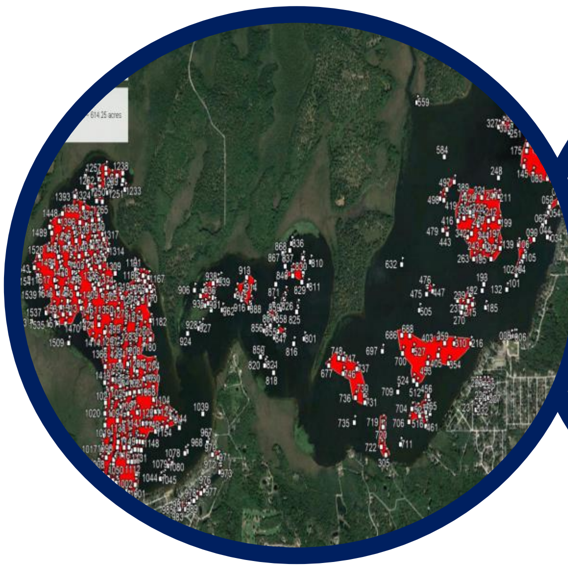
Lake St. Helen Aquatic Vegetation Management Plan with Professional Management Recommendations Roscommon County, Michigan



Provided for: Lake St. Helen Association Board

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1.0 EXECUTIVE SUMMARY

Lake St. Helen is a 2,487.2-acre lake located in Richfield Township in Roscommon County, Michigan (T.22-23N, R1W). The lake has approximately 16.6 miles of shoreline (including the lake canals and up to the marsh lines) and a mean depth of approximately 4.8 ft (Restorative Lake Sciences, 2022). The lake water volume was estimated at 10,573.9 acre-feet (Restorative Lake Sciences, 2022) and the maximum depth was recorded at 24.2 feet. The fetch (longest distance across the lake) was determined to be 2.3 miles at the east end and 1.6 miles at the west end (Restorative Lake Sciences, 2022). The lake is divided into three contiguous basins and Restorative Lake Sciences refers to them as west (Third Lake), central (Middle Lake), and east (First Lake) basins. The east (First Lake) basin is the deepest. Three major inflows (tributaries) enter the lake and includes Russell Creek, Carter Creek, and Marsh Creek. Lake St. Helen has an outlet at the south branch of the Au Sable River which empties into Lake Huron. There is a lake level control structure (dam) that was constructed in 1930 that is located downstream of the lake on the river. There are summer and winter legal lake levels set at 1,155.3 ft above mean sea level, and 1,154.8 ft above mean sea level, respectively. These are enforced during ice-free months.

A whole-lake aquatic plant survey and scan of aquatic vegetation biovolume was conducted on July 26-29, 2022. The lake scan consisted of 43,569 GPS points and the aquatic vegetation sampling survey utilized 1,555 GPS points in the lake. Based on this data, Lake St. Helen contains 20 native submersed, 4 native floating-leaved, and 7 native emergent aquatic plant species. This represents a very high and healthy biodiversity of native aquatic plants with 31 native aquatic plant species. The most dominant native aquatic plants were the submersed Fern-leaf Pondweed and Wild Celery. There were 4 exotic invasive species found and included Eurasian Watermilfoil (EWM), Curly-leaf Pondweed (CLP), Starry Stonewort (SS), and Purple Loosestrife. Approximately 614.3 acres of Eurasian watermilfoil were found, and 17.3 acres of invasive Starry Stonewort were found. There were only two locations where Purple Loosestrife were found and a small patch of Curly-leaf Pondweed.

Management recommendations are included later in this report but the recommended use of herbicides on Curly-leaf Pondweed and Purple Loosestrife are not recommended due to low cover. The Eurasian Watermilfoil and Starry Stonewort must be urgently addressed to reduce their relative cover and protect the numerous native aquatic plant species in the lake. There has been a 33% increase in EWM cover since the last significant lake survey, but the native aquatic plant biodiversity is similar.

The following conclusions and recommendations can be made based on this evaluation:

1. Protect the robust and healthy native aquatic plant biodiversity in the lake.
2. Reduce invasive species such as Eurasian Watermilfoil and Starry Stonewort.
3. Although Curly-leaf Pondweed is an invasive aquatic plant, it will not likely take over the lake as there are so many other native pondweeds that are successfully outcompeting the Curly-leaf Pondweed.
4. Purple Loosestrife can be hand-removed without the use of herbicides were it is found. The roots must be removed with a shovel and all of the plant discarded.
5. A few areas of shoreline erosion were found during the survey. Areas such as these contribute soils and nutrients to the lake and should be stabilized as soon as possible. A future inventory for this parameter is recommended. This is to protect the good water quality of the lake over time.
6. A licensed aquatic herbicide applicator should be retained for treatments beginning in 2023. To avoid any conflicts of interest, an independent consulting limnologist (Restorative Lake Sciences) should be retained to oversee all lake treatments and make objective treatment recommendations.
7. In nearshore areas, especially beaches, the use of benthic mats and weed rollers can reduce aquatic plant germination and growth without the use of chemicals.
8. The use of aquatic herbicides should be limited to ONLY areas of invasive aquatic plant growth and due to the large cover of Eurasian Watermilfoil, not all areas should be treated at one time. This could stress the lake fishery which is a very critical component of the Lake St. Helen ecosystem.
9. Consider future purchase of a boat washing station when the invasives are reduced. The systems are costly (usually around $30,000 per unit) but are worth the investment. Periodic grants are available.

The overall water quality of Lake St. Helen was measured as good with moderate nutrients such as phosphorus and nitrogen and fair water clarity with elevated chlorophyll-*a* concentrations. The pH of the lake indicates that it is a neutral lake. The specific conductivity and total dissolved solids were both low and favorable. Often, this is due to the position of the lake in more rural areas.

Restorative Lake Sciences recommends an annual whole-lake GPS survey and scan to determine the relative abundance of all native and invasive aquatic plant species, their relative abundance, and the percent cover of the lake surface area as well as follow up surveys in key areas. This data will be used each year to make management decisions about where to treat and what method(s) to use as these may change with time and results. Survey data can also be used to determine treatment efficacy.

Restorative Lake Sciences recommends continued education of lake riparians on nutrient reduction to the lake and lake protection Best Management Practices (BMP's) such as proper shoreline stewardship and protection of the immediate watershed surrounding the lake.

2.0 LAKE ECOLOGY BACKGROUND INFORMATION

2.1 Introductory Concepts

Limnology is a multi-disciplinary field which involves the study of the biological, chemical, and physical properties of freshwater ecosystems. A basic knowledge of these processes is necessary to understand the complexities involved and how management techniques are applicable to current lake issues. The following terms will provide the reader with a more thorough understanding of the forthcoming lake management recommendations for Lake St. Helen. The purpose of this study and report is to evaluate the current aquatic vegetation communities in the lake as they relate to water quality and to provide scientifically-sound and affordable management options to the Lake St. Helen community.

2.1.1 Lake Hydrology

Aquatic ecosystems include rivers, streams, ponds, lakes, and the Laurentian Great Lakes. There are thousands of lakes in the states, and each possesses unique ecological functions and socio-economic contributions (O'Neil and Soulliere 2006). In general, lakes are divided into four categories:

- Seepage Lakes,
- Drainage Lakes,
- Spring-Fed Lakes, and
- Drained Lakes.

Some lakes (seepage lakes) contain closed basins and lack inlets and outlets, relying solely on precipitation or groundwater for a water source. Seepage lakes generally have small watersheds with long hydraulic retention times which render them sensitive to pollutants. Drainage lakes receive significant water quantities from tributaries and rivers. Drainage lakes contain at least one inlet and an outlet and generally are confined within larger watersheds with shorter hydraulic retention times. As a result, they are less susceptible to pollution. Spring-fed lakes rarely contain an inlet but always have an outlet with considerable flow. The majority of water in this lake type originates from groundwater and is associated with a short hydraulic retention time. Drained lakes are similar to seepage lakes, yet rarely contain an inlet and have a low-flow outlet. The groundwater and seepage from surrounding wetlands supply the majority of water to this lake type and the hydraulic retention times are rather high, making these lakes relatively more vulnerable to pollutants. The water quality of a lake may thus be influenced by the quality of both groundwater and precipitation, along with other internal and external physical, chemical, and biological processes. **Lake St. Helen may be categorized as a drainage lake with springs as it receives external water supplies from three major inflows, contains some springs, and has an outlet with a dam. The inflows include Russell Creek, Carter Creek, and Marsh Creek. Lake St. Helen has an outlet at the south branch of the Au Sable River which empties into Lake Huron.**

2.1.2 Lake Eutrophication

All inland lakes experience some degree of lake aging. This process occurs when nutrients such as phosphorus and nitrogen are introduced to a lake and cause accelerated aquatic vegetation and algae growth. Over time, the lake basin becomes shallower and organic material accumulates on the lake bottom. This organic material serves as a nutrient-rich substrate for further primary production in the form of vegetation and algae growth. Shallow, small lakes and canals are most vulnerable to this natural process due to less depth and probability of accumulation. Shallow waters also have warmer water temperatures, and this creates an ideal environment for aquatic vegetation and algae growth. The largest threat to inland lakes is the accelerated lake ageing “eutrophication” from land use activities such as agriculture, urban runoff, and failing septic systems. Millions of dollars are spent annually in Michigan alone to counteract the effects of lake eutrophication in order to gain full property value benefits and improve recreation and lake fisheries. Figure 1 shows this gradual process of eutrophication. **The shallow mean depth of Lake St. Helen makes it quite vulnerable to eutrophication.**

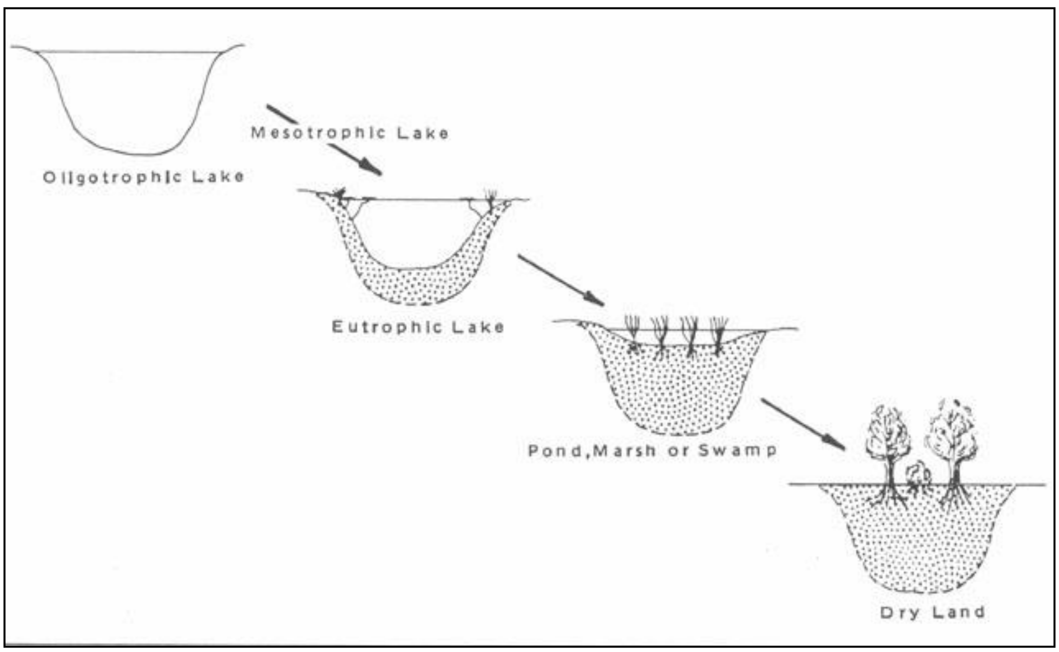

Figure 1. A diagram showing the lake aging (eutrophication) process.

2.1.3 Biodiversity and Habitat

A healthy aquatic ecosystem possesses a variety and abundance of niches (environmental habitats) available for all of its inhabitants. The distribution and abundance of preferable habitat depends on limiting man’s influence from man and development, while preserving sensitive or rare habitats. As a result of this, undisturbed or protected areas generally contain a greater number of biological species and are considered more diverse.

A highly diverse aquatic ecosystem is preferred over one with less diversity because it allows a particular ecosystem to possess a greater number of functions and contribute to both the intrinsic and socio-economic values of the lake. Healthy lakes have a greater biodiversity of aquatic macroinvertebrates, aquatic macrophytes (plants), fishes, zooplankton, phytoplankton, and may possess a plentiful yet beneficial benthic microbial community (Wetzel, 2001). **Lake St. Helen has a very high biodiversity, and one major goal should be to maintain this biodiversity while reducing invasive aquatic plant species with very targeted treatments.**

2.1.4 Watersheds and Land Use

A watershed is defined as an area of land that drains to a common point. It is influenced by both surface water and groundwater resources that are often impacted by land use activities. In general, larger watersheds possess more opportunities for pollutants to enter the ecosystem, altering the water quality and ecological communities. In addition, watersheds that contain abundant development and industrial sites are more vulnerable to water quality degradation since from pollution which may negatively affect both surface and ground water. Since many inland lakes in Michigan are relatively small in size (i.e., less than 300 acres), they are inherently vulnerable to nutrient and pollutant inputs, due to the reduced water volumes and small surface areas. As a result, the living (biotic) components of the smaller lakes (i.e., fishery, aquatic plants, macro-invertebrates, benthic organisms, etc.) are highly sensitive to changes in water quality from watershed influences. Land use activities have a dramatic impact on the quality of surface waters and groundwater.

In addition, the topography of the land surrounding a lake may make it vulnerable to nutrient inputs and consequential loading over time. Topography and the morphometry of a lake dictate the ultimate fate and transport of pollutants and nutrients entering the lake. Surface runoff from the steep slopes surrounding a lake will enter a lake more readily than runoff from land surfaces at or near the same grade as the lake. In addition, lakes with steep drop-offs may act as collection basins for the substances that are transported to the lake from the land.

All land uses contribute to the water quality of the lake through the influx of pollutants from non-point and point sources. Non-point sources are often diffuse and arise when climatic events carry pollutants from the land into the lake. Point-source pollutants are discharged from a pipe or input device and empty directly into a lake or watercourse. Activities, such as residential land use, industrial land use, agricultural land use, water supply land use, wastewater treatment land use, and storm water management, influence the watershed of a particular lake. **Residential land use activities involve the use of lawn fertilizers on lakefront lawns, the utilization of septic tank systems for treatment of residential sewage, the construction of impervious (impermeable, hard-surfaced) surfaces on lands within the watershed, the burning of leaves near the lakeshore, the dumping of leaves or other pollutants into storm drains, and removal of vegetation from the land and near the water.**

In addition to residential land use activities, agricultural practices by vegetable crop and cattle farmers may contribute nutrient loads to lakes and streams. Industrial land use activities may include possible contamination of groundwater through discharges of chemical pollutants.

3.0 LAKE ST. HELEN PHYSICAL CHARACTERISTICS

3.1 The Lake St. Helen Basin

Lake St. Helen is a 2,487.2-acre lake located in Richfield Township in Roscommon County, Michigan (T.22-23N, R1W). The lake has approximately 16.6 miles of shoreline (including the lake canals and up to the marsh lines)and a mean depth of approximately 4.8 ft (Restorative Lake Sciences, 2022; Figure 2). The lake water volume was estimated at 10,573.9 acre-feet (Restorative Lake Sciences, 2022) and the maximum depth was recorded at 24.2 feet. The fetch (longest distance across the lake) was determined to be 2.3 miles at the east end and 1.6 miles at the west end (Restorative Lake Sciences, 2022). The lake is divided into three contiguous basins and Restorative Lake Sciences refers to them as west (Third Lake), central (Middle Lake), and east (First Lake) basins. The east (First Lake) basin is the deepest. Three major inflows (tributaries) enter the lake which includes Russell Creek, Carter Creek, and Marsh Creek. Lake St. Helen has an outlet at the south branch of the Au Sable River which empties into Lake Huron. There is a lake level control structure (dam) that was constructed in 1930 that is located downstream of the lake on the river. There are summer and winter legal lake levels set at 1,155.3 ft above mean sea level, and 1,154.8 ft above mean sea level, respectively. These levels are enforced during ice-free months.

The lake is classified as a meso-eutrophic (moderately nutrient-enriched) aquatic ecosystem with a large-sized littoral (shallow) zone that supports rigorous submersed rooted, aquatic plant growth. A whole-lake sediment bottom hardness scan (Figure 3; Table 1) revealed that most of the sediment on the lake bottom hardness is organic with sand deposits nearshore.

Table 1. Lake St. Helen relative hardness of the lake bottom by category or hardness and percent over of each category (relative cover).

Lake Bottom Relative Hardness Category	# GPS Points in Each Category (Total =43,569)	% Relative Cover of Bottom by Category
0.0-0.1	648	1.5
0.1-0.2	9,491	21.8
0.2-0.3	20,944	48.1
0.3-0.4	12,087	27.7
>0.4	399	0.9

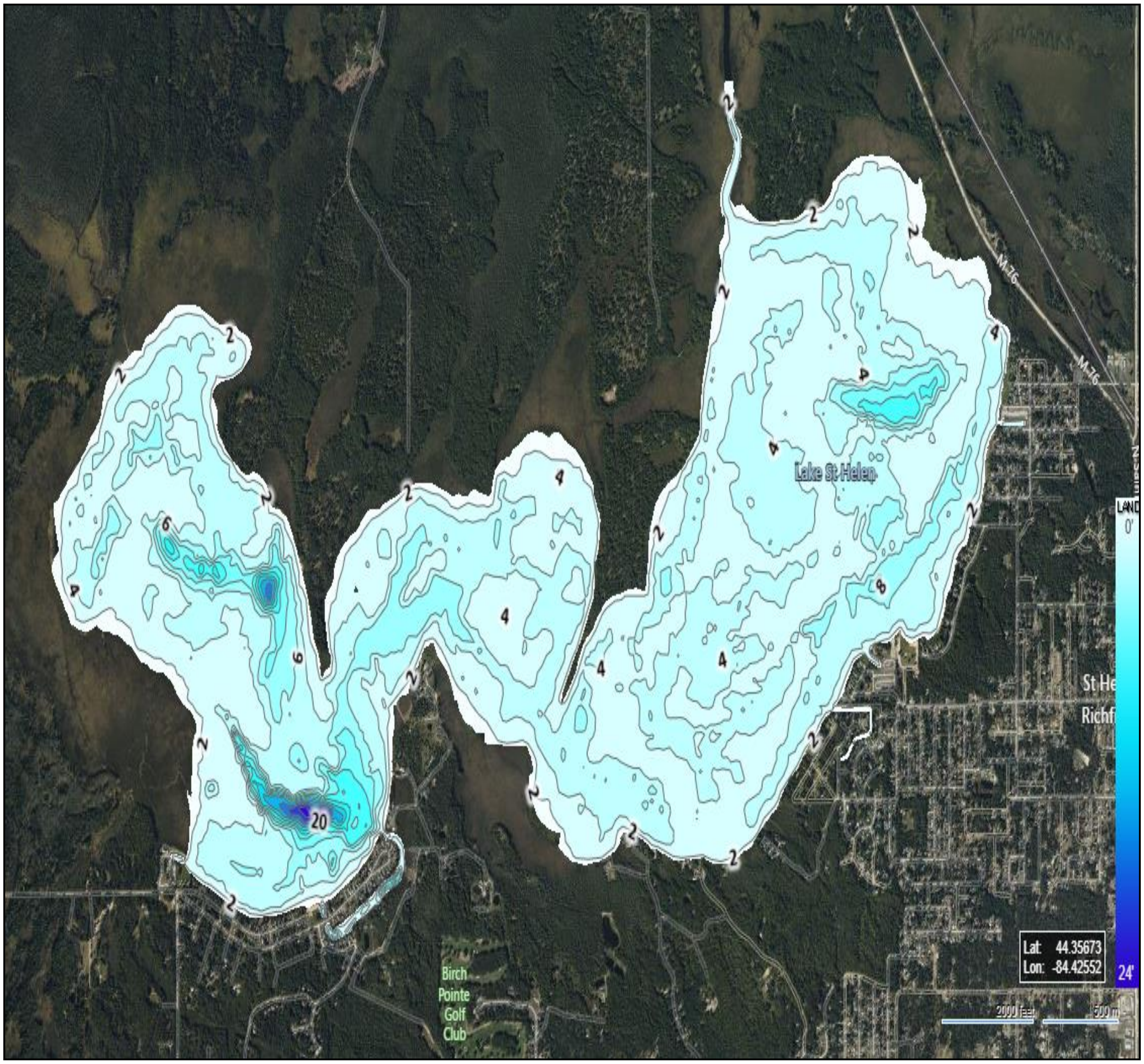

Figure 2. Lake St. Helen Depth Contour Map, Roscommon County, Michigan (RLS, 2022).

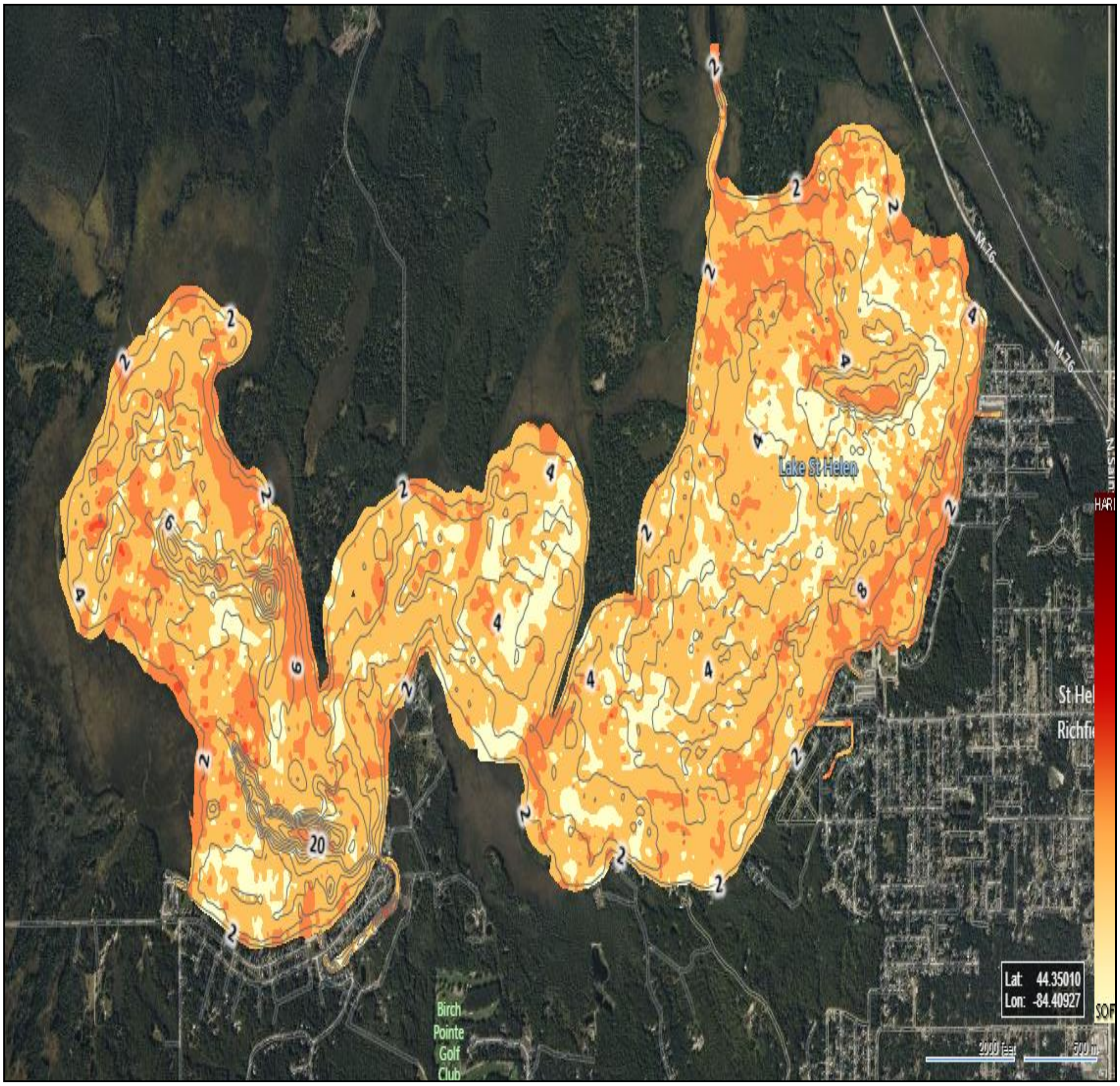

Figure 3. Lake St. Helen sediment bottom hardness scan map (RLS, 2022). Note: On this map of relative bottom hardness, areas with firmer more consolidated sediments appear as dark orange whereas areas with soft bottom appear as light beige in color.

4.0 LAKE ST. HELEN 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 each lake is affected by geology, 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. **Lake St. Helen is classified as meso-eutrophic which means it contains moderate nutrient concentrations.**

Table 2. Lake Trophic Status Classification Table

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

4.1 Water Quality Parameters

Parameters such as, but not limited to, dissolved oxygen, water temperature, conductivity, total dissolved solids, pH, total phosphorus total Kjeldahl nitrogen, chlorophyll-*a*, and Secchi transparency, are critical indicators of water quality. On July 29, 2022, Restorative Lake Sciences collected water samples from within 3 deep basins in Lake St. Helen. The results are discussed below and are presented in Tables 3-5. A map showing the sampling locations for all water quality samples collected from the deep basins is shown below in Figure 4. All water samples and readings were collected on July 29, 2022 with the use of a Van Dorn horizontal water sampler and calibrated Eureka Manta II® multi-meter probe with parameter electrodes, respectively. Chlorophyll-*a* was measured *in situ* with a calibrated chlorophyll-*a* meter from Turner Designs®. All other water quality samples were analyzed at NELAC-certified Trace Analytical Laboratories in Muskegon, Michigan.

Figure 4. Locations for water quality sampling of the 3 basins in Lake St. Helen (July 29, 2022). NOTE: West (Third Lake), Central (Middle Lake), and East (First Lake).

4.1.1 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^{-1} to sustain a healthy warm-water fishery. 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^{-1}) with the use of a calibrated Eureka Manta II® dissolved oxygen meter. During the summer months, dissolved oxygen at the surface is generally higher due to the exchange of oxygen from the atmosphere with the lake surface, whereas dissolved oxygen is lower at the lake bottom due to decreased contact with the atmosphere and increased biochemical oxygen demand (BOD) from microbial activity.

Dissolved oxygen concentrations during the July 29, 2022 sampling event ranged from 8.4-8.7 mg L^{-1}, with concentrations of dissolved oxygen higher at the surface and slightly lower at the bottom.

4.1.2 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". 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 29, 2022 water temperatures of Lake St. Helen demonstrated the lack of a thermocline in the deep basins and ranged from a low of 21.9°-22.9°C. This is a favorable water temperature given the time of year when many shallow lakes can exceed water temperatures of 25°C.**

4.1.3 Specific Conductivity

Specific conductivity is a measure of the amount of mineral ions present in the water, especially those of salts and other dissolved inorganic substances. It increases under anoxic (low dissolved oxygen) conditions. Conductivity generally increases with the amount of dissolved minerals and salts in a lake. Specific conductivity was measured in micro Siemens per centimeter (µS cm^{-1}) with the use of a calibrated Eureka Manta II® conductivity probe meter. **The specific conductivity for Lake St. Helen deep basins ranged from 186-253 mS cm^{-1} during the July 29, 2022 sampling event.**

These values are moderately low for an inland lake and favorable. Baseline parameter data such as conductivity are important to measure the possible influences of land use activities (i.e. road salt influences) on Lake St. Helen over a long period of time, or to trace the origin of a substance to the lake in an effort to reduce pollutant loading.

4.1.4 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. TDS was measured with the use of a calibrated Eureka Manta II® TDS probe in mg L^{-1}. Spring values are usually higher due to increased watershed inputs from spring runoff and/or increased planktonic algal communities. **The TDS in Lake St. Helen ranged from 119-154 mg L^{-1} for the deep basins on July 29, 2023, which is favorable. The preferred range for TDS in surface waters is between 0-1,000 mg L^{-1}.**

4.1.5 pH

pH is the measure of acidity or alkalinity 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 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 changes on a daily basis due to changes in aquatic plant photosynthesis which actively grow during the daytime and respire at night. Generally speaking, the pH is usually lower in the hypolimnion (bottom depths) of a lake. **The pH of Lake St. Helen ranged from 8.2-8.4 S.U. during the July 29, 2022 sampling event. This range is ideal for an inland lake.**

4.1.6 Total Kjeldahl Nitrogen

Total Inorganic Nitrogen (TKN) is the sum of nitrate (NO_3^-), nitrite (NO_2^-), ammonia (NH_4^+) nitrogen and organic nitrogen forms in freshwater systems. TIN was analyzed in the laboratory with Method EPA 300. Rev 2.1 and Method EPA 350.1, 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 ground 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. **The TKN concentrations in Lake St. Helen during the July 29, 2022 sampling event ranged from 0.6-0.8 mg L^{-1}, which is moderately low for an inland lake.**

4.1.7 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.

TP is measured in the laboratory with Method 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 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 the laboratory in micrograms per liter (µg L^{-1}) with the use of a chemical auto analyzer and Method EPA 200.8, Rev. 5.4. **The TP concentrations in the deep basins of Lake St. Helen ranged from 13-19 µg L^{-1} on July 29, 2022. These concentrations are moderate and indicative of mesotrophic waters.**

4.1.8 Chlorophyll-a and Algae

Chlorophyll-*a* is a measure of the amount of green plant pigment present in the water, typically in the form of planktonic algae. High chlorophyll-*a* concentrations are indicative of nutrient-enriched lakes. Concentrations greater than 6 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* was measured in situ in micrograms per liter (µg L^{-1}) with the use of a calibrated Turner Designs® fluorimeter.

The chlorophyll-*a* concentrations in Lake St. Helen were determined by collecting composite samples of the algae throughout the water column at each of the 3 deep basin sites from just above the lake bottom to the lake surface. **The chlorophyll-*a* concentrations in the deep basins ranged from 3.0-4.0 µg L^{-1} on July 29, 2022.** These values indicate that planktonic algae are prominent in the water column. It is likely that these values are higher in the spring after spring runoff or in late summer when water temperatures increase and lead to the growth of algae in the water column (planktonic form) or on the surface (filamentous form).

4.1.9 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 (Figure 5). Secchi disk transparency is measured 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 are usually correlated with increased aquatic plant and algae growth and higher suspended solids. Eutrophic systems generally have Secchi disk transparency measurements less than 7.5 feet due to turbidity caused by excessive planktonic algae growth. Further, elevated phytoplankton and turbidity, also are associated with decreased Secchi transparency. **The Secchi transparency of Lake St. Helen ranged from 3.8-7.1 feet over the deep basins of Lake St. Helen during the July 29, 2022 sampling event.** This transparency is adequate to allow abundant growth of algae and aquatic plants in the majority of the littoral (shallow) zone of the lake and is likely higher when the water temperatures are cooler and less algae is present. Lake St. Helen contains a fair amount of tannins in the water which imparts a tea-color stain to the water. Tannins are a natural component of the lake being adjacent to large forests and wetlands. 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.

Figure 5. A Secchi disk

Table 3. Lake St. Helen water quality parameter data collected over Deep Basin 1 West (Third Lake) on July 29, 2022.

Depth m	*Water Temp °C*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*TDS mg L^{-1}*	*TP mg L^{-1}*	*TKN mg L^{-1}*	*Chl-a µg L^{-1}*	*Secchi ft.*
0	22.9	8.5	8.2	186	119	--	--	--	7.1
1.0	22.9	8.5	8.2	186	119	--	--	--	--
2.0	22.9	8.5	8.2	186	119	--	--	--	--
3.0	22.9	8.5	8.2	186	119	--	--	--	--
4.0	22.8	8.5	8.2	188	120	0.019	0.8	3.0	--
5.0	22.7	8.5	8.2	186	119	--	--	--	--
6.0	22.5	8.5	8.2	187	120	--	--	--	--
7.0	22.5	8.4	8.2	253	154	--	--	--	--

Table 4. Lake St. Helen water quality parameter data collected over Deep Basin 2 Central (Middle Lake) on July 29, 2022.

Depth m	*Water Temp °C*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*TDS mg L^{-1}*	*TP mg L^{-1}*	*TKN mg L^{-1}*	*Chl-a µg L^{-1}*	*Secchi ft.*
0	22.6	8.6	8.4	197	126	--	--	--	7.1
0.5	22.6	8.6	8.3	196	126	--	--	--	--
1.0	22.5	8.6	8.4	196	125	--	--	--	--
1.5	22.5	8.6	8.4	195	125	0.013	0.6	4.0	
2.0	22.5	8.6	8.4	194	124	--	--	--	
2.5	22.5	8.6	8.4	194	124	--	--	--	

Table 5. Lake St. Helen water quality parameter data collected over Deep Basin 3 East (First Lake) on July 29, 2022.

Depth m	*Water Temp °C*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*TDS mg L^{-1}*	*TP mg L^{-1}*	*TKN mg L^{-1}*	*Chl-a µg L^{-1}*	*Secchi ft.*
0	22.2	8.7	8.4	222	142	--	--	--	3.8
0.5	22.2	8.7	8.4	222	142	--	--	--	--
1.0	22.2	8.7	8.4	222	142	--	--	--	--
1.5	22.2	8.7	8.4	223	142	0.014	0.7	4.0	--
2.0	22.1	8.7	8.4	222	142	--	--	--	--
2.5	22.0	8.7	8.4	222	142	--	--	--	--
3.0	21.9	8.7	8.4	222	142	--	--	--	--

5.0 LAKE ST. HELEN AQUATIC VEGETATION COMMUNITIES

5.1 Overview of Aquatic Vegetation and the Role for Lake Health

The overall health of Lake St. Helen is strongly connected to the type and density of aquatic vegetation present in the lake. Aquatic plants (macrophytes) are an essential component in the littoral zones of most lakes in that they serve as 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. 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) 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., 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. Similarly, an overabundance of exotic aquatic plant species can also negatively impact native aquatic plant communities and create an unbalanced aquatic ecosystem. **The biodiversity present in Lake St. Helen is optimum and ideal for a healthy lake fishery, but it is being threatened by invasive aquatic plants.**

5.2 Aquatic Vegetation Sampling Methods

The aquatic plant sampling methods used for lake surveys of aquatic plant communities commonly consist of shoreline surveys, visual abundance surveys, transect surveys, AVAS surveys, and Point-Intercept Grid surveys. Such surveys are conducted on most inland lakes 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 and shallow mean depth of Lake St. Helen, a whole-lake GPS Point-Intercept grid matrix survey (Figure 6) was conducted from July 26-29, 2022 to assess all aquatic plants, including submersed, floating-leaved, and emergent species. **The lake scan consisted of 43,569 GPS points and the aquatic vegetation sampling survey utilized over 1,555 sampling points within the lake.** The lake bottom was scanned with the use of a side-scan sonar GPS device to scan the aquatic plant biovolume, bathymetric contours, and sediment bottom hardness of the lake (using a Lowrance® HDS 8 unit with BioBase® software). Figure 7 below shows the aquatic vegetation biovolume in Lake St. Helen. Table 6 below displays the actual aquatic vegetation biovolume data that corresponds to the map.

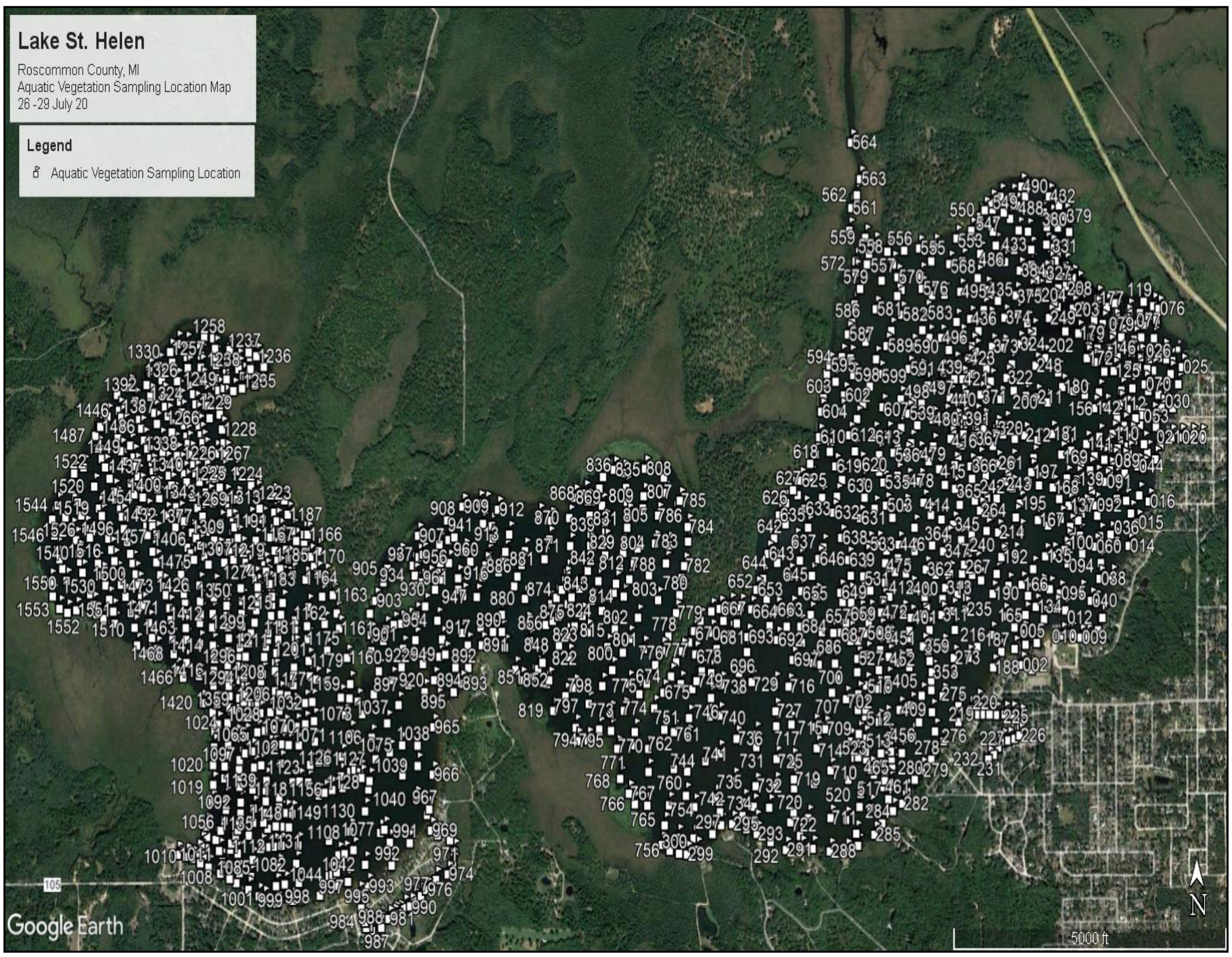

Figure 6. Aquatic vegetation sampling point locations in Lake St. Helen (July 26-29, 2022).

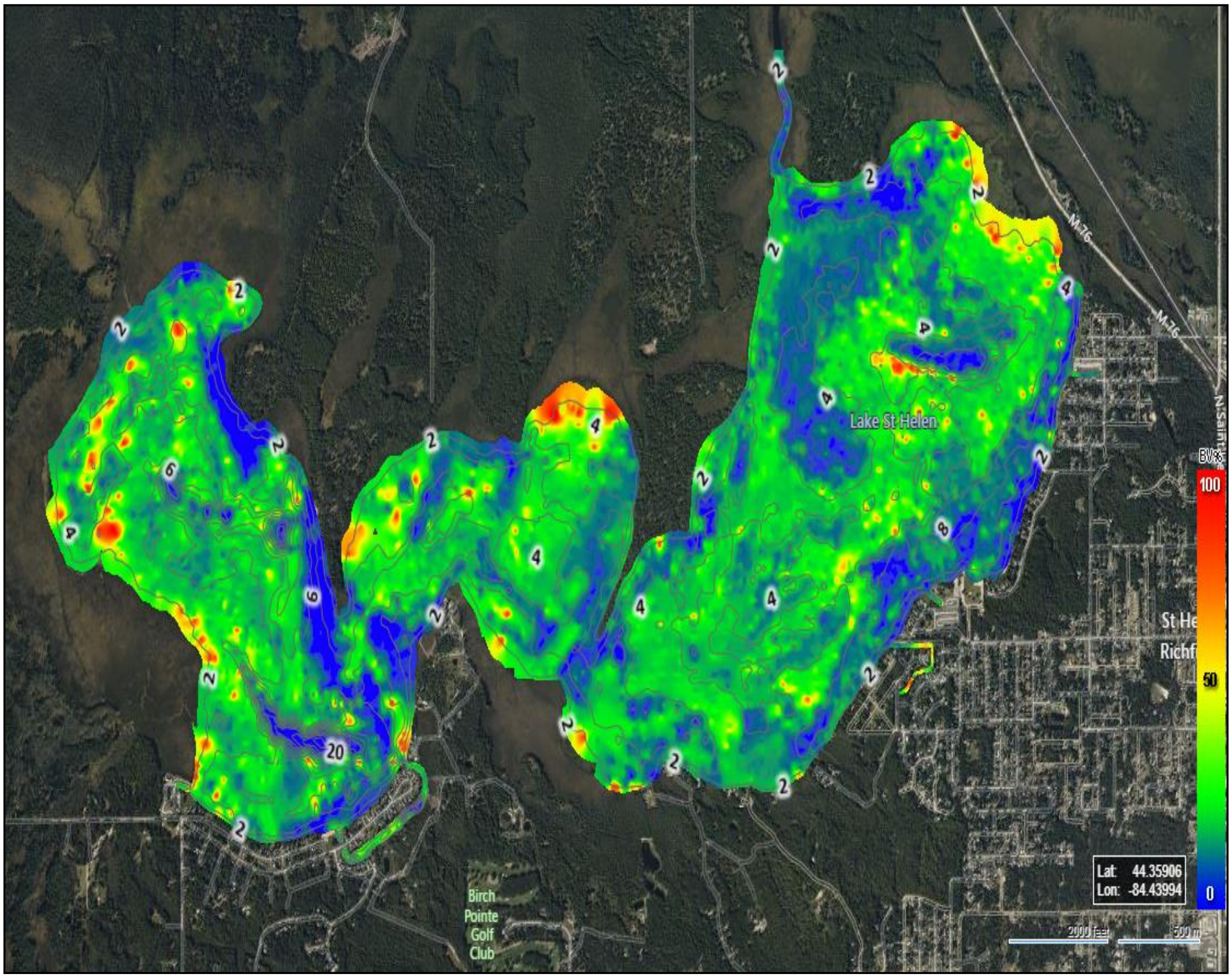

Figure 7. Aquatic vegetation biovolume scan map of Lake St. Helen (July 26-29, 2022). Note: The blue color represents areas that are not covered with aquatic vegetation. The green color represents low-growing aquatic vegetation, and the red colors represent high-growing aquatic vegetation. This scan does not differentiate between invasive and native aquatic vegetation biovolume which is why the GPS-point intercept survey is also executed in concert with the whole-lake scan.

Table 6. Lake St. Helen aquatic vegetation biovolume by category percent cover of each category (relative cover on July 26-29, 2022).

Biovolume Cover Category	% Relative Cover of Bottom by Category
0-20%	70.3
20-40%	23.8
40-60%	3.3
60-80%	0.3
>80%	2.3

5.3 Lake St. Helen Exotic Aquatic Macrophytes

Exotic aquatic plants (macrophytes) are not native to a particular site, but 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.

Exotic aquatic plants (macrophytes) are not native to a particular site, but 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 8) 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 (Figure 9) 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 614.3 acres of Eurasian Watermilfoil was found in Lake St. Helen during the July 26-29, 2022 survey (Figure 10) and an intensive management program is proposed below. Eurasian Watermilfoil growth in Lake St. Helen is capable of producing dense surface canopies in shallow areas. The species of invasive aquatic plants present, and relative abundance of each plant are recorded and then the amount of cover in the littoral zone is calculated.

Figure 8. Hybrid Eurasian Watermilfoil plant with seed head and fragments (©RLS).

Figure 9. Hybrid Eurasian Watermilfoil Canopy on an inland lake (©RLS).

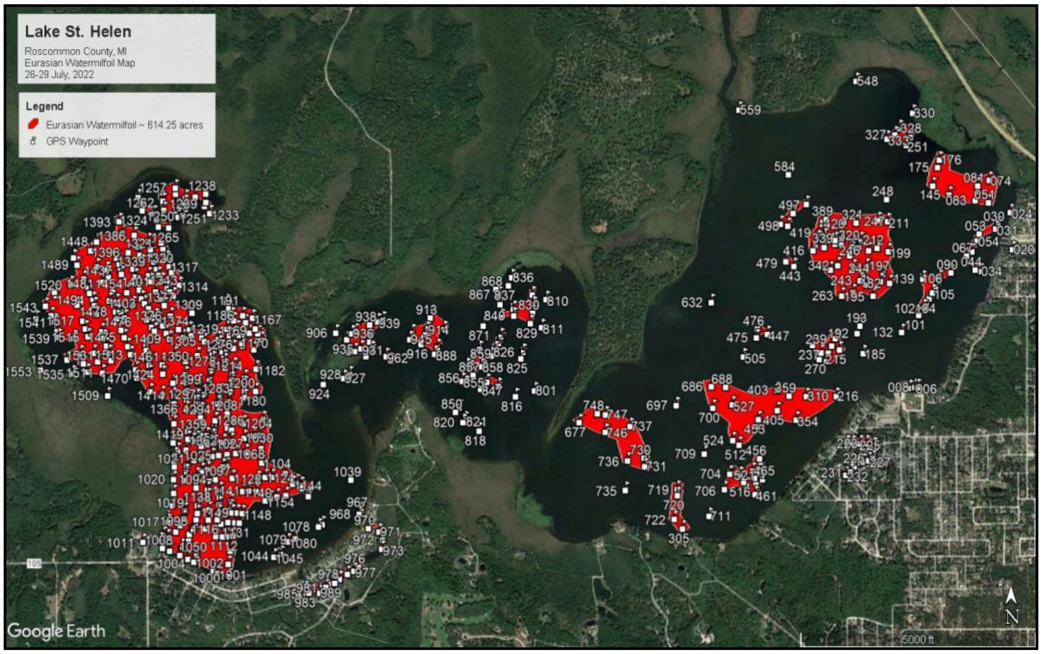

Figure 10. Eurasian Watermilfoil distribution in Lake St. Helen (July, 2022).

Curly-leaf Pondweed (*Potamogeton crispus*; Figure 11) 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. The plant does not reproduce by fragmentation as milfoil does; however, the turions may be deposited in the lake sediment and germinate in following seasons. Fortunately, the plant naturally declines around mid-July in most lakes and thus is not likely to be prolific throughout an entire growing season. **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. It was present in a small area of the lake and was not abundant at the time of the survey.**

Purple Loosestrife (*Lythrum salicaria*; Figure 12) is an imminent threat to the wetland habitat around the lake as it can rapidly displace native emergent aquatic plants. **This plant was found in two locations of the lake.**

Starry Stonewort (*Nitellopsis obtusa*; Figure 13) 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.**

These conditions make St. Helen Lake vulnerable to its growth. Approximately 17.3 acres were found throughout the lake, but this may change between surveys and years.

Maps showing the distribution of invasive Starry Stonewort, and Curly-leaf Pondweed and Purple Loosestrife in and around Lake St. Helen are shown below in Figures 14 and 15, respectively.

Figure 11. Curly-leaf Pondweed ©RLS

Figure 12. Purple Loosestrife ©RLS

Figure 13. Starry Stonewort ©RLS

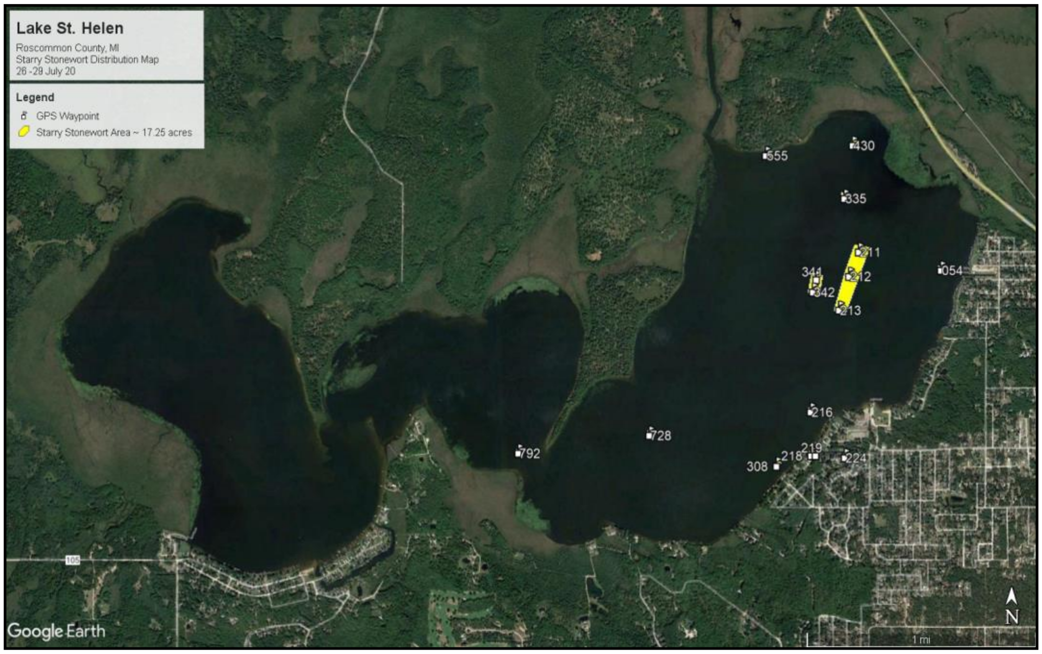

Figure 14. Starry Stonewort distribution in Lake St. Helen (July 26-29, 2022).

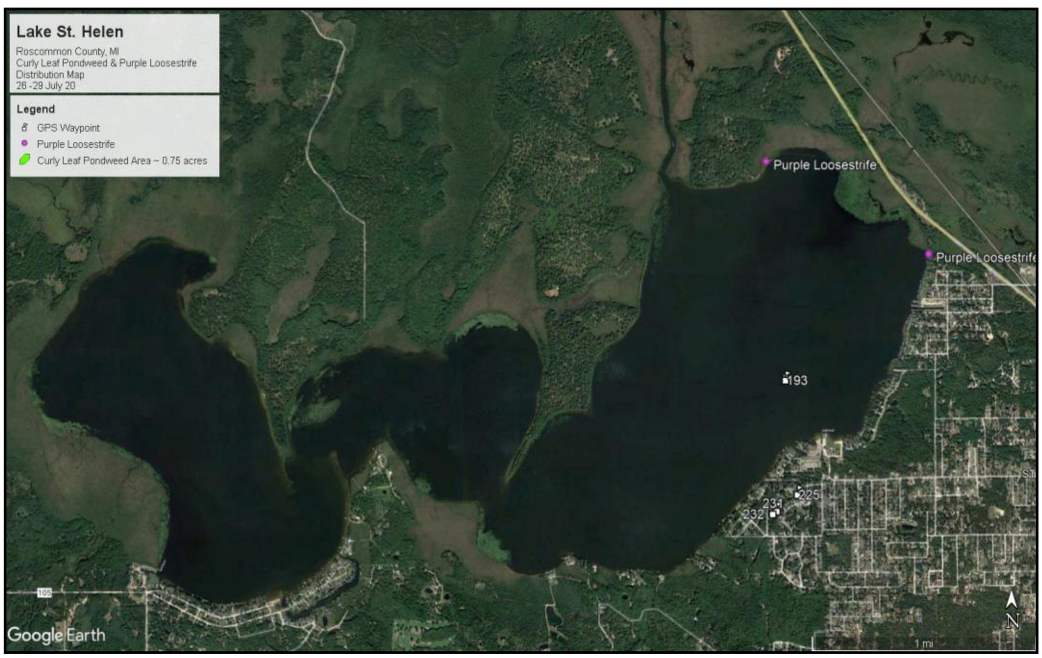

Figure 15. Curly-leaf Pondweed and Emergent Purple Loosestrife distribution in and around Lake St. Helen (July 26-29, 2022).

5.4 Lake St. Helen 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 (Watermilfoils). 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.

Lake St. Helen contained 20 native submersed, 4 floating-leaved, and 7 emergent aquatic plant species, for a total of 31 native aquatic macrophyte species (Tables 7 and 8). 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). Photos of all native aquatic plants are shown below in Figures 11-16. The majority of the emergent macrophytes may be found along the shoreline of the lake. The majority of the floating-leaved lily pads can be found near the shoreline and near wetlands.

The most dominant aquatic plant in the main part of the lake included the submersed Fern-leaf Pondweed and Wild Celery. Fern-leaf Pondweed generally grows along the lake bottom and forms dense beds. Wild Celery has long, green, ribbon-like leaves and can grow very thick in shallow areas. After Wild Celery has been fertilized, it forms a distinctive coil. The emergent plants, such as (Cattails), and *Scirpus acutus* (Bulrushes) are critical for shoreline stabilization as well as for wildlife and fish spawning habitat. Wild Rice was also prevalent in a few areas and also assists with sediment stabilization. Additionally, the floating-leaved aquatic plants such as yellow and white water lilies and Watershield are excellent fishery cover and house numerous snails and aquatic macroinvertebrates that are critical for the fishery food chain.

Table 7. Lake St. Helen native aquatic plant species relative abundance (July 26-29, 2022).

Native Aquatic Plant Species Name	*Aquatic Plant Common Name*	*A Level*	*B Level*	*C Level*	*D Level*
Chara vulgaris	Muskgrass	67	40	11	0
Stuckenia pectinatus	Thin-leaf Pondweed	4	0	0	0
Potamogeton zosteriformis	Flat-stem Pondweed	7	2	0	0
Potamogeton robbinsii	Fern-leaf Pondweed	279	495	80	3
Potamogeton gramineus	Variable-leaf Pondweed	8	2	0	0
Potamogeton praelongus	White-stem Pondweed	5	0	0	0
Potamogeton richardsonii	Clasping-leaf Pondweed	10	3	0	0
Potamogeton natans	Floating-leaf Pondweed	4	2	0	0
Potamogeton illinoensis	Illinois Pondweed	337	362	3	0
Potamogeton amplifolius	Large-leaf Pondweed	94	45	1	0
Potamogeton pusillus	Small-leaf Pondweed	5	2	0	0
Zosterella dubia	Water Stargrass	2	2	0	0
Vallisneria americana	Wild Celery	127	45	4	0
Myriophyllum sibiricum	Northern Watermilfoil	1	0	0	0
Myriophyllum heterophyllum	Variable Watermilfoil	0	3	0	0
Ceratophyllum demersum	Coontail	9	1	0	0
Elodea canadensis	Common Waterweed	78	18	1	0
Utricularia vulgaris	Common Bladderwort	18	1	1	0
Utricularia minor	Mini Bladderwort	2	0	0	0
Najas guadalupensis	Southern Naiad	61	1	0	0
Nymphaea odorata	White Waterlily	54	84	12	1
Nuphar variegata	Yellow Waterlily	57	205	5	0
Brasenia schreberi	Watershield	25	33	3	0
Lemna minor	Duckweed	0	1	0	0
Typha latifolia	Cattails	31	50	2	0

Schoenoplectus acutus	Bulrushes	37	52	6	0
Eleocharis sp.	Spike rushes	0	1	0	0
Pontedaria cordata	Pickerelweed	47	84	7	0
Decodon verticillatus	Swamp Loosestrife	7	2	0	0
Zizania aquatica	Wild Rice	13	2	2	8
Scirpus subterminalis	Submersed Bulrushes	47	41	4	0

Table 8. Lake St. Helen native aquatic plant species frequency (July 26-29, 2022).

Native Aquatic Plant Species Name	***Aquatic Plant Common Name***	***Frequency (% Sampling Locations Found)***
Chara vulgaris	Muskgrass	7.6
Stuckenia pectinatus	Thin-leaf Pondweed	0.3
Potamogeton zosteriformis	Flat-stem Pondweed	0.6
Potamogeton robbinsii	Fern-leaf Pondweed	55.1
Potamogeton gramineus	Variable-leaf Pondweed	0.6
Potamogeton praelongus	White-stem Pondweed	0.3
Potamogeton richardsonii	Clasping-leaf Pondweed	0.8
Potamogeton natans	Floating-leaf Pondweed	0.4
Potamogeton illinoensis	Illinois Pondweed	45.1
Potamogeton amplifolius	Large-leaf Pondweed	9.0
Potamogeton pusillus	Small-leaf Pondweed	0.3
Zosterella dubia	Water Stargrass	0.3
Vallisneria americana	Wild Celery	58.7
Myriophyllum sibiricum	Northern Watermilfoil	0.1
Myriophyllum heterophyllum	Variable Watermilfoil	0.2
Ceratophyllum demersum	Coontail	0.6
Elodea canadensis	Common Waterweed	6.2
Utricularia vulgaris	Common Bladderwort	1.3
Utricularia minor	Mini Bladderwort	0.1
Najas guadalupensis	Southern Naiad	4.0
Nymphaea odorata	White Waterlily	9.7
Nuphar variegata	Yellow Waterlily	17.2
Brasenia schreberi	Watershield	3.9
Lemna minor	Duckweed	0.1
Typha latifolia	Cattails	5.3

Schoenoplectus acutus	Bulrushes	6.1
Eleocharis sp.	Spike rushes	0.1
Pontedaria cordata	Pickerelweed	8.9
Decodon verticillatus	Swamp Loosestrife	0.6
Zizania aquatica	Wild Rice	1.6
Scirpus subterminalis	Submersed Bulrushes	5.9

Figure 16. Dense beds of Wild rice on Lake St. Helen (July, 2022).

Figure 17. Chara (Muskgrass) ©RLS

Figure 18. Thin-leaf Pondweed ©RLS

Figure 19. Flat-stem Pondweed ©RLS

Figure 20. Fern-leaf Pondweed ©RLS

Figure 21. Variable-leaf Pondweed ©RLS

Figure 22. White-stem Pondweed ©RLS

Figure 23. Clasping-leaf Pondweed ©RLS

Figure 24. Illinois Pondweed ©RLS

Figure 25. Large-leaf Pondweed ©RLS

Figure 26. Floating-leaf Pondweed ©RLS

Figure 27. Water Stargrass ©RLS

Figure 28. Wild Celery ©RLS

Figure 29. Northern Watermilfoil ©RLS

Figure 30. Variable Watermilfoil ©RLS

Figure 31. Coontail ©RLS

Figure 32. Elodea ©RLS

Figure 33. Common Bladderwort ©RLS

Figure 34. Mini bladderwort ©RLS

Figure 35. Southern Naiad ©RLS

Figure 36. Sago Pondweed ©RLS

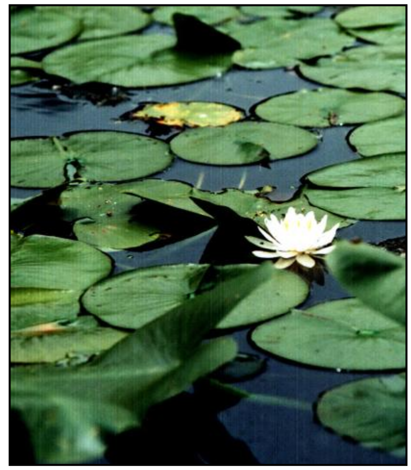

Figure 37. White Waterlily ©RLS

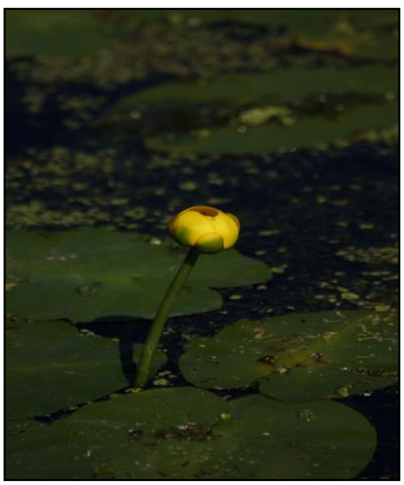

Figure 38. Yellow Waterlily ©RLS

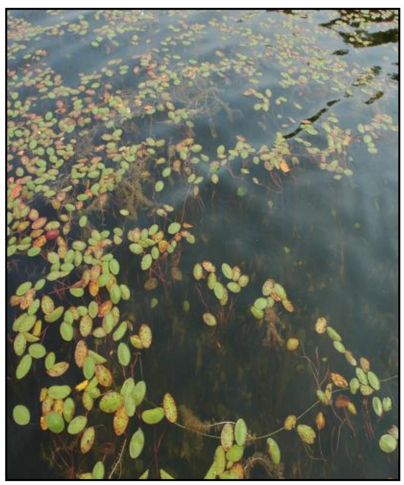

Figure 39. Watershield ©RLS

Figure 40. Duckweed ©RLS

Figure 41. Pickerelweed ©RLS

Figure 42. Cattails ©RLS

Figure 43. Bulrushes ©RLS

Figure 44. Spike Rushes ©RLS

Figure 45. Swamp Loosestrife ©RLS

Figure 46. Wild Rice ©RLS

Figure 47. Submersed Bulrushes ©RLS

6.0 LAKE ST. HELEN MANAGEMENT IMPROVEMENT METHODS

6.1 Lake St. Helen Aquatic Plant Management Methods

Improvement strategies, including the management of only invasive aquatic plants, control of land and shoreline erosion, and further nutrient loading from external sources, are available for the various problematic issues facing Lake St. Helen. Long-term lake management components involve both within-lake (basin) and around-lake (watershed) solutions to protect and restore complex aquatic ecosystems. **The goals of a lake improvement program are to improve aquatic vegetation biodiversity, improve water quality and wildlife habitat, protect recreational use of a water resource and protect waterfront property values.** Regardless of the management goals, all management decisions must be site-specific and should consider the socio-economic, scientific, and environmental components of the lake management plan.

The management of nuisance level exotic aquatic plants is necessary in Lake St. Helen due to accelerated growth and distribution. Management options should be environmentally and ecologically sound and financially feasible. Options for control of aquatic plants are limited yet some are capable of achieving strong results when used properly. Exotic aquatic plant species should be managed with solutions that will yield long-term results. The sections below discuss the individual lake management methods (tools) and then ultimately lead to a section with specific recommendations using those methods.

6.1.1 Aquatic Herbicides and Applications

The use of aquatic chemical herbicides is regulated by the Michigan Department of Environment, Great Lakes, and Energy (EGLE) and requires a permit. Aquatic herbicides are generally applied via an airboat or skiff equipped with mixing tanks and drop hoses (Figure 48). The permit contains a list of approved herbicides for a particular body of water, as well as dosage rates, treatment areas, and water use restrictions. **Contact and systemic aquatic herbicides are the two primary categories used in aquatic systems.**

Contact herbicides such as diquat, flumioxazin, and hydrothol cause damage to leaf and stem structures; whereas systemic herbicides are assimilated by the plant roots and are lethal to the entire plant. **Wherever possible, it is preferred to use a systemic herbicide for longer-lasting aquatic plant control of invasives. In Lake St. Helen, the use of contact herbicides (such as diquat and flumioxazin) would be highly discouraged since those offer short-term control of plants and are most commonly used on nuisance native aquatic plant species. The native aquatic plants within Lake St. Helen are critical for the lake fishery and should all be protected. They also assist with preventing further infestations from invasives. Contact herbicides could be used for the Starry Stonewort, however, but they are often used in combination with chelated copper.**

Algaecides such as copper sulfate should also be avoided on Lake St. Helen. **Copper accumulates in lake sediments and bio-persists over time. It is harmful to sediment biota and can be released into the water column with sediment perturbations.**

Systemic herbicides such as 2, 4-D and triclopyr are the two primary systemic herbicides used to treat milfoil that occurs in a scattered distribution. Fluridone (trade name, SONAR®) is a systemic whole-lake herbicide treatment that is applied to the entire lake volume in the spring and is used for extensive infestations. The objective of a fluridone treatment is to selectively control the growth of milfoil in order to allow other native aquatic plants to germinate and create a more diverse aquatic plant community. **Due to the cost and potential impacts of fluridone on native aquatic plants in Lake St. Helen, the use of fluridone is not recommended.**

Systemic herbicides such as 2, 4-D, triclopyr, and ProcellaCOR® are the primary systemic herbicides used to treat Eurasian Watermilfoil, but 2,4-D has shallow well restrictions and ProcellaCOR® is cost-prohibitive given the current EWM quantity in Lake St. Helen. Thus, the use of liquid triclopyr with adjuvant (a sinking agent) is recommended. This approach has been very successful on other lakes with large treatment areas and minimal impacts to native aquatic plant species. Paradise Lake in Emmet County, Michigan is an excellent recent example.

Figure 48. An herbicide treatment airboat and crew preparing for a lake treatment.

6.1.2 Mechanical Harvesting

Mechanical harvesting involves the physical removal of nuisance aquatic vegetation with the use of a mechanical harvesting machine (Figure 49). The mechanical harvester collects numerous loads of aquatic plants as they are cut near the lake bottom. The plants are off-loaded onto a conveyor and then into a dump truck.

Harvested plants are then taken to an offsite landfill or farm where they can be used as fertilizer. Mechanical harvesting is preferred over chemical herbicides when primarily native aquatic plants exist, or when excessive amounts of plant biomass need to be removed**. Mechanical harvesting is usually not recommended for the removal of watermilfoil since the plant may fragment when cut and re-grow on the lake bottom. This technology would have the most efficacy on very large weed beds but is still not needed at this time. It could be used to thin dense areas of pondweed once all of the EWM is reduced and only if the pondweeds prohibit recreation and navigation on the lake.**

Figure 49. A mechanical harvester.

6.1.3 Diver Assisted Suction Harvesting (DASH)

Suction harvesting via a Diver-Assisted Suction Harvesting (DASH) boat (Figure 50) involves hand removal of individual plants by a SCUBA diver in selected areas of lake bottom with the use of a hand-operated suction hose. Samples are dewatered on land or removed via fabric bags to an offsite location. **This method is generally recommended for small (less than 10 acres) spot removal of vegetation since it is usually cost-prohibitive on a larger scale.** The advantage it has is that it can be selective in what species it removes since a diver is guiding the suction hose to targeted plants. This process may remove either plant material or sediments and may require a USACE bottomlands permit. Furthermore, this activity may cause re-suspension of sediments (Nayar et *al*., 2007) which may lead to increased turbidity and reduced clarity of the water.

Figure 50. A DASH boat for hand-removal of watermilfoil or other nuisance vegetation. ©Restorative Lake Sciences, LLC

6.1.4 Benthic Barriers and Nearshore Management Methods

The use of benthic barrier mats (Figure 51) or Weed Rollers (Figure 52) have been used to reduce weed growth in small areas such as in beach areas and around docks. The benthic mats are placed on the lake bottom in early spring prior to the germination of aquatic vegetation. They act to reduce germination of all aquatic plants and lead to a local area free of most aquatic vegetation. Benthic barriers may come in various sizes between 100-400 feet in length. They are anchored to the lake bottom to avoid becoming a navigation hazard. The cost of the barriers varies among vendors but can range from $100-$1,000 per mat. Benthic barrier mats can be purchased online at: www.lakemat.com or www.lakebottomblanket.com. The efficacy of benthic barrier mats has been studied by Laitala et *al.* (2012) who report a minimum of 75% reduction in invasive milfoil in the treatment areas. Lastly, benthic barrier mats should not be placed in areas where fishery spawning habitat is present and/or spawning activity is occurring.

Weed Rollers are electrical devices which utilize a rolling arm that rolls along the lake bottom in small areas (usually not more than 50 feet) and pulverizes the lake bottom to reduce germination of any aquatic vegetation in that area. They can be purchased online at: www.crary.com/marine or at: www.lakegroomer.net.

Both methods are useful in shallow lakes such as Lake St. Helen and work best in beach areas and near docks to reduce nuisance aquatic vegetation growth. These technologies could be used in beach areas on the lake if the bottom substrate is consolidated (firm).

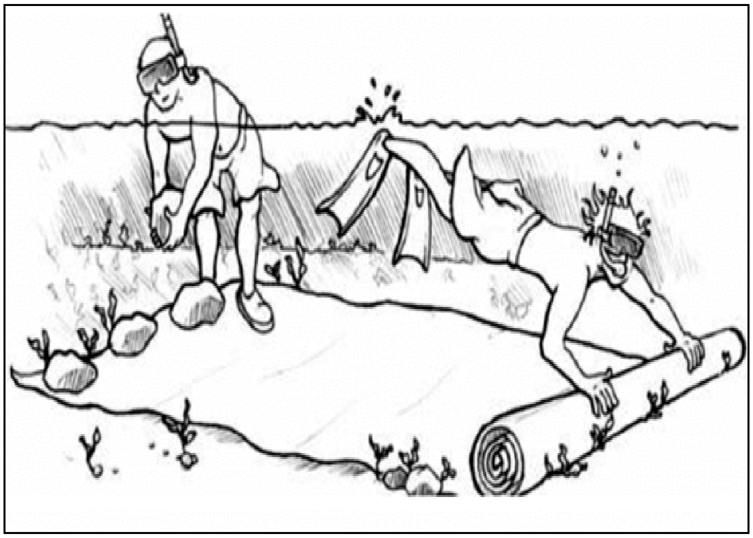

Figure 51. A Benthic Barrier. Photo courtesy of Cornell Cooperative Extension.

Figure 52. A Weed Roller.

6.1.5 Boat Washing Stations

In 2019, the Michigan Natural Resources Environmental Protection Act (PA 451 of 1993, Part 413) was amended with new boating and fishing laws that aim to prevent the introduction and spread of invasive aquatic species. Due to this amendment, technologies such as boat washing stations are becoming prevalent and necessary.

With over 13 million registered boaters in the U.S. alone, the need for reducing transfer of aquatic invasive species (AIS) has never been greater. The Minnesota Sea Grant program identifies five major boat wash scenarios which include: 1) permanent washing stations at launch sites, 2) Portable drive-thru or transient systems, 3) Commercial car washes, 4) Home washing, and 5) Mandatory vs. volunteer washing. Boat washing stations are voluntary for incoming and exiting boaters. Boat washing stations promote the Clean Waters Clean Boats volunteer education program by educating boaters to wash boating equipment (including trailers and bait buckets) before entry into every lake. Critical elements of this education include: 1) how to approach boaters, 2) demonstration of effective boat and trailer inspections and cleaning techniques, 3) the recording of important information, 4) identification of high-priority invasive species, and 5) sharing findings with others. **Once a boat washing station is in place on Lake St. Helen, the Association should work together to educate the public and lake users on proper cleaning techniques and other invasive species information. A "Landing Blitz" can be held once the station is in place and the public can be invited to a field demonstration of how to use the washing station.** Figure 53 displays a typical CD3 boat washing station that is solar-lowered.

Figure 53. A boat washing station on an inland lake.

7.0 LAKE ST. HELEN IMPROVEMENT CONCLUSIONS & RECOMMENDATIONS

The information given in the aforementioned sections for the long-term management of Lake St. Helen should be considered for effective management and ultimate protection of the lake water quality, balance of native aquatic plants, and protection of waterfront property values. **The overall goals of this proposed management program are listed in Table 9 along with where the proposed improvements should be implemented in and around the lake. The proposed aquatic vegetation management program conclusions and recommendations include the following:**

1. Protect the robust and healthy native aquatic plant biodiversity
2. Reduce invasive species such as Eurasian Watermilfoil and Starry Stonewort
3. Although Curly-leaf Pondweed is an invasive aquatic plant, it will not likely take over the lake as there are so many other native pondweeds that are successfully outcompeting the Curly-leaf Pondweed.
4. Purple Loosestrife can be hand-removed without the use of herbicides were it is found.
5. A few areas of shoreline erosion were found during the survey (Figure 54). Areas such as these contribute soils and nutrients to the lake and should be stabilized as soon as possible.

Figure 54. Lake St. Helen shoreline erosion (July, 2022).

6. A licensed aquatic herbicide applicator should be retained for treatments beginning in 2023. To avoid any conflicts of interest, an independent consulting limnologist (Restorative Lake Sciences) should be retained to oversee all lake treatments and make objective treatment recommendations.
7. In nearshore areas, especially beaches, the use of benthic mats and weed rollers can reduce aquatic plant germination and growth without the use of chemicals.
8. The use of aquatic herbicides should be limited to ONLY areas of invasive aquatic plant growth and due to the large cover of Eurasian Watermilfoil, not all areas should be treated at one time. This could stress the lake fishery which is a very critical component of the Lake St. Helen ecosystem.
9. Consider future purchase of a boat washing station when the invasives are reduced. The systems are costly (usually around $30,000 per unit) but are worth the investment. Periodic grants are available.

If the improvement methods described above are implemented, the balance of the Lake St. Helen ecosystem will improve over time. Such improvements will take considerable time and financial investment. RLS has prepared the optimum herbicide options for cost and responsibility to the ecosystem below in Table 10.

Table 9. Proposed lake improvement methods for Lake St. Helen's Improvement plan.

Lake Management Activity	Primary Goal	Secondary Goal	Best Locations to Use
Systemic aquatic herbicides for Eurasian Watermilfoil	To reduce % cover of EWM throughout lake	To protect native aquatic plant biodiversity	ONLY where EWM is located
Contact herbicides for Starry Stonewort control	To stop it from spreading to other areas of the lake	To protect native aquatic plant biodiversity	ONLY where SS is located
Benthic Barriers/Weed Rollers	To prevent germination of nuisance weeds in beach areas	To reduce dependency on chemicals in nearshore areas	Beach areas only
Lake Vegetation Surveys/Scans	To determine % cover by invasives and use as data tool	To compare year to year reductions in nuisance vegetation areas	Entire lake, annually and follow-ups as needed
Water Quality Monitoring	To determine trophic status of the lake annually	To compare trend in water quality parameters with time	Main Lake, 3 Tributaries

7.1 Cost Estimates for Lake St. Helen Aquatic Vegetation Management:

The proposed lake improvement and management program for Lake St. Helen is recommended to begin as soon as possible. **Since aquatic herbicide treatments at this scale are likely to be the costliest improvement, it may be conducted over a period of 3-5 years or more to reduce annual cost an reduce cover of invasives over time.** A breakdown of estimated costs associated with the various proposed treatments in Lake St. Helen is presented in Table 10. 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.

Table 10. Lake St. Helen proposed lake improvement program costs (2023-2027).

Proposed Lake St. Helen Improvement Item	Year 1 Costs	Years 2-5 (Annual) Costs
Professional services (limnologist management of lake, oversight, water quality, processing, education)[1]	$14,000	$15,000
EWM treatment using liquid triclopyr at 3.0 gal/acre[2] @$370/acre x 614.3 acres	$202,950 (if divide by 5 years= $40,590 annually)	$40,590
Starry Stonewort Treatment (using chelated copper and hydrothol) @$300/acre x 17.3 acres	$6,487.50	$6,487.50
Contingency[3]	$6,108	$6,208
Total Annual Estimated Cost	$67,185.50	$68,285.50
Per Riparian Lot (N=290)	$231.67	$235.47

[1] Professional services includes comprehensive management of the lake with two annual GPS-guided, aquatic vegetation surveys, pre and post-treatment surveys for aquatic plant control methods, oversight and management of the aquatic plant control program and all management activities, all water quality monitoring and evaluation of all improvement methods, review of all invoices from contractors and others billing for services related to the improvement program, education of local riparians and attendance at up to two regularly scheduled annual board or Association meetings. Meetings may also be held by Zoom if necessary.

[2] Herbicide treatment scope may change annually due to changes in the distribution and/or abundance of aquatic plants.

[3] Contingency is 10% of the total project cost, to assure that extra funds are available for unexpected expenses. Note: Contingency may be advised and/or needed for future treatment years.

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