Aquatic Vegetation Survey 2021
Torch Lake

by

Tip of the Mitt Watershed Council

Survey performed and report written by Tip of the Mitt Watershed Council

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Introduction

Aquatic plant communities are an important component of lake ecosystems. Submerged macrophytes, or plants and algae larger enough to be seen by the naked eye, provide food and shelter for other organisms within the ecosystem, such as fish and invertebrate communities. Like almost all plants, macrophytes supply oxygen to the system via photosynthesis. Macrophyte photosynthesis can also potentially reduce eutrophication in lakes through the uptake of nutrients, which decreases nutrient availability to phytoplankton (Canfield *et al*. 1984). By reducing the amount of nutrients in the water column, aquatic plants decrease the likelihood of algal blooms. Macrophytes also reduce effects of water turbulence (Canfield *et al*. 1984), helping to reduce erosion along shorelines and nearshore areas.

Lake ecosystems that have do not have healthy and abundant macrophyte communities are less biologically diverse due to the lack of habitats and food resources on which organisms rely. Typically, fewer macrophyte communities also corresponds with greater nuisance algae populations and increased erosion of the shoreline. Removal or loss of native plant communities could also make it more inviting for invasive species, such as Eurasian watermilfoil (*Myriophyllum spicatum)*, to dominate the ecosystem, which could further change the community structure.

Despite all the benefits of aquatic plant communities, an overabundance of species, especially invasive species, can be detrimental to lake ecosystems. Excessive plant growth can disrupt recreational uses of the lake, such as boating, fishing, and swimming, as well as ecosystem functions like habitat for fish and other aquatic life. Lakes that contain excessive nuisance plant growth can require management programs to control the effects of the plant community on the ecosystem.

The management of aquatic plant communities is important to maintain a stable lake ecosystem. Aquatic plants surveys are a way to understand the macrophyte community by recording plant species, abundance, density, and the presence of invasive species. Due to the Elk River Chain of Lakes Watershed’s abundance of surface water (34,000 acres) it

has taken various efforts over the years to monitor for invasive species. A combination of whole-lake comprehensive surveys, shoreline-only surveys, and spot checks have informed stakeholders and set the stage for implementation of effective control measures. In 2012, Three Lakes Association's (TLA) interns collected vegetation samples on Torch Lake, Clam Lake, and Lake Bellaire (20-25 samples each), looking specifically for invasive species. Tip of the Mitt Watershed Council conducted whole-lake aquatic plant surveys on Clam and Bellaire Lakes in 2013 with funds from the Dole Family Foundation. In 2014 and 2015, the Watershed Council conducted shoreline surveys on fifteen lakes and rivers in the watershed including Torch Lake looking for baseline data on five invasive species:

1. Eurasian Phragmites *(Phragmites australis)*
2. Purple loosestrife (*Lythrum salicaria*)
3. Curly-leaf pondweed (*Potamogeton crispus*)
4. Quagga mussels (*Dreissena bugensis*)
5. Eurasian watermilfoil (*Myriophyllum spicatum*)

Survey results also noted the presence of zebra mussels (*Dreissena polymorpha*); however, their presence was widely known and not the target for the survey.
In addition to the shoreline surveys, whole-lake comprehensive surveys were performed on Hanley Lake, Intermediate Lake, Elk Lake, and Lake Skegemog. The work was funded by The Clean Michigan Initiative – Clean Water Fund. Additionally, the Michigan Department of Environment, Great Lakes, and Energy conducted a cursory survey of Torch Lake, looking for both invasive plant and animal species as well as native plants. Since 2015, many lake associations have monitored known sites of invasives and pursued treatment. The local Charlevoix, Antrim, Kalkaska, Emmet Cooperative Invasive Species Management Area (CAKE CISMA) also surveyed the Upper Chain of Lakes for purple loosestrife and invasive *Phragmites* in 2019.

Three Lakes Association and Torch Lake Protection Alliance (TLPA) received a grant from the Dole Family Foundation in July 2021 to contract with Tip of the Mitt Watershed Council to complete a comprehensive aquatic plant survey of the entire lake, including the lagoon in the Torch River at the outlet of the lake. The goals of this survey were to 1)

identify all species of plants in the lake including their extent, location, and density in order to establish baseline knowledge of known vegetation species throughout the whole lake, 2) assess the success of ongoing treatment of invasive species, and 3) compare and assess trends in vegetation where data was available. This work will be described in the remainder of the report.

Study Area

Torch Lake is located in Antrim County, Michigan (Figure 1). Formerly a deep, fjord-like bay of ancient Lake Michigan, Torch Lake became an inland lake when a sand bar formed across the mouth of the bay (now the lake's northwest end). The lake is ranked second largest by surface area in Michigan, at 18,473 acres. Its great depth (285 feet) gives it by far the greatest depth and water volume of any inland lake in the state. It is also Michigan's longest inland lake. Bottom sediments in the deepest waters are grey or white in color due to the deposition of marl with only low levels of organic material. Almost everywhere, the lake has a wide, sandy, shallow region paralleling the shore, which ends in a steep drop-off. This area is often covered by a community of diatomaceous algae called golden brown algae. Named tributaries include the Clam River (Torch Lake's major inlet), Spencer, Wilkinson, and Eastport Creeks. All of the other tributaries are small and unnamed.

The absence of organic material in Torch Lake's substrate makes it difficult for plants to grow as they need nutrients present in organic material. However, a number of interesting features on the lake bottom have created mini catchment areas for debris to settle and create a more suitable environment for plant growth. One of the most significant features is the Torch River lagoon, which was created when the river was dredged so barges filled with lumber could navigate it in the late 1800s and early 1900s. The outlet of Torch Lake was also narrowed by being built up with sand that was sucked from the lake. The removal of sand from Torch Lake created a series of linear holes that are deeper than the surrounding sandbar. They are colloquially known as "sand sucker holes" (personal communication with Crystal Beach residents). The lagoon is now a backwater to the Torch River. Both the lagoon and the sand sucker holes can easily be seen on an aerial

map and both are covered in plants. Both of these areas are also prone to invasive species, potentially more than other areas of the lake because of the original substrate disruption. Other features that are easily discernible on aerials are an old boiler resting on the lake's bottom north of Alden Harbor and fish cribs (installed in 2012) located south of the Torch Lake Township Boat Ramp. These areas provide excellent habitat for plant growth

due to their ability to slow down wave action and catch nutrient-laden sediment.

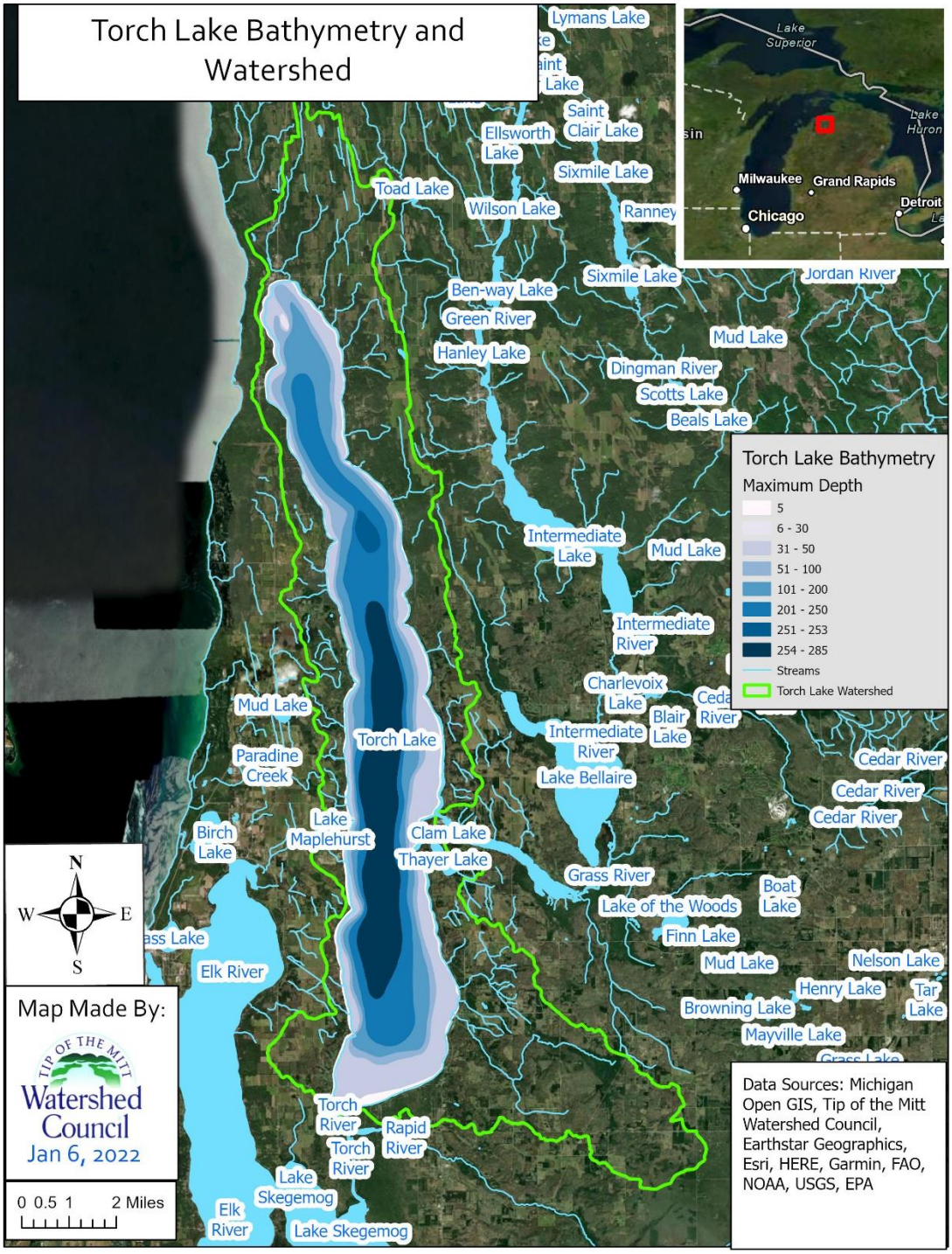

Figure 1. Torch Lake bathymetry and surrounding watershed features.

Methods

The survey was conducted over 11 days between August 3, 2021, and October 6, 2021. Plant samples were collected using grappling rakes (made by attaching the head of a double-sided bow rake to a rope). Visual assessments from boats and drones aided in mapping and identifying plant communities. Individual data points were captured on iPads using Survey123 for ArcGIS. Survey123 collects quantitative, qualitative, and spatial information that makes creating, sharing, and analyzing surveys easy. Specimens were collected, identified, photographed, and recorded into Survey123 forms. Where specimens could not be identified in the field, a sample of the vegetation was collected in a water-filled Whirl-Pak. Samples were labeled with their corresponding site ID and kept in a refrigerator at 4 degrees C. Samples were identified using Michigan Flora dichotomous keys in November 2021.

A total of 150 sites were sampled through all vegetated lake areas (Figure 2). Sample sites were determined by creating transects from the shore approximately 500 feet apart. Known or potential invasive species sites were sampled as close to provided GPS coordinates as possible. Provided GPS points included locations on Torch Lake, the Torch River Lagoon, and the Clam River. Additional sample points were collected near known or invasive species sites to rule out the possibility of invasive species spread. Sample sites were chosen as close to the middle of plant communities as possible. Where communities were larger than what could be sampled at a single sample point, multiple samples were collected in the interior and edges of plant communities. At each sample site, the boat was anchored, usually with two anchors. A new Survey123 form was opened after anchoring at the site on an iPad, which used cellular signal from cell phone hot spots to acquire GPS coordinates automatically. Survey123 geopoints have a precision range of one square meter. Grappling hooks were used as sampling devices and thrown in four directions from the boat to obtain a sufficient sample. When possible, a visual assessment of the site was used to ensure that all plant species were accounted for. Specimens sighted in the water that were not represented in the grappled samples were noted in observations and included in density estimations.

Most vascular plant specimens were identified to the species level except for some species of bulrush, naiad, chara, and burr-reed. All species present were recorded and estimated to one of seven possible density categories using the following subjective scale: 1- Very Light; 2- Light; 3- Light/Moderate; 4- Moderate; 5- Moderate/Heavy; 6- Heavy; 7- Very Heavy. The same scale was used to determine the overall density for a site using Very Light to indicate only a few stems and Very Heavy to indicate plants reaching the water's surface. If multiple throws at a site with visible plants resulted in no specimens, that site was documented as having little to no vegetation and assigned a scale value of 0. No vegetation rake was thrown in areas where there was no visible vegetation. A majority of the specimens were identified in the field.

Survey123 automatically created a Graphic Information System (GIS) shapefile with all information from the survey forms. The sample point layer was overlaid with an aerial map of Torch Lake and the surrounding area to display survey results. Density data for each sample point were displayed on the map to assess patterns and trends.

Line and point features, as well as photographs and field notes, were used to create polygons representing distinct plant communities. Plant community polygons were determined based on like characteristics in a lake area's plant assemblage and density. Attributes for plant community polygons included density, dominant community, other species present, and community description.

Because a large area of Torch Lake's littoral zone was unpopulated with plant communities, the area was digitized using ArcGIS Map Service World Imagery (0.3m resolution). Additionally, Tip of the Mitt Watershed Council-created drone imagery was used for digitizing in select areas with invasive species (approximately 1.2 cm resolution). A Torch Lake polygon derived from a Michigan Department of Natural Resources hydrography layer was used as the outside line of the digitized littoral zone. While this polygon does not capture every detail of Torch Lake's shoreline, it is a standard shape that is widely used and can be easily found on Michigan's GIS Open Data website. The inside line of the digitized littoral zone polygon was created by following a

distinct line between the shallow area of Torch Lake (lighter on World Imagery) and the deeper depths (darkest color on World Imagery). The Torch River Lagoon was digitized by following the shoreline in an orthoimage created by a Tip of the Mitt Watershed Council drone. Once the littoral zone areas were completed, the Erase tool was used in ArcGIS Pro to delete areas in the littoral zone that had plants found in the survey. The resulting feature class represents an area that has no plants.

Drone imagery was collected over three days in September 2021 using a DJI Phantom 4 V2 drone equipped with a polarizing filter. Imagery was collected in autonomous missions set up in the DroneDeploy app installed on an iPhone X. The iPhone X was connected to a DJI Phantom 4 Pro Advanced Remote Controller GL300F using a lightning cord. Most areas were completed in one mission except for the Torch River Lagoon, which was completed in three. Shorter mission times allowed operators to manually capture the drone in between flights instead of letting it autonomously land on the boat. Autonomous landing is not desired due to potential rocking and moving of the boat which could cause the boat to move away from the drone's automatically set home point. Flights were taken at 150 feet in altitude using at least 80% overlap. Overlap percentages were chosen based on recommendations from MapsMadeEasy. All projects are stored on a DroneDeploy app and can be reused for replicating the imagery collection in the future. Drone imagery was downloaded on to a Watershed Council desktop and stored on the network server.

Pix4D Mapper software was used to process images and create orthomosaics. Automatic settings were used on all orthomosaics. The three Torch Lagoon missions were run as one project in Pix4D. When necessary, additional orthomosaics were created using ArcGIS Pro Ortho Mapping. While Pix 4D shows better contrast and coloring, Ortho Mapping did a better job processing corners. Ortho Mapping orthomosaics and Pix4D orthomosaics were both used to digitize areas with invasives in the Torch River Lagoon

and Alden Harbor.

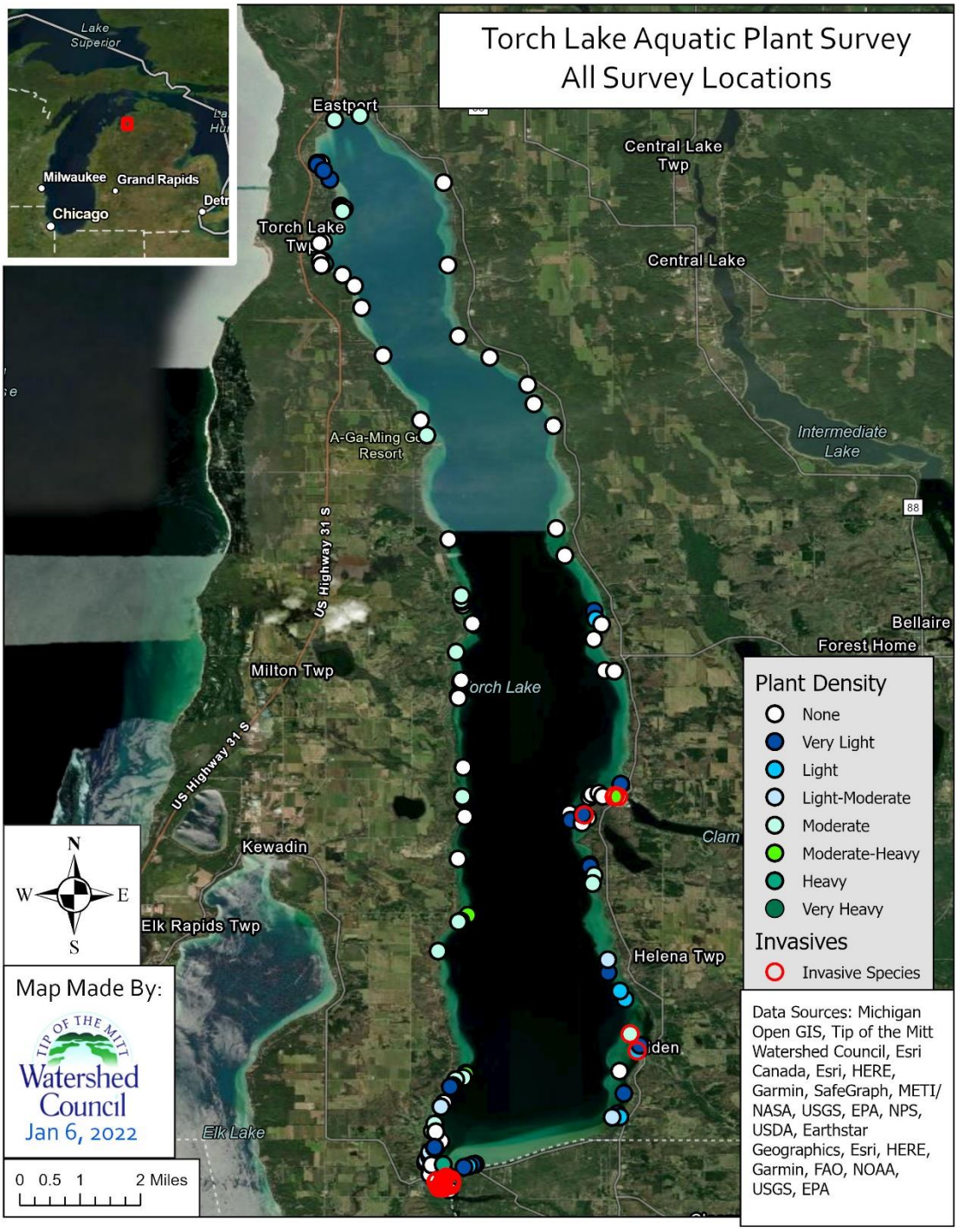

Figure 2. Survey points and dominant plant communities on Torch Lake.

Results

Sample Sites: Species and Density

In total, 25 taxa were found during the survey. Sixteen different plant taxa were found in Torch Lake and twenty were found on the lagoon. One additional species (invasive *Phragmites*) was found on the Clam River. The most frequently found plant was muskgrass (*Chara spp.),* found at 47% of sites on Torch Lake and 66% of sites on the Torch River Lagoon (Table 1, *Plants may have been found at more than one site

Table 2). The next three frequently-found plants on Torch Lake were eel grass (*Valisneria americanum*), sago pondweed (*Stuckenia pectinata*), and variable-leaf pondweed (*Potamogeton gramineus*). The only invasive species found on Torch Lake itself was Eurasian watermilfoil (*Myriophyllum spicatum)* at three sites. Eurasian watermilfoil was the second-most commonly found plant on the Torch River Lagoon, being found at nearly 50% of the sites. Other invasive species found on the lagoon include curly-leaf pondweed (*Potamogeton crispus*) and purple loosestrife (*Lythrum salicaria).* Close-up maps of survey points and aerials imagery can be found in Appendix A and B.

Table 1. Plant taxa freqency found in Torch Lake 2021

Latin Name	Common Name	Sites Found	Percent of Sites Found
Chara spp.	Muskgrass	55	47.41
Valisneria americanum	Eel grass	13	11.21
Stuckenia pectinata	Sago pondweed	11	9.48
Potamogeton gramineus	Variable-leaf pondweed	11	9.48
Potamogeton richardsonii	Richardson's pondweed	9	7.76
Potamogeton amplifolius	Large-leaved pondweed	8	6.90
Potamogeton illinoensis	Illinois pondweed	7	6.03
Najas flexilis	Slender naiad	5	4.31
Myriophyllum spicatum	Eurasian watermilfoil	3	2.59
Elodea canadensis	American waterweed or pondweed	3	2.59
Myriophyllym sibiricum	Common watermilfoil	3	2.59
Potamogeton praelongus	Whitestem pondweed	3	2.59

Potamogeton zosteriformis	Flat-stem pondweed	1	0.86
Schoenoplectus spp.	Bulrush spp.	1	0.86
Potamogeton robbinsii	Robbin's pondweed	1	0.86
Ranunculus flabellaris	Water crowfoot	1	0.86
	Total Sites*	116	

*Plants may have been found at more than one site

Table 2. Plant taxa freqency found in Torch River Lagoon 2021

Latin Name	Common Name	Sites Found	Percent of Sites Found
Chara spp.	Muskgrass	15	60
Myriophyllum spicatum	Eurasian watermilfoil	12	48
Valisneria americanum	Eel grass	9	36
Elodea canadensis	American waterweed or pondweed	7	28
Potamogeton richardsonii	Richardson's pondweed	6	24
Potamogeton zosteriformis	Flat-stem pondweed	5	20
Najas flexilis	Slender naiad	4	16
Nuphar variegata	Yellow pond lily	4	16
Potamogeton crispus	Curly-leaf pondweed	3	12
Stuckenia pectinata	Sago pondweed	2	8
Potamogeton amplifolius	Large-leaved pondweed	2	8
Myriophyllym sibiricum	Common watermilfoil	2	8
Nymphaea odorata	White water lily	2	8
Potamogeton natans	Floating-leaf pondweed	2	8
Lythrum salicaria	Purple loosestrife	2	8
Potamogeton gramineus	Variable-leaf pondweed	1	4
Potamogeton strictifolius	Narrow-leaf pondweed	1	4
Ranunculus flabellaris	Water crowfoot	1	4
Sparganium spp.	Burr-reed	1	4
Schoenoplectus pungens	Common three-square	1	4
	Total	25	

The majority of sites on Torch Lake had no plants at all (

Table 3). Of the sites with no plants found (45), golden brown algae was noted as being prevalent at twelve sites. Of sites with plants, a moderate plant density was the most common, followed by “very light”. Few sites had very heavy or heavy density. The minimum taxa found was zero and maximum was six. Including the zeros, the average was 1.2 taxa per site. Excluding the zeros, the average was 1.9 taxa per site.

Table 3. Plant density at sample sites on Torch Lake 2021

Plant Density	Number of Sites
None	45
Very Light	20
Light	9
Light to Moderate	11
Moderate	24
Moderate to Heavy	5
Heavy	2
Very Heavy	0
Total	116

Individual sites on the Torch River Lagoon were denser and had a greater diversity of plants than Torch Lake. The majority of sites had densities between moderate and very heavy (Table 4). The minimum taxa found was one and the maximum was eight, yielding an average of 3.5 taxa per site.

Table 4. Plant density at sample sites on Torch River Lagoon 2021

Plant Density	Number of Sites
None	0
Very Light	0
Light	0
Light to Moderate	1
Moderate	11
Moderate to Heavy	9
Heavy	3
Very Heavy	1
Total	25

Plant Communities and Density

Torch Lake

Plants cover 0.38% of the Torch Lake's total lake bottom, based on this survey, and 1.91% of the littoral zone (Table 5). Muskgrass the most dominant plant community, accounting for 97.03% of the total vegetated area. It was the solely dominant species at 67.32 acres and was mixed in with other plants including pondweeds, eel grass, and common watermilfoil at 0.30 acres. Pondweed and eel grass were the next most dominant communities. Eurasian watermilfoil was only dominant in 0.01 acres. The majority of

plant communities found were considered very light, making up 61.30% of the total vegetated area (Table 6). Heavy plant communities accounted for 1.00 acres, representing 0.01% of the total lake area. Maps of plant density coverage can be found in Appendix A.

Table 5. Dominant plant communities and coverage in Torch Lake 2021.

Dominant community	Area (acres)	Percentage of Total Vegetated Area	Percentage of Total Littoral Zone Area	Percentage of Total Lake Area
None	3570.61	--	98.09	19.33
Muskgrass	67.32	97.03	1.85	0.36
Pondweed	1.24	1.79	0.03	0.01
Eel grass	0.33	0.47	0.01	0.00
Muskgrass and pondweed	0.20	0.29	0.01	0.00
Water stargrass	0.11	0.17	0.00	0.00
Muskgrass and eel grass	0.06	0.09	0.00	0.00
Muskgrass and common watermilfoil	0.03	0.04	0.00	0.00
Bulrush	0.03	0.04	0.00	0.00
Common watermilfoil	0.02	0.03	0.00	0.00
Eurasian watermilfoil (potential)	0.02	0.03	0.00	0.00
Eel grass and bladderwort	0.01	0.02	0.00	0.00
Eurasian watermilfoil	0.01	0.01	0.00	0.00
Total	3639.99			
Total with plants	69.38	1.91	0.38	

Table 6. Plant community density in Torch Lake 2021.

Density	Area (acres)	Percentage of Total Vegetated Area	Percentage of Total Littoral Zone Area	Percentage of Total Lake Area
None	3570.61	--	98.09	19.33
Very Light	42.55	61.30	1.17	0.23
Light	8.78	12.66	0.24	0.05
Light-Moderate	15.17	21.85	0.42	0.08
Moderate	1.73	2.49	0.05	0.01
Moderate-Heavy	0.17	0.25	0.00	0.00
Heavy	1.00	1.44	0.03	0.01
Very Heavy	0.00	0.00	0.00	0.00
Total	3640.02			

Torch River Lagoon

Plants covered 37.63% of the Torch River Lagoon (

Table 7). Muskgrass was the solely dominant species at 4.09 acres. It accounted for another 1.05 acres mixed in with pondweed and eel grass. Two invasive species were found to be dominant in certain areas. Eurasian watermilfoil was dominant over 0.042 acres (0.25% of the total lagoon) and purple loosestrife was dominant over 0.001 acres (0.01% of the total lagoon). The majority of plant communities found were very light, similar to the rest of Torch Lake (Table 8). However, heavy and very heavy plant communities account for 0.65 acres, amounting to 3.93% of the total lagoon area.

Table 7. Dominant plant communities and coverage in the Torch River Lagoon 2021.

Dominant Community	Area (acres)	Percentage of Total Vegetated Area	Percentage of Total Lagoon Area
None	10.323	165.72	62.37
Muskgrass	4.085	65.57	24.68
Muskgrass, Pondweed, Eel Grass	0.864	13.86	5.22
Yellow Pond-lily	0.533	8.55	3.22
Elodea	0.465	7.46	2.81
Muskgrass and Pondweed	0.189	3.03	1.14
Eel Grass	0.043	0.68	0.26
Eurasian Watermilfoil	0.042	0.67	0.25
Burr-Reed and Bulrush	0.007	--	0.04
Three-square Bulrush	0.002	0.04	0.01
Purple Loosestrife	0.001	0.02	0.01
		0.00	0.00
Total	16.55		
Total with plants	6.23	37.63%	

Table 8. Plant community density in the Torch River Lagoon 2021.

Density	Area (acres)	Percentage of Total Vegetated Area	Percentage of Total Lagoon Area
None	10.32	--	62.30
Very Light	0.00	0.00	0.00
Light	0.00	0.04	0.01
Light-Moderate	0.38	10.95	2.30
Moderate	2.39	68.62	14.40
Moderate-Heavy	2.83	81.26	17.05
Heavy	0.61	17.51	3.67
Very Heavy	0.04	1.23	0.26
Total	16.57		

Discussion

This survey focused on the littoral zone, or shallow transition area between the shoreline and deeper water, on Torch Lake (Figure 3. Diagram of lake zones from WisconsinLakes.org). The littoral zone typically provides enough light and nutrient-rich sediment for plants to grow. Torch Lake's littoral zone is characterized mostly by sand and some areas of rock. There is very little debris or soft sediment for plants to root into in the majority of the lake. Torch Lake is also oligotrophic, meaning it has very little nutrients in the water column. Torch Lake measures two miles wide at the widest point and nineteen miles long. The lake's long fetch (the lake surface over which wind blows) may create enough wave action to prevent plants from rooting. The factors above may be contributing to extremely low abundance and diversity of plants.

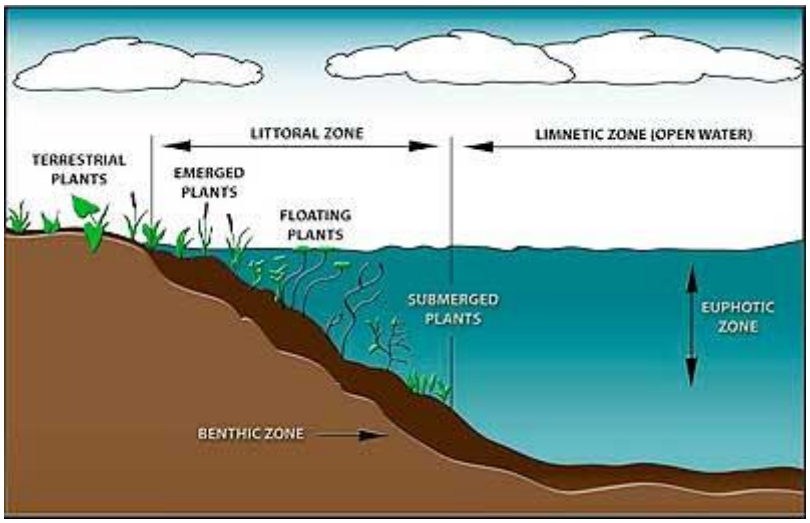

Figure 3. Diagram of lake zones from WisconsinLakes.org

In addition to focusing on the littoral zone, special attention was paid to public accesses, marinas, and camps/clubs. As boating is the main transporter of invasive species on inland lakes in Michigan, accesses that allowed more users would have a greater chance of having invasive species present. Only two public accesses had invasive species: Alden Harbor and Butch's Marina. Both of these areas are likely dredged, causing a great disturbance of the soil, and they are both well protected from wave action. The substrate disturbance and protection likely makes these two areas easy to colonize for invasive species. Other major accesses that were checked include Eastport Landing, Village of

Torch Lake Boat Launch, YMCA Camp Hayo-Went-Ha, Torch Lake Yacht and Country Club, public access off of NW Torch Lake Dr, and the Torch River Bridge DNR Launch. While these sites were open to many users, their substrate was not suitable for many plants. Eastport Landing had the most plants with a few small patches of pondweeds.

River and stream inlets were another source of focus owing to their propensity to add nutrients and sediment to the lake. Eastport Creek had a few pondweeds located about 250 feet southeast of its outlet (also near the Eastport Landing access). Wilkinson Creek did not have any plants associated with its outlet. The Clam River outlet did not yield any plants, even though it is Torch Lake's largest inlet. Spencer Creek enters Torch Lake to the north of Alden Harbor. It was difficult to get the Watershed Council boat near the shore there due to the public swimming area and rocks. No plants were observed from shore.

The many spit formations (points) of Torch Lake's gently undulating shoreline protected the lake bottom on their leeward sides and provided an accumulation spot for sediment on windward sides. Many points had accumulated debris, but only a few had plant communities taking advantage of the suitable habitat. Points with plant communities include Sand Point, the unnamed point near the terminus of Sutter Rd., French Point, and Deepwater Point. The areas with the greatest densities of sample points with plants were the northwest and southwest corners of the lake. The northeast side had the greatest expanses of areas with no plants. More plants were found on the southeast side (south of Clam Lake to the sandbar) than on the majority of the west side. The highest plant densities and invasive species were concentrated in calm, harbor areas and along obstructions that could cause sediment to accumulate.

Comparison to Other Lakes

Tip of the Mitt Watershed Council has performed plant surveys on 18 other lakes in Northern Michigan since 2005 (Table 9). Torch Lake was below average in all categories of comparison. It has fewer total taxa in the lake, fewer total taxa per sampling site, a smaller vegetated area, and fewer densely vegetated sites than all other lakes surveyed.

Torch Lake was most similar to Elk Lake (surveyed in 2015), which also had a small vegetated area and few densely vegetated sites.

Table 9. Comparison of vegetation surveys conducted in Northern Michigan.

Lake Name	Survey Year	Lake Size (acres)	Max Depth (ft)	Total Taxa In Lake	Taxa Average Per Site	Vegetated Lake Area	Densely Vegetated Sites[†]
Adams	2010	43	18	27	4.9	99%	66%
Bellaire	2013	1810	95	27	2.9	18%	8%
Black	2014	10,133	50	38	3.9	18%	15%
Clam	2013	446	27	28	4.1	69%	43%
Crooked	2008	2,351	50	28	2.8	56%	13%
Elk	2015	8194	195	27	0.6	4%	0.5%
Hanley	2014	89	27	29	6.3	94%	34%
Intermediate	2014	1,570	70	30	2.7	23%	1%
Larks	2020	600	9	24	1.8	36%	10%
Long	2013	398	61	30	3.9	29%	11%
Douglas	2019	3,780	80	22	5.7	22%	33%
Millecoquins	2005	1,116	12	20	6	95%	61%
Mullett	2007	17,205	144	42	3.1	19%	13%
Paradise	2008	1,947	17	24	5	58%	28%
Pickerel	2008	1,083	70	20	1.5	24%	5%
Skegemog	2014	2,766	29	30	2.2	67%	0%
Torch	2021	18,473	300	16	1.2	<1%	0%
Walloon	2013	4,620	100	32	1.8	22%	3%
Wycamp	2006	689	7	35	4.9	83%	24%
AVERAGE	NA	NA	NA	28	3.6	48%	20%

**All surveys performed at least in part by TOMWC.*
[†]*Includes sites with plant density classified as heavy or very heavy compared to all sites. (including where no plants were found).*

Comparison to Previous Plant Surveys on Torch Lake and the Torch River Lagoon

In 2012, 23 sites were monitored for aquatic plants on Torch Lake by TLA interns (Sierra , Stillwell, & Pedersen, 2012). The 2012 survey found only eight species in the lake. The 2021 survey identified an additional eight species for a total of sixteen. GPS points provided by TLA were imported into ArcGIS using the XY Table to Point tool. It is

likely that some GPS points were collected using equipment with less accuracy or a different coordinate system, as two points showed up on the map on land, rather than on water. During analysis of plants identified in 2012 compared to 2021, if points were within a few hundred feet of each other, they were assumed to be relatively in the same community. The shorelines of Torch Lake and the Torch River were surveyed by Tip of the Mitt Watershed Council for invasive species only in 2015. That survey found 21 locations with invasive species (five Eurasian watermilfoil, one narrow-leaf cattail (*Typha latifolia*), and fifteen purple loosestrife (Tip of the Mitt Watershed Council, 2015). The 2015 survey also found fourteen locations of purple loosestrife along a one-mile stretch on Torch Lake's western shore, centered directly across from the Clam River. Torch Lake was surveyed by CAKE CISMA in 2019 for purple loosestrife and *Phragmites* (CAKE CISMA, 2021). CAKE CISMA found neither of each invasive species on the lake. The 2021 survey conducted by the Watershed Council had the same result. For areas where data was available in previous surveys and reports, comparisons were made over time to determine differences in coverage, density, and plant species found (Table 10).

Table 10. Comparison of plant locations and species from 2012, 2015, and 2021

General Location and First Observation Site ID	2012 Species Present	2015	2021 Species Present	Change in Plant Community
Outlet of Clam River (T1, T3)	Muskgrass (*Chara spp.*) and wild celery (*Valisneria americanum*)	No data	None	Decrease in species and extent
Stoney Point/Long Tree Point Embayment (T4, T5)	Eurasian watermilfoil (*Myriophyllum spicatum*) and pondweeds (*Stuckenia* and *Potamogeton spp*.)	18,000 sq. ft. of Eurasian watermilfoil, heavy density.	Eurasian watermilfoil, approx. 10 sq. ft., light-moderate density. Pondweeds and muskgrass.	17,990 sq. ft. reduction in invasive species coverage
South of Lone Tree Point (T6, T7)	Large-leaved pondweed (*Potamogeton amplifolius*)	No data	Same as 2012	None
T8	Muskgrass (*Chara spp.*) and Thin leaf/Sago pondweed (*Stuckenia spp.*)	No data	Same as 2012	None
Alden Harbor (T10)	Eurasian watermilfoil (*Myriophyllum spicatum)*, pondweeds (*Potamogeton spp.*), and Wild celery (*Valisneria americanum*	Eurasian watermilfoil, total area of 2,050 sq. ft. ranging from light to moderate	Eurasian watermilfoil, total area 50 sq. ft., light density. Same native plants as 2012 plus, common watermilfoil (*Myriophyllum sibiricum*).	2000 sq. ft decrease in invasive species coverage plus greater plant diversity
Sand Sucker Holes (T12)	Muskgrass (*Chara spp.*), Thin leaf pondweed (*Stuckenia spp.*), Flat-stem pondweed (*Potamogeton zosteriformis*), Wild celery (*Valisneria americanum*), and Clasping-leaf/Richardson's	No data	American waterweed (*Elodea canadensis*) and Muskgrass (*Chara spp.*)	Decrease in species and extent

	pondweed (*Potamogeton richardsonii*), and Illinois pondweed (*Potamogeton illinoiensis*)			
Outlet of Torch Lake near Torch River (T13, T14, T15, T16)	Muskgrass (*Chara spp*), Thin leaf pondweed (*Stuckenia spp*), Wild celery (*Valisneria americanum*), and American pondweed (*Elodea Canadensis*)	No data	Water Stargrass (*Heteranthera dubia*), Muskgrass (*Chara spp.*), and Large-leaved Pondweed (*Potamogeton amplifolius*)	Different species, extent unknown
T17	Muskgrass (*Chara spp.*)	No data	Muskgrass (*Chara spp.*) (likely) and golden-brown algae	None
T18	Muskgrass (*Chara spp.*)	No data	None	Decrease in species and extent
T19, T20, 21	Muskgrass (*Chara spp.*)	No data	Muskgrass (*Chara spp.*), Large-leaved Pondweed (*Potamogeton amplifolius*)	One new species
T22	Muskgrass (*Chara spp.*) and Thin leaf/sago pondweed (*Stuckenia spp*)	No data	Same as 2012	None
T23	Muskgrass (*Chara spp.*)	No data	Same as 2012	Continues to be *Chara*
T24	Muskgrass (*Chara spp.*) and Thin leaf/sago pondweed (*Stuckenia spp.*)	No data	Muskgrass (*Chara spp.*)	Decrease in species
	No data			

TL100 (44.8882157, -85.2745746)	No data	150 sq. ft. of narrow-leaf cattail, moderate density	Not checked	Unknown, ubiquitous species
Marina between Torch River and Torch River Lagoon (TR100)	No data	100 sq. ft. of curly-leaf pondweed, light	2047 sq. ft. curly-leaf pondweed, moderate	1,937 sq. ft. increase, increase in density
Torch River Lagoon (TR 102, TR50, TR51)	No data	185 sq ft. of curly-leaf pondweed, light-moderate	Very light density	Extent and density significantly decreased
Torch River Lagoon (TR5, TR6, TR7, TR8, TR103, TR105)	No data	2302 sq. ft. purple loosestrife, light-moderate density	Only found in two locations on northwest shore	Extent and density significantly decreased
Torch River (TR2, TR3, TR101)	No data	~200 sq. ft. between Torch Lake and Torch River Lagoon	Not observed	Appears eradicated from Torch River in this area
Torch River Lagoon (TR104)	No data	500 sq. ft., heavy density	Not checked	Unknown, ubiquitous species

The Michigan Department of Environment, Great Lakes, and Energy (EGLE) surveyed Torch Lake in 2015. EGLE surveys 10-20 inland lakes annually with a focus on ones at high risk for species on Michigan's watch list. Their protocol employs a lake meander with rake tosses, visual observations, and targeted snorkeling/wading at sites with high likelihood of having invasive species, such as boat launches and inlets. While looking for species on Michigan's watch list, surveyors also note native species and common invasive species. In 2015, surveyors found Eurasian watermilfoil at the Stoney Point/Long Tree Point Embayment and Alden Harbor (Michigan Department of Environment, Great Lakes, and Energy, 2022). They found one additional native plant species (arrowhead or *Sagittaria sagittifolia)* that was not found in the Watershed Council's 2021 survey. EGLE also found banded mystery snails (*Viviparus georgianus),* round gobies (*Neogobius melanostomus),* Quagga mussels (*Dreissena bugensis),* zebra mussels (*Dreissena polymorpha),* and the rusty crayfish (*Faxonius rusticus*).

The only invasive species observed by the Watershed Council in 2021 that was not previously known about was Eurasian watermilfoil in the marina between the Torch River and Torch River Lagoon. This likely was colonized from Eurasian watermilfoil that was found in the Torch River in 2015.

Assessment of Invasive Species Treatments

The Watershed Council was able to find records of recent invasive species treatments from TLA, CAKE CISMA, and MiWaters (a website run by the state of Michigan containing permits and compliance related to water regulations). These records were compared with observations by lake association volunteers and Watershed Council staff observations. Eurasian watermilfoil appears to be eradicated in the sand sucker holes. The remaining sites with Eurasian watermilfoil are being managed well with current treatment methods and no new sites were found during surveys. Some sites have only a few plants, but they remain significant because single plants have the ability to produce large colonies by spreading shoots underground. 175 sq. ft of Purple loosestrife was treated in the Torch River Lagoon in 2021 a few weeks after Watershed Council staff surveyed the area. Table 11 contains a summary of recent invasive species treatments and outcomes.

Table 11. Recent invasive species treatments and post-observations.

Location	Notes
Clam River Boatwell (44.9419, -85.2828)	Eurasian watermilfoil last treated 8/20. Observed to be "widespread but thin" 6/21. 10-20 plants found 9/21.
Butch's Marina (44.9422, -85.2836)	Eurasian watermilfoil last treated 9/20. Observed to be "widespread but thin" 6/21. Covers three slips at end of dock starting at second one in 8/21.
Stoney Point/Long Tree Point Embayment (44.9422, -85.2911)	Eurasian watermilfoil last treated 9/20. Observed to be "much reduced and thin" 6/21. Less than 10 stems found 9/21.
Old Boiler (44.8849, -85.2801)	Eurasian watermilfoil last treatment unknown. Observed 6/21 "much reduced, moderate." At least 25 stems or plants observed 8/21. EWM surrounds boiler, clustered at each end.
Alden Harbor (44.8809, -85.2781)	Eurasian watermilfoil last treated 9/20. Observed 6/21 to be a few scattered strands. 8/21 observed only at end of lighthouse approx. 40 ft south.
Sandbar-Sucker Holes (44.8538, -85.317)	Eurasian watermilfoil last treated 6/20. No EWM observed 6/21 or 8/21. Overall footprint of vegetated area appears to have gotten smaller over time.
Torch Lagoon (44.8507059, -85.32426590	Purple loosestrife last treated by CAKE CISMA 8/21. No post-treatment observations.

Conclusion

The whole-lake survey of plants found 16 different plant taxa in Torch Lake and 20 in the Torch River Lagoon. Plants ranged in density on Torch Lake from none to heavy, with the majority of sites surveyed having no plants. Over 116 survey sites, the average number of plants per site was 1.2 taxa. Plants were found to cover 0.38% of Torch Lake's total bottom and 1.91% of the littoral zone. Eurasian watermilfoil was only dominant over 4356 sq. ft. Plants ranged in density on the Torch River Lagoon from light-moderate

to very heavy. Over 25 survey sites, the average number of plants per site was 3.5 taxa. Eurasian watermilfoil was only dominant over 1829.52 sq. ft. Compared to eighteen other lakes in Northern Michigan surveyed by the same methods, Torch Lake was below average in all categories of comparison including fewer total taxa per sampling site, a smaller vegetated area, and fewer densely vegetated sites. Ongoing treatments for Eurasian watermilfoil and curly-leaf pondweed were successful, as reduced populations were found compared to previous survey efforts. This survey found the highest number of taxa compared to previous surveys; however, comparisons between earlier plant communities showed decrease diversity and extent.

Water quality monitoring carried out weekly each summer by volunteers through the Watershed Council's Volunteer Lake Monitoring Program and every three years by Watershed Council staff in the Comprehensive Water Quality Monitoring Program shows Torch Lake is an oligotrophic lake with very high water quality, low nutrients, and little productivity (Tip of the Mitt Watershed Council, 2021) (Figure 4). Vegetation is typically an important factor in water quality as it can take up nutrients and reduce wave action along shorelines to keep erosion at bay. Water clarity influences the depth at which plants can grow and plants can improve water clarity by trapping sediment and nutrients. Due to having such a small area covered in plants, vegetation on Torch Lake is unlikely to play a significant role in the overall lake water clarity and quality. Likely land use plays a more significant role in the health of the lake, making shoreline best practices even more important. Torch Lake may be at an equilibrium, maintaining an ecosystem nearly unchanged from its origins as part of Lake Michigan. Invasive species could change the ecosystem for the worse, which makes continued management efforts so paramount.

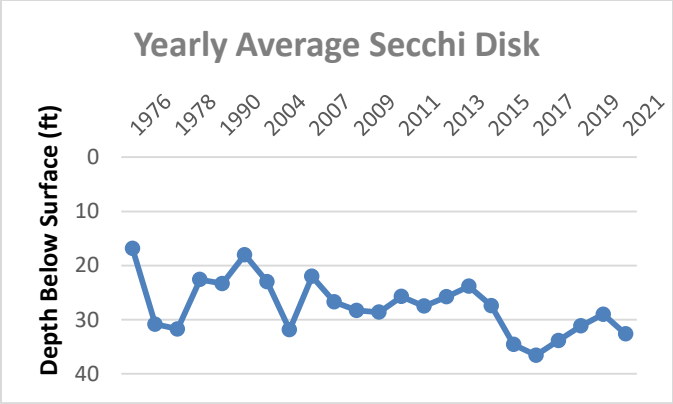

Figure 4. Secchi disk transparency readings greater than 15 feet deep are considered oligotrophic. Torch Lake's longest monitored site has gotten steadily clearer since 1976.

Recommendations

1. Share the results of the survey with Three Lakes Association; Torch Lake Protection Alliance; Dole Family Foundation; the Charlevoix, Antrim, Kalkaska, Emmet (CAKE) Cooperative Invasive Species Management Area (CISMA); Paddle Antrim; and the Elk River Chain of Lakes Watershed Protection Implementation Team.

2. Provide information to riparian land owners from local and state-wide invasive species and landscape practices resources, for instance, the MI Shoreland Stewards program.

3. Encourage lake association board members and riparian land owners to attend educational programs about invasive species and lake health.

4. Maintain invasive species signage and handouts at boat launches and public accesses.

5. Continue working with mobile boat wash station groups such as Tip of the Mitt Watershed Council and Clean Boats, Clean Waters to offer boat wash station and education opportunities.

6. Use the Midwest Invasive Species Information Network (MISIN) app and website to report sightings on invasive species. Ensure data in this report is sent to MISIN.

7. Lake associations should consider getting an administrative treatment account in MISIN so their treatment information can be uploaded.

8. Maintain a crew of volunteers that can respond to invasive species sightings around the lake.

9. Continue efforts to treat small patches of invasive species.

10. Continue annual surveys of known invasive species locations.

11. Due to the size of Torch Lake, consider breaking up future comprehensive surveys into smaller parts and/or use existing imagery from the state of Michigan.

12. Periodically survey known patches of invasives with drone imagery every 2-4 years.

13. More frequently assess calm areas (i.e. boatwells, Torch River Lagoon, Alden Harbor, northwest corner, and southwest corner) than areas with a lot of wave action like the sand bar and northeast side.

14. The Watershed Council and lake associations should continue to comment on water resource permits for projects that disrupt the lake bottom (e.g. dredging) as those areas are more prone to invasive species colonization.

15. Work with marina between Torch River and Torch River Lagoon to treat Eurasian watermilfoil and curly-leaf pondweed.

16. Repeat this survey comprehensively every 10-15 years to look for trends.

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Appendix A. Torch Lake 2021 Survey Points and Resulting Dominant Plant Communities

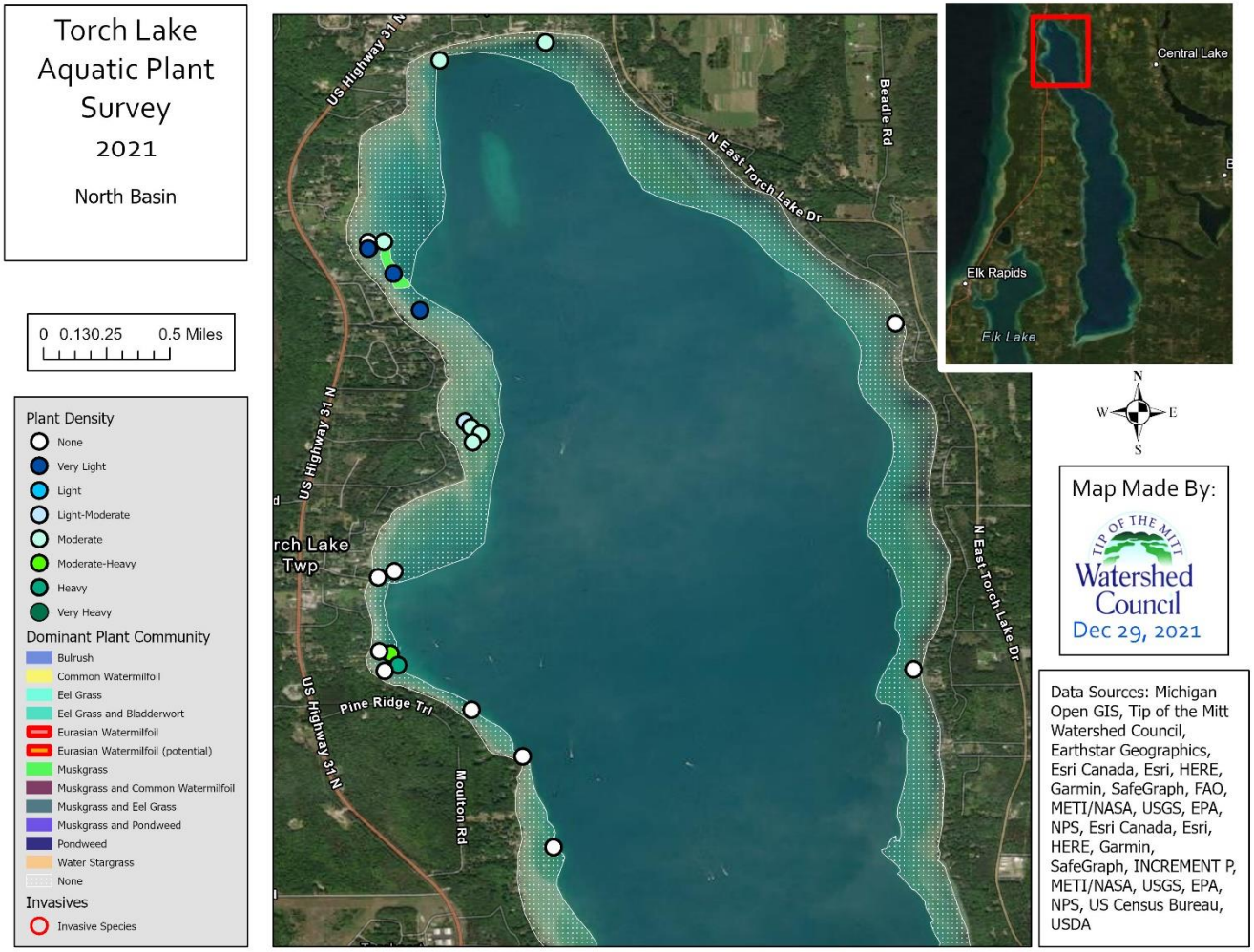

Figure 5. Survey points and dominant plant communities on Torch Lake's north basin.

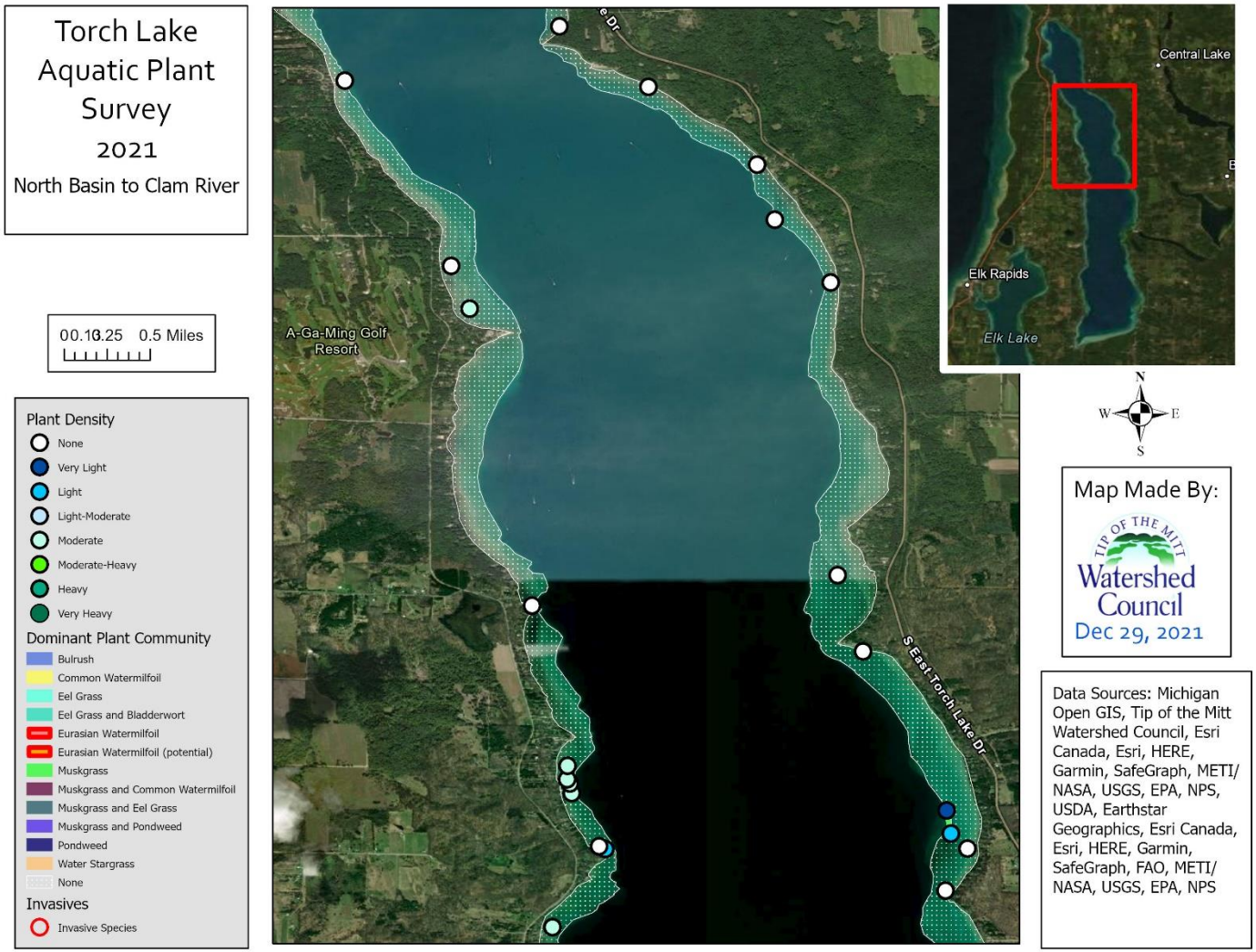

Figure 6. Survey points and dominant plant communities from Torch Lake's north basin to the Clam River.

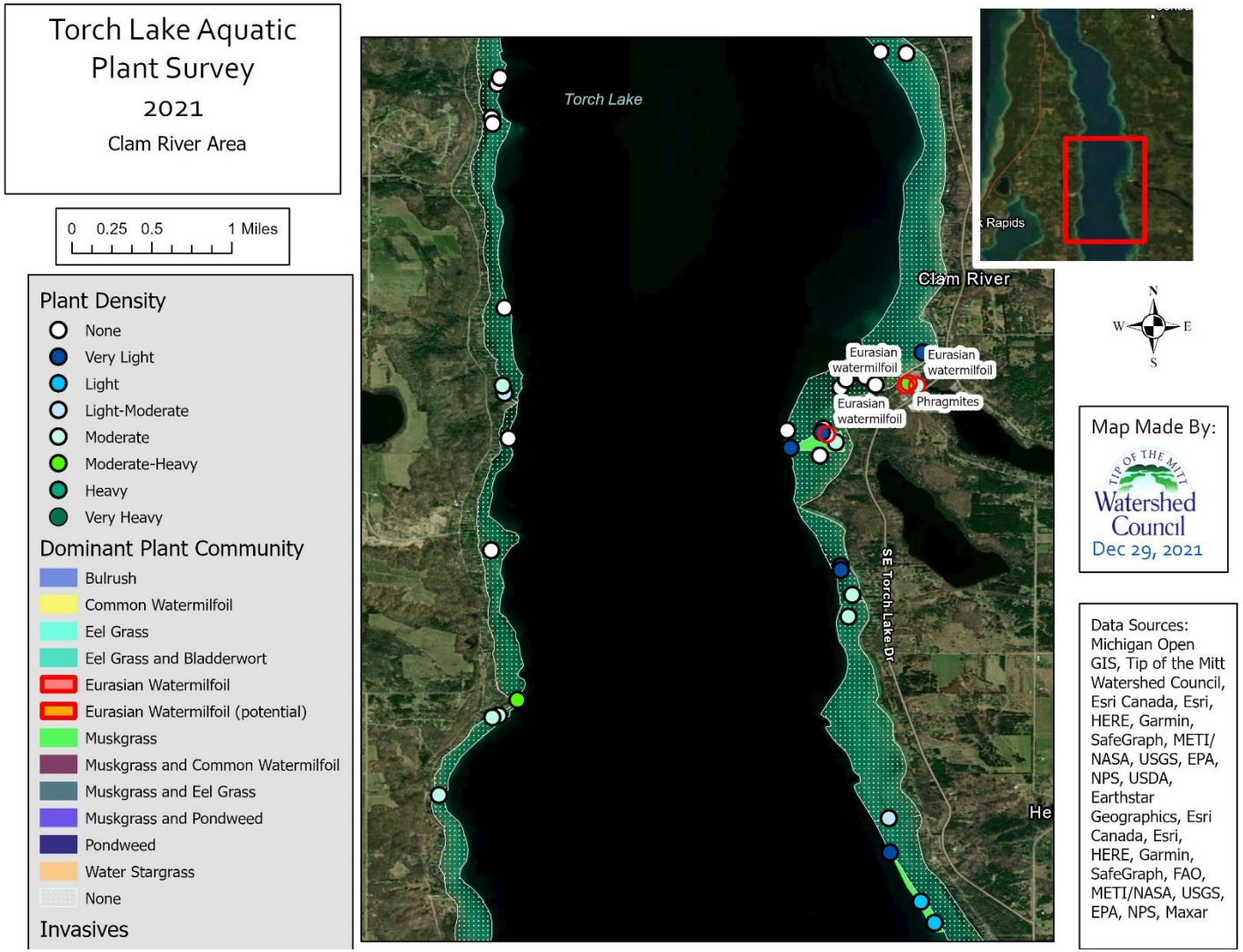

Figure 7. Survey points and dominant plant communities near the Torch Lake's Clam River inlet.

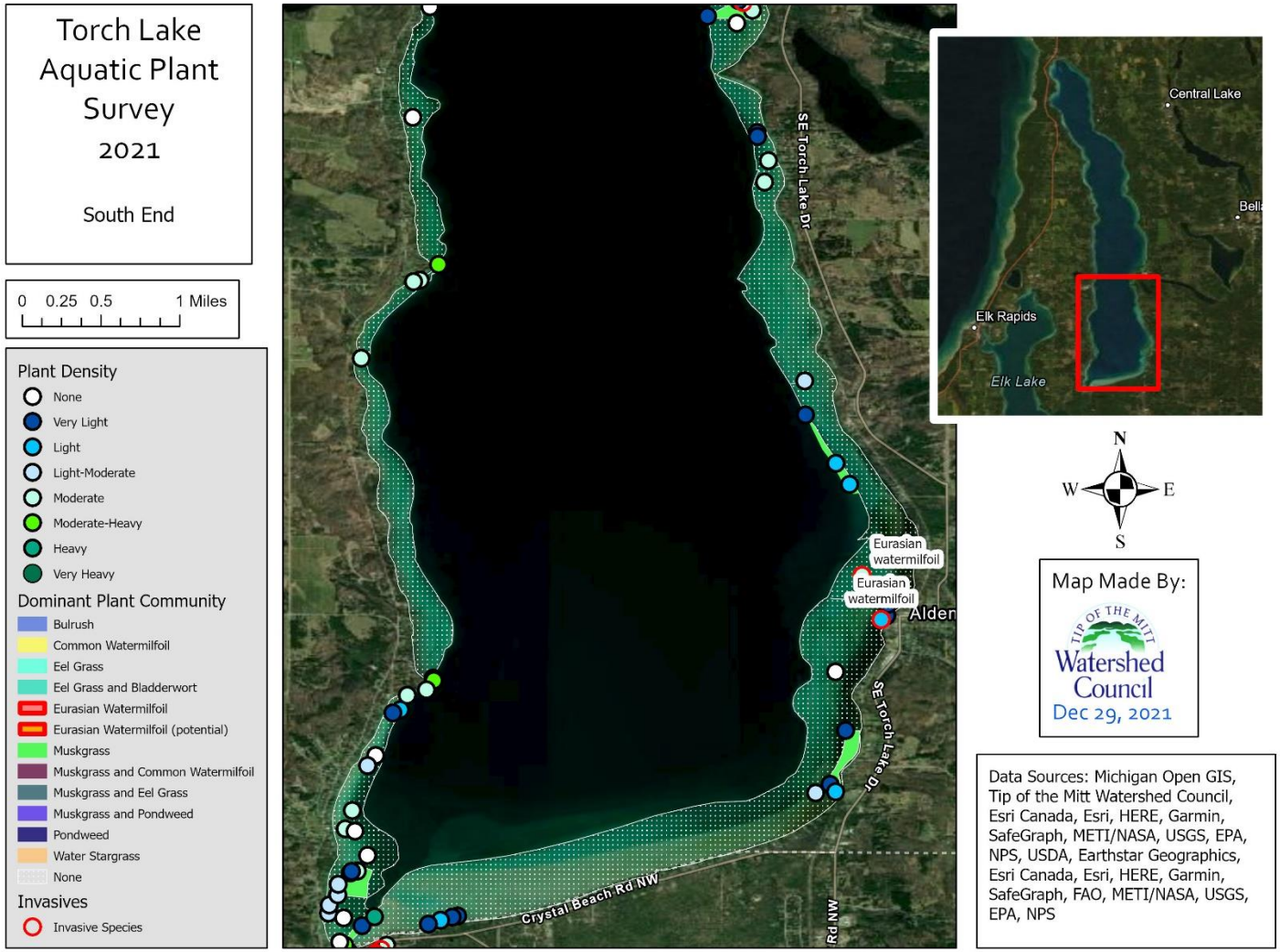

Figure 8. Survey points and dominant plant communities in Torch Lake's south end.

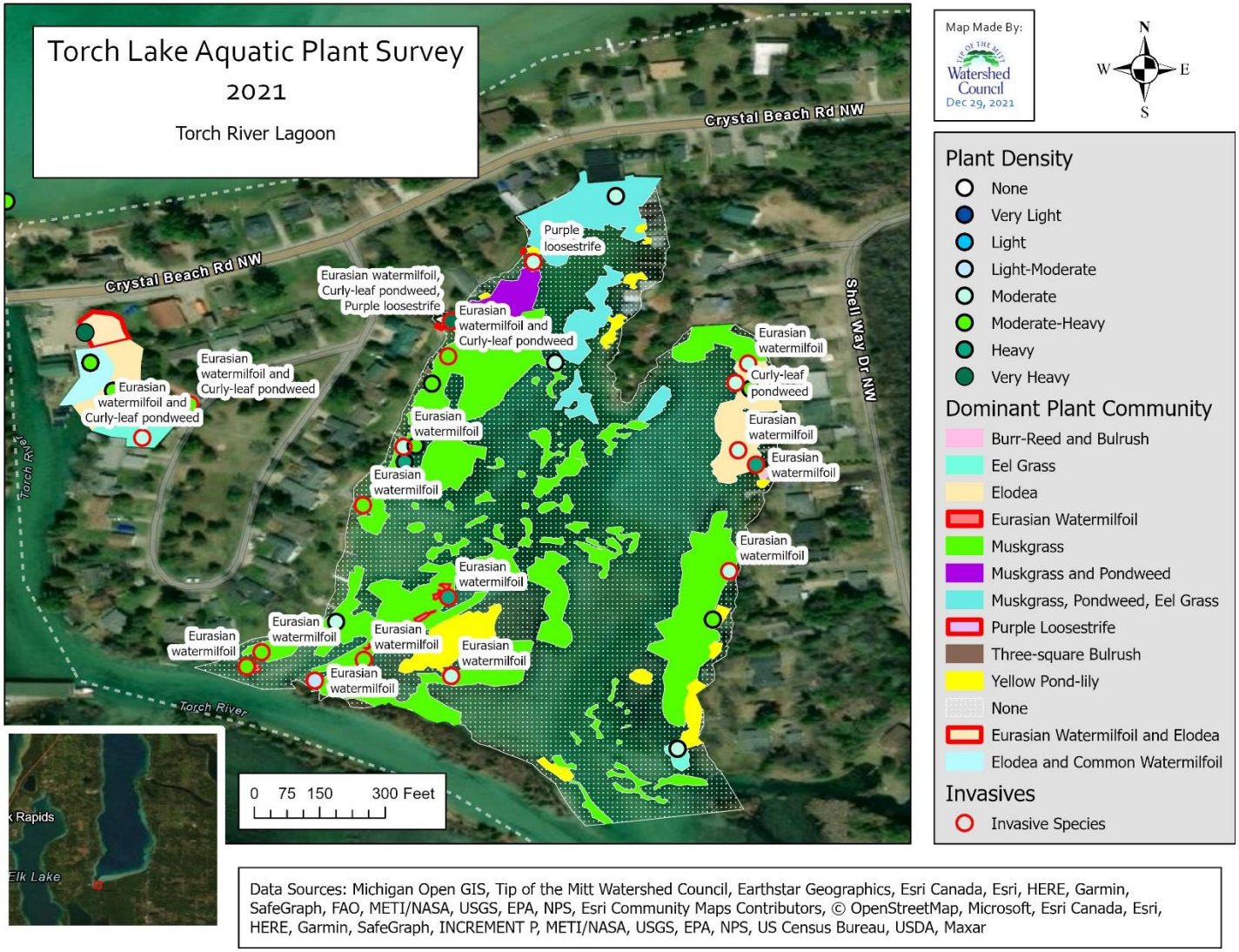

Figure 9. Survey points and dominant plant communities in the Torch River Lagoon.

Appendix B. Aerial view of invasive species.

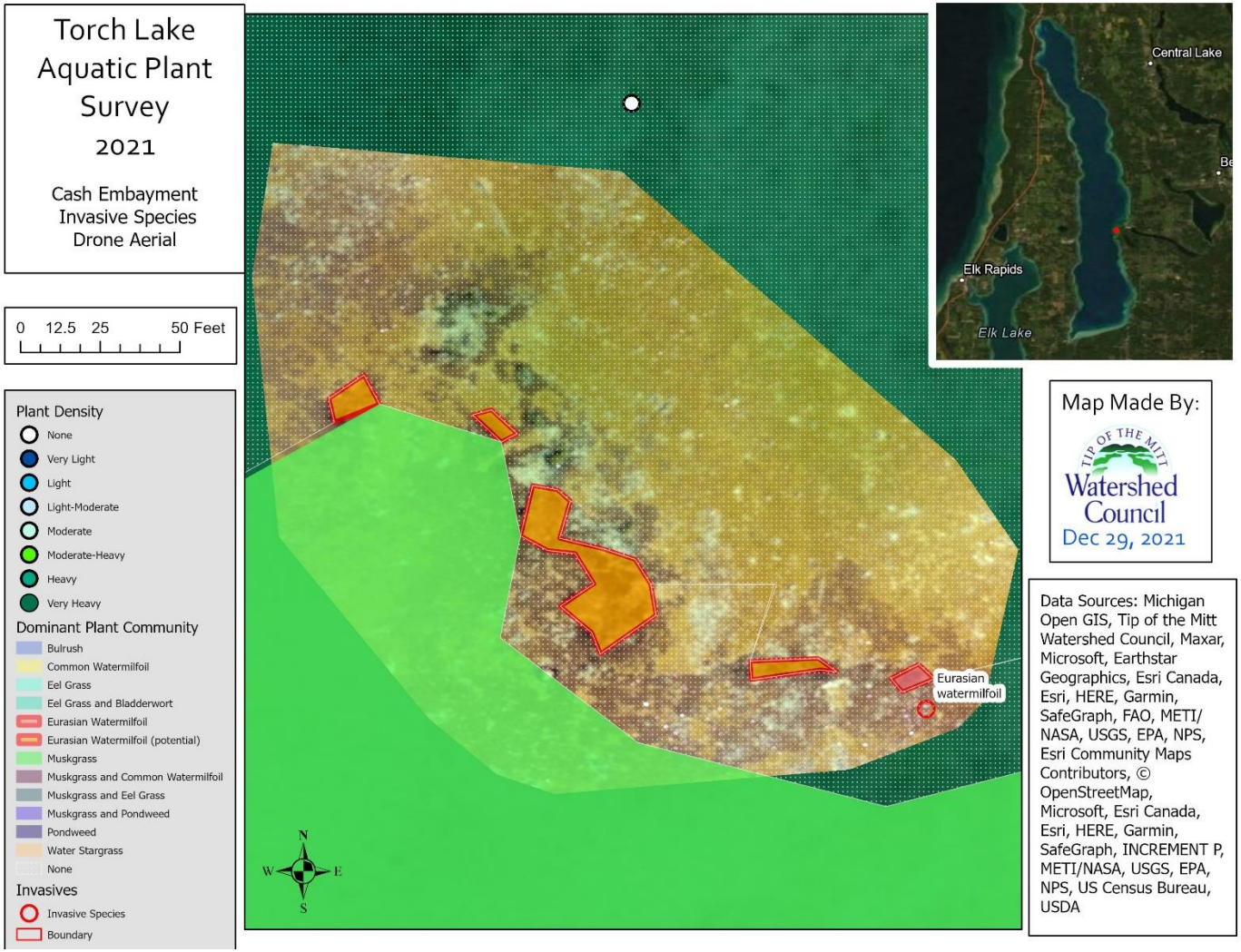

Figure 10. Invasive species digitized from drone aerials in the Stoney Point/Long Tree Point Embayment.

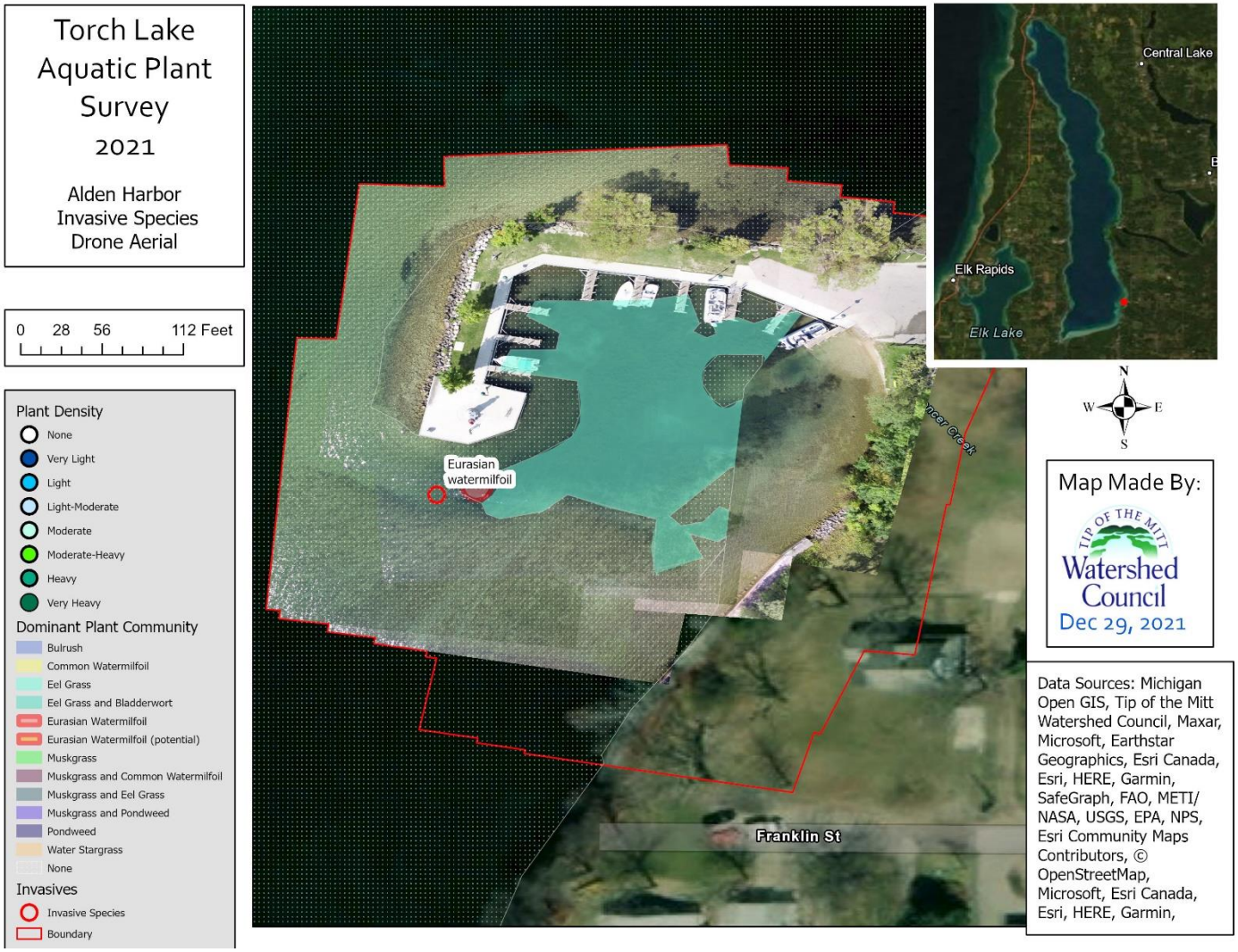

Figure 11. Invasive species digitized from drone aerials in the Alden Harbor.

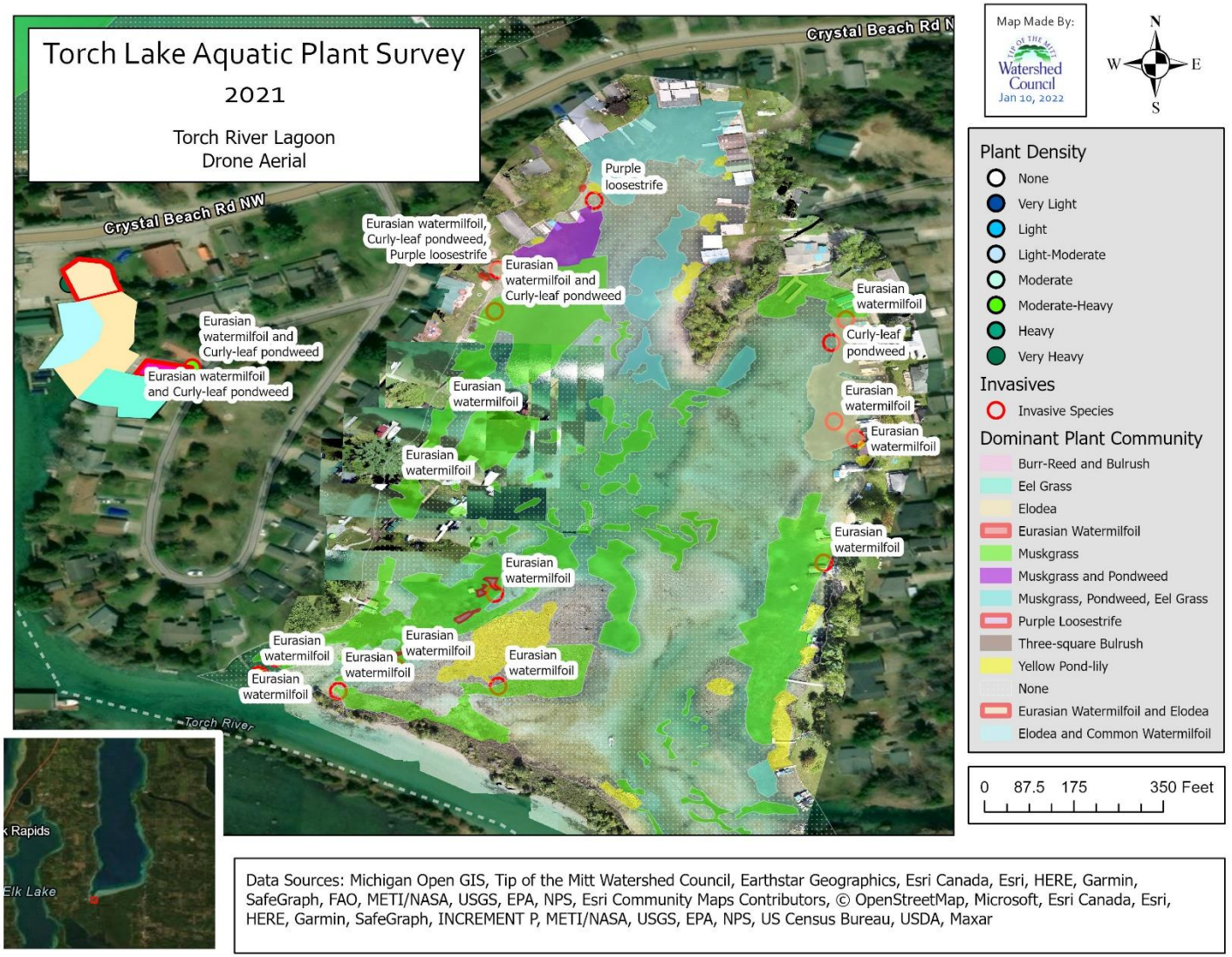

Figure 12. Invasive species digitized from drone aerials in the Torch River Lagoon.

Appendix **C. Raw invasive species survey data.**

CreationDate	Lake Name	Site ID	Water Depth (ft)	Comments	Invasive	Latitude	Longitude
2021-08-03 22:31:31	Torch Bayou	1	4	Really small variety of flat leafed pondweed close to shore. Vegetation extemds fro, the shoreline for about 30 ft. Two small patches of chara on their own about 20-30 ft from shore.	Eurasian watermilfoil	44.84912285	-85.3252774
2021-08-03 22:31:33	Torch Bayou	3	4	Some stems	Eurasian watermilfoil	44.84949044	-85.32502267
2021-08-03 22:31:41	Torch Bayou	6	5	Water marigold could be water crowfoot. Just some stems of CLP. Took a sample to double check EWM. 11-19-21 double checked by CK. 13 pairs of leaflets and limp.	Eurasian watermilfoil and Curly-leaf pondweed	44.85005873	-85.3247423
2021-08-03 22:31:50	Torch Bayou	7	2	Eleocharis is what is suspected in picture 1. Also sedge here. Purple loosestrife found. Add pt digitize.	Eurasian watermilfoil, Curly-leaf pondweed, Purple loosestrife	44.85027905	-85.32472227
2021-08-03 22:31:57	Torch Bayou	13	5	12-15-21 CK changed P. robbinsii to P. Richardsonii.	Eurasian watermilfoil	44.85001402	-85.32285872
2021-08-03 22:31:59	Torch Bayou	15	3	Took a sample of pondweed leaves. CK checked leaves on 11/29/21. Likely P. strictifolius based on sharp tip. Not found in this county previously. Should recheck. Added P. strictifolius to this record. Kept sample.	Eurasian watermilfoil	44.84946856	-85.32292058
2021-08-03 22:32:01	Torch Bayou	16	3	Few stems of eurasian water milfoil. CK changed P. robbinsii to P. richardsonii due to name swap.	Eurasian watermilfoil	44.84937695	-85.32280851
2021-08-03 22:32:02	Torch Bayou	17	2	Took a sample of a pondweed sp. Ck chcekd 11/29/21. Very mucronate tip. Need to measure width. either P. friesii or P. obtusifolius. No changes made to record. Saved sample.	Eurasian watermilfoil	44.84871004	-85.32297741
2021-08-03 22:32:05	Torch Bayou	20	2	Lily feet is 100 ft in diameter in log patch area. Southern part of lily patch has heavy chara. Rest of lily patch ewm is moderate. Took a sample of milfoil. Bulrushes all along the point on the torch river. CK 11-30-21 checked EWM sample. It has 13-14 leaflets on each side and a clipped top. Still EWM.	Eurasian watermilfoil	44.84804984	-85.32472386
2021-08-03	Torch	21	12	Just a few stems of ewm	Eurasian watermilfoil	44.84802264	-85.32557982

22:32:06	Bayou						
2021-08-03 22:32:09	Torch Bayou	22	3	Ck 12-15-21 changed P. robbinsii to P. richardsonii due to name swap.	Eurasian watermilfoil	44.84819963	-85.32591577
2021-08-03 22:32:10	Torch Bayou	23	3	Large 20ft patch of dense EWM	Eurasian watermilfoil	44.84810981	-85.32600763
2021-08-03 22:32:12	Torch Bayou	25	20	Large (~40ft) patch of EWM	Eurasian watermilfoil	44.84854538	-85.32474247
2021-08-03 22:32:13	Torch Bayou	26	15	Surrounded by chara. Long narrow strip of EWM	Eurasian watermilfoil	44.8481521	-85.32527346
2021-08-03 22:32:16	Torch Bayou	27	3	EWM at end of dock, curly leaf pondweed in each slip, narrowleaf pondweed throughout. Ck changed P. robbinsii to P. richardsonii due to name swap.	Eurasian watermilfoil and Curly-leaf pondweed	44.84975703	-85.32636361
2021-08-03 22:32:17	Torch Bayou	28	3	What we identified as eel grass may be somthing else. Has crunchy and curly aesthetic. CK 11-30-21 checked sample. Not in good enough shape to ID. Looked up pics and still believe it is eel grass.	Eurasian watermilfoil and Curly-leaf pondweed	44.8495479	-85.32666335
2021-08-04 22:21:07	Torch Lake	41	4	10 stems or so. About a 12-15 ft diameter circle of EWM patch	Eurasian watermilfoil	44.88093259	-85.27830748
2021-08-04 22:21:11	Torch Lake	43	10	No samples. Patch is 12x12'. Very dense patch with at least 25 stems/plants. Pretty tall. Two big clusters one at each end. Ewm surrounds boiler.	Eurasian watermilfoil	44.88497477	-85.28007346
2021-09-01 21:06:58	Torch Lake	61	5.1	Ewm less than 10 stems. Cash embayment 1 site. Robbinsi has two-ranked leaves and boat tip. Nothing to north v rocky. Chara is there. Eel grass pieces found in west. CK doublechecked pic 120921. Boat tip, persistent stipule, and clasping stem makes it P. praelongus. Changed from P. Robbinsii.	Eurasian watermilfoil	44.93749359	-85.29099173
2021-09-08 14:22:33	Clam River	128	2.9	10-20 plants in private boat well	Eurasian watermilfoil	44.94189413	-85.28283027
2021-09-08 17:45:38	Clam River	66.1	3	Covers three slips starting at second one in. As far as I can tell. Pontoons are over the ewm.	Eurasian watermilfoil	44.94212018	-85.28358666