Index to habitat quality for fish and macroinvertebrates. *Journal of Freshwater Ecology* 7(2): 113-125.

Lyons, J. 1989. Changes in the abundance of small littoral-zone fishes in Lake Mendota, Wisconsin. *Canadian Journal of Zoology* 67:2910-2916, 10.1139/z89-412

Madsen, J.D., J.W. Sutherland, J.A. Bloomfield, L.W. Eichler, and C.W. Boylen. 1991. The decline of native vegetation under dense Eurasian watermilfoil canopies, *Journal of Aquatic Plant Management* 29, 94-99.

Michigan Department of Natural Resources, 2009. Otsego Lake Report 2009-71.

Newroth, P.R. 1985. A review of Eurasian watermilfoil impacts and management in British Columbia. Pp. 139-153. In: Proc. First Int. Symp. On watermilfoil (*M. spicatum*) and related Haloragaceae species. July 23-24, 1985. Vancouver, BC, Canada. Aquatic Plant Management Society, Inc.

Reed, C.G. 1977. History and disturbance of Eurasian milfoil in the United States and Canada. *Phytologia* 36: 417-436.

University of Michigan Biological Station, 1980. A Water quality survey of Otsego Lake, Michigan. Technical Report No. 10. 72 pgs.

Wetzel, R. G. 2001. Limnology: Lake and River Ecosystems. Third Edition. Academic Press, 1006 pgs.