HIGGINS LAKE AQUATIC PLANT SURVEY

2017 and 2018 Results

Prepared for:

The Higgins Lake Foundation

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Higgins Lake is an iconic example of the lake systems located in Michigan's northern lower-peninsula. Lakes in this region were formed as Pleistocene glaciers retreated, leaving behind large ice blocks embedded in deep deposits of sand and gravel. The sand/gravel surface geology provides for active groundwater flow as well as expansive shallow areas, ideal for recreational activities.

However, Higgins Lake, like all lakes in the region, has been broadly impacted by human activity. Beginning with the logging era, northern Michigan lakes have experienced a continual addition of sediment and nutrients, particularly phosphates. Work completed on nearby Douglas Lake identified a distinct shift in conditions during the early 1900s. The presence of charcoal in the associated sediment horizon indicates that the shifts occurred during the end of the logging era when large wildfires swept across the region.

More recently, phosphate, most likely derived from residential septic systems and transported via groundwater to the shallow areas of the lake, has steadily increased since the late 1990s (Martin, Kendal, and Hyndman). The addition of nutrients drives many of the biological process that are symptomatic of the process of eutrophication; increasing algal growth with a shift toward blue-green algae, increased macrophyte growth, particularly aggressive invasive species such as Eurasian milfoil, and the accumulation of organic sediments.

In Higgins Lake, the response by aquatic plants to nutrient addition may be amplified by improved water clarity resulting from the introduction of zebra mussels. The combination of factors may allow for increased plant biomass and the expansion of plant beds into deeper regions of the lake.

The purpose of this study was to develop baseline data on the current distribution and abundance of aquatic plants in Higgins Lake. This preliminary report provides a summary of plant surveys that were conducted along 21 transects located around the lake.

Submergent Macrophyte Community Assessment

A. Characterize the Current Aquatic Plant Community

The original work plan had indicated that I would establish 20 transects for characterizing plant communities, however, a miss calculation in distance between transects resulted in only 19 transects surveyed in 2017 (Fig. 1a). Two additional transects were surveyed in 2018 (Fig. 1b) In addition, weather conditions limited our ability to sample some deep water areas in the northeast basin and macrophyte communities may extend farther offshore than indicated by the transect boundaries.

Individual transect locations are identified for reference (Figs. 2-10) except transect 4 (Fig. 3); the transect did extend from HL4a to the shoreline. Individual transects ranged in length from between 150 m (465 ft) to over 700 m (2170 ft) in length. Macrophyte growth was relatively limited in shallow areas (<4 ft deep); the majority of plant growth was observed at the upper edge of the drop-off, and extending into relatively deep areas (>20 ft)

In total, 12 different plant taxa were identified from sample transects surveyed during 2017. Given the size of Higgins Lake, I believe that additional sampling would reveal other taxa. Chara (a macroscopic algal) typically accounted for the greatest relative abundance along individual transects and appears to be the most widely distributed macroscopic plant (Tables 1-19). Although Chara has limited value to higher trophic levels (few if any organisms eat Chara), it is a good indicator of groundwater flow into streams and lakes.

Eurasian milfoil (EWM) was the only exotic species identified during this project. This taxon appears to grow as part of mixed plant beds (Fig. 11) to forming monospecific stands (Fig. 12) that may start as small isolated stands (Fig 13). General observations suggest that EWM fragments collect in shallow depressions or along physical structures (submerged logs) and establish isolated populations at these locations (Fig. 14).

Plant biomass samples were collected from a majority of the survey transects (Figs. 15 and 16). Biomass (g/m^2) was determined as both wet weight and dry weight (Table 22) to allow for general comparisons among sites and due to differences in taxonomic composition. Both wet weights varied between 901.17 g/m^2 to 7080.65 g/m^2. Dry weight exhibited similar variation ranging from 260.79 g/m^2 2347.15 g/m^2. Five of 17 biomass samples were greater than 1000.00 g/m^2 dry weight. These values are similar to the results of studies conducted on Muskegon Lake and White Lake, both relatively eutrophic systems.

Plant biomass is the result of several ecological factors including warm temperatures, light, and nutrients. Given the high values recorded at several locations, the environmental conditions for plant growth seem to be quite favorable. Normally, plant growth in northern lakes is limited by nutrients, however, nutrient concentrations in Higgins Lake sediments appears to be more than adequate.

B. Above Ground Biomass of EWM at Sites Associated with DASH Boat Operation.

EWM samples were collected from three locations during 2017 and an additional location during 2018. These data suggest that EWM growth in some areas is substantially greater than would be expected in a lake classified as oligotrophic. Specifically, biomass near the West DNR boat launch was the highest recorded wet and dry weights (5540.36 g/m^2 and 930.40 g/m^2 respectively).

C. Additional Observations

Two groups of organisms, blue-green algae and zebra mussels, were observed to be relatively abundant in isolated locations around the lake. Zebra mussels were observed in low numbers throughout the shallow area of the lake, particularly on hard substrates, but they were abundant along transects 9 and 10. There is little hard substrate along these two transects, but close inspection found that zebra mussels were buried in the fine sediment with only a small portion of their shell exposed to the overlying water. A more complete search of shallow regions may reveal similar areas with relatively high zebra mussel densities. In addition, I found zebra mussels in very high densities on the stems and leaves of macrophytes. It is not unreasonable to suggest that the total density of zebra mussels on macrophytes is sufficient to effectively filter significant quantities of lake water on a daily basis. Zebra mussels clarify the water column allowing greater light penetration through the water. In addition, zebra mussels are known to concentrate organic material on the bottom of a lake. This organic material is then decomposed releasing inorganic nutrients (nitrogen and phosphorus), which may then be available to rooted aquatic plants.

The blue-green algae visible along transects 7, 8, and 13 is in the genus *Gleotrichia*. This taxon has the capacity for nitrogen fixation and is common in mesotrophic lakes that have experienced increased concentrations of phosphates.

Figure 1a
HI13
Higgins Lake
HI14
HI15
HI12
HI11
HI16
Higgins Lake
HL10
Flynn Island
HL9
HI18
HL5
HL6
HL7
HL8
HI19
HL4
HI20
HL1
HL3
HL2
Legend
Feature 1
Flynn Island
©2017 Google
N
1 mi

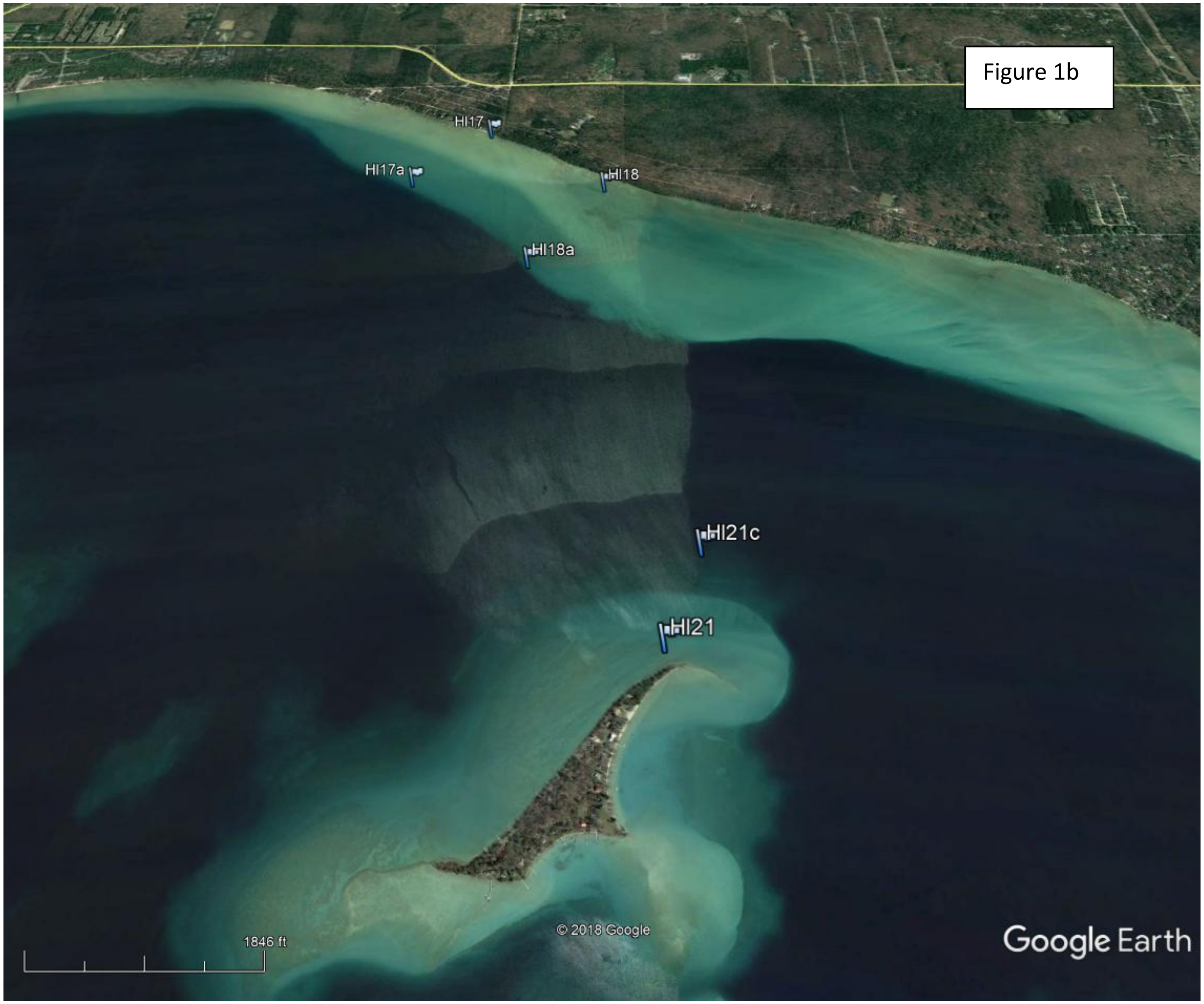

Figure 1a & 1b. Locations of transects established for aquatic macrophyte surveys.

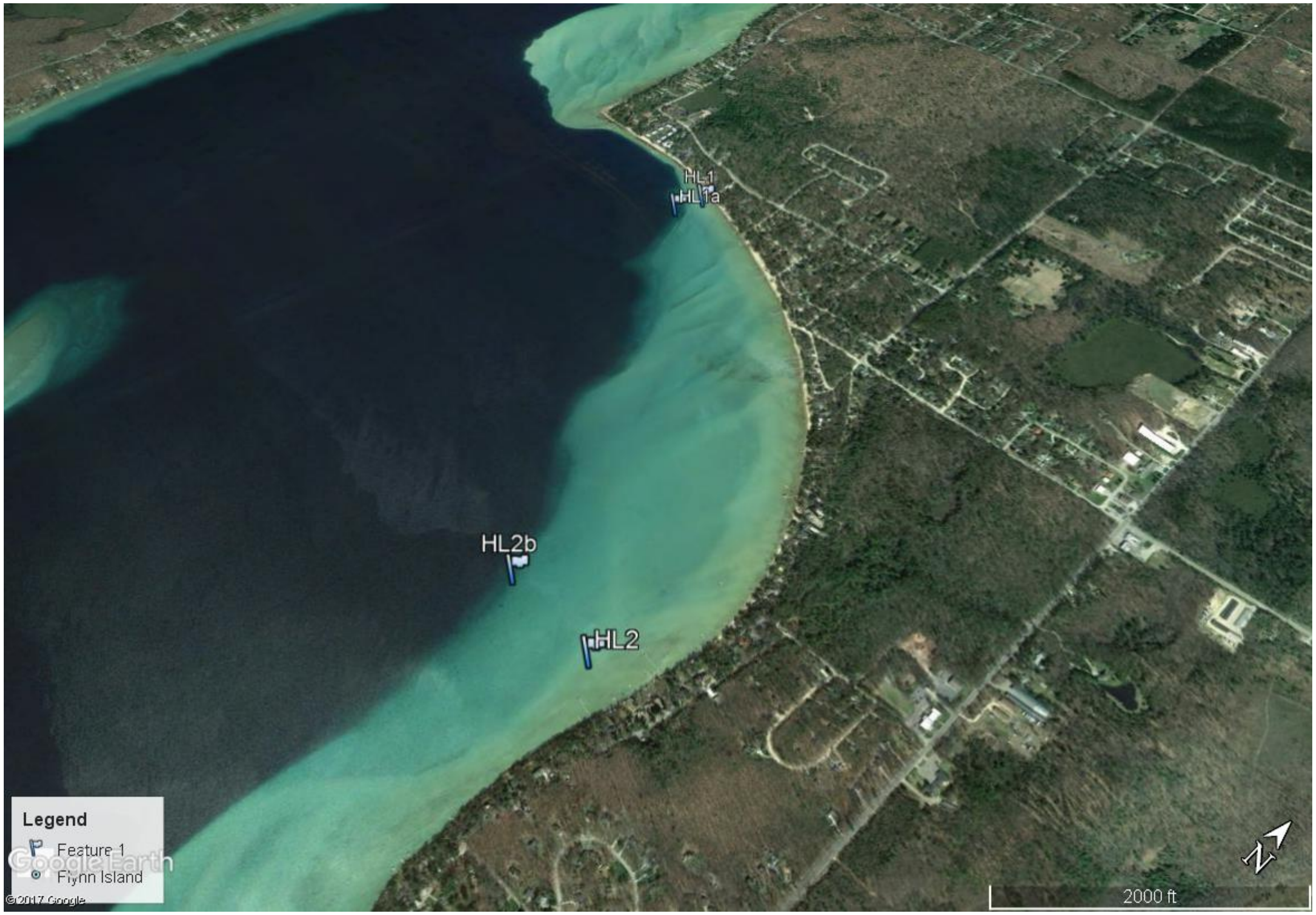

Figure 2. Locations and extent of transects HL1 and HL2.

Figure 3. Locations and extent of transects HL3 and HL4. HL4 extends from HL4a to shore.

Figure 4. Locations and extent of transects HL5 and HL6.

Figure 5. Locations and extent of transects HL7 and HL8.

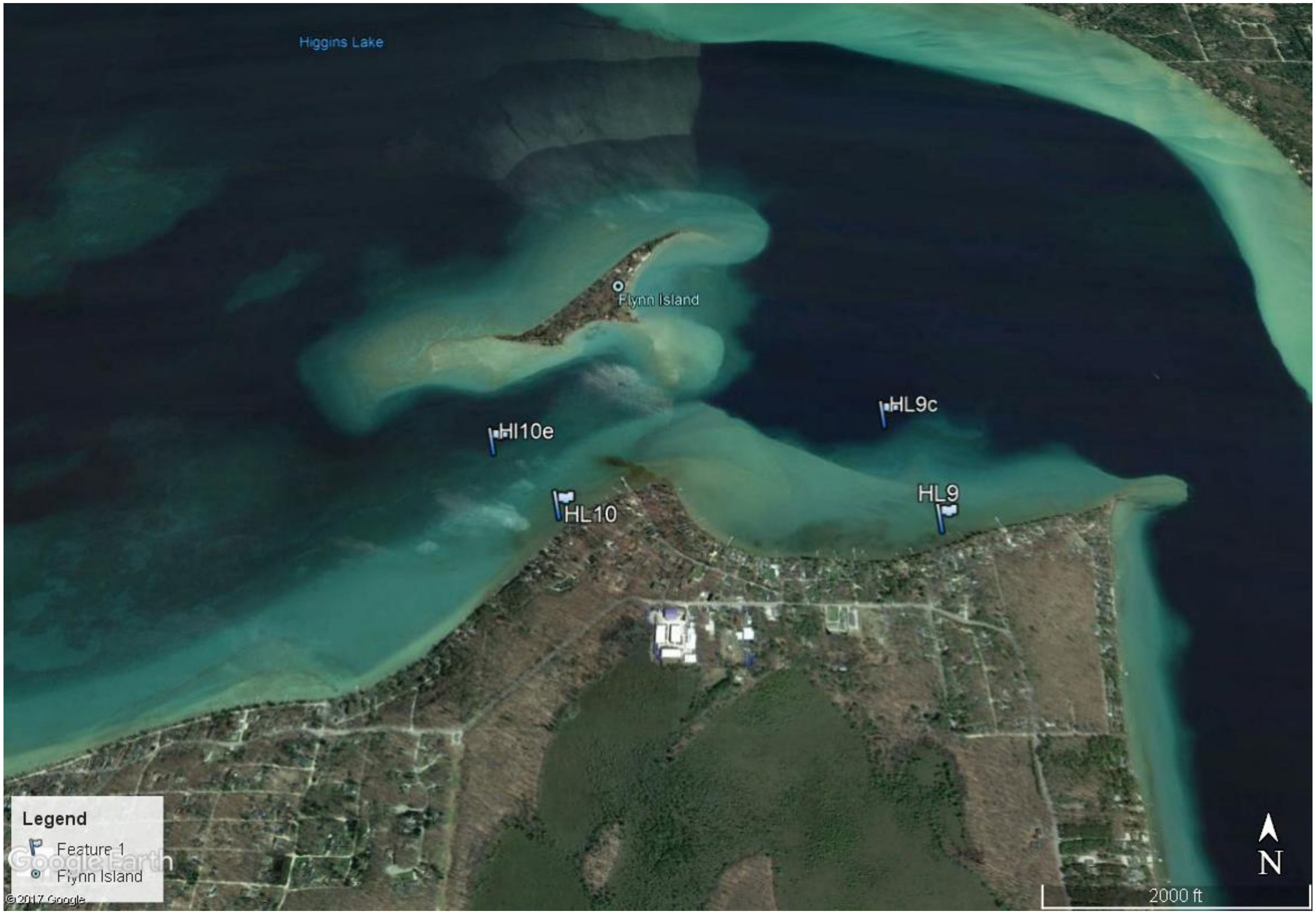

Figure 6. Locations and extent of transects HL9 and HL10.

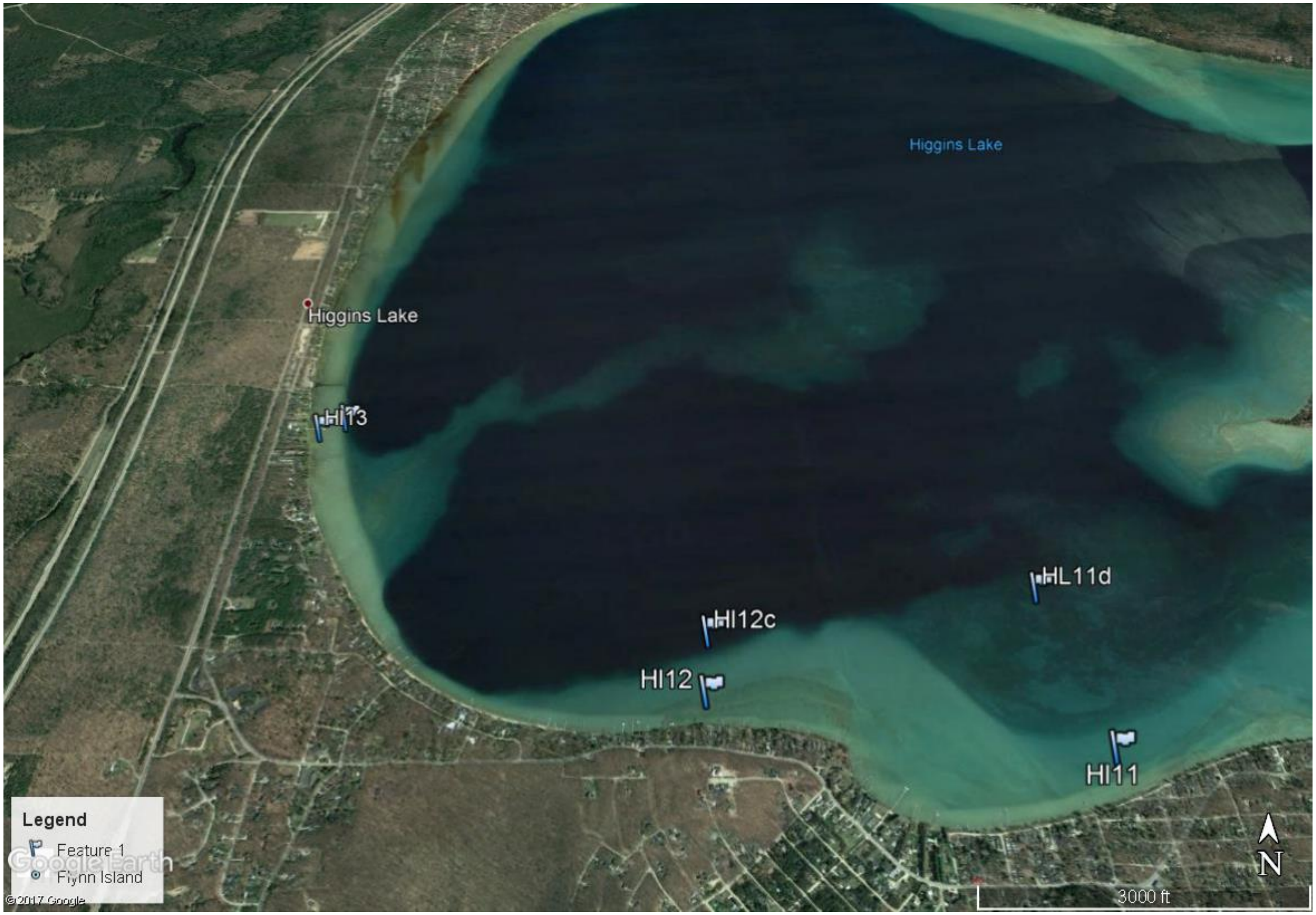

Figure 7. Locations and extent of transects HL11, HL12, and HL13.

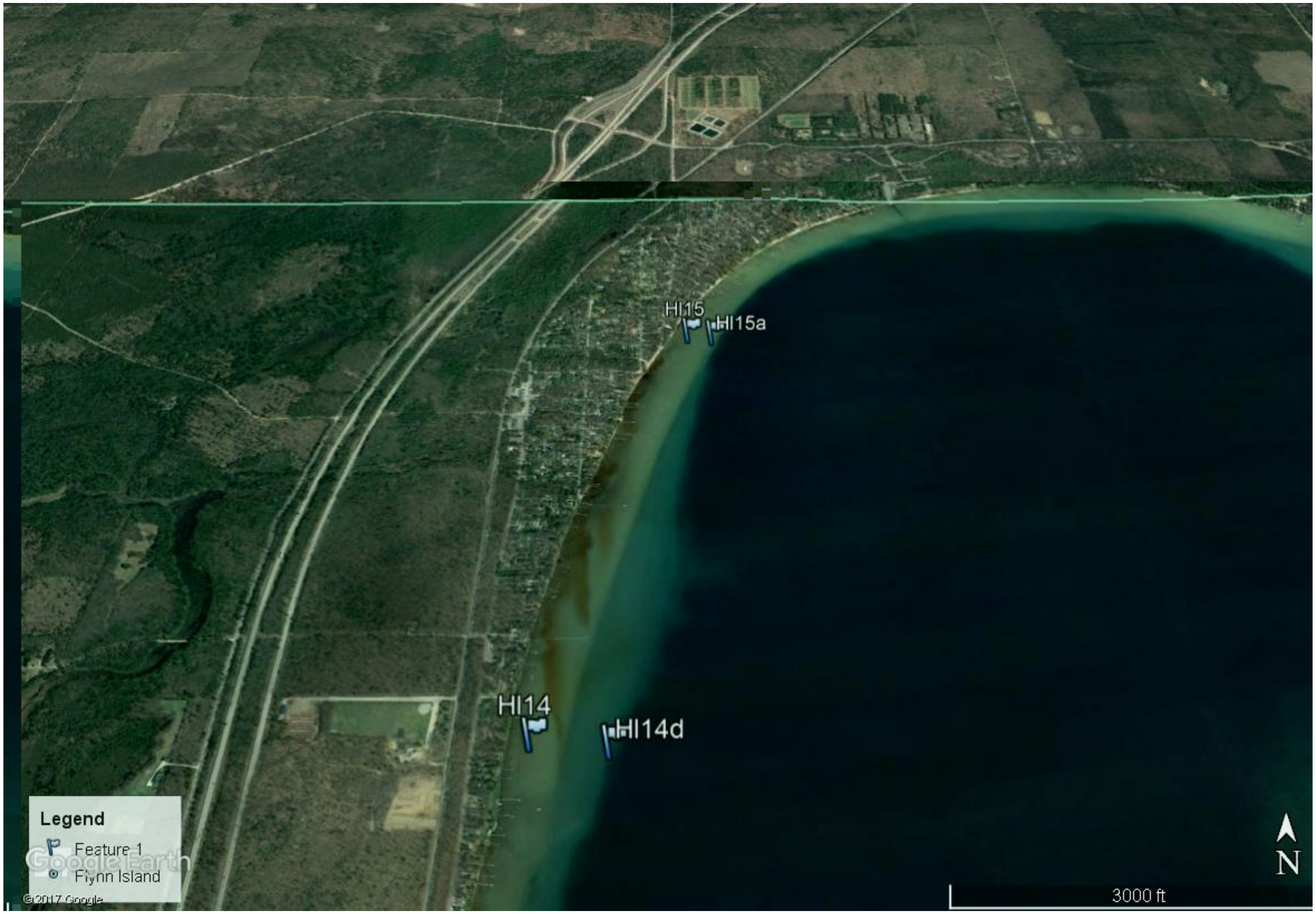

Figure 8. Locations and extent of transects HL14 and HL15.

Figure 9. Locations and extent of transects HL16, HL17, and HL18.

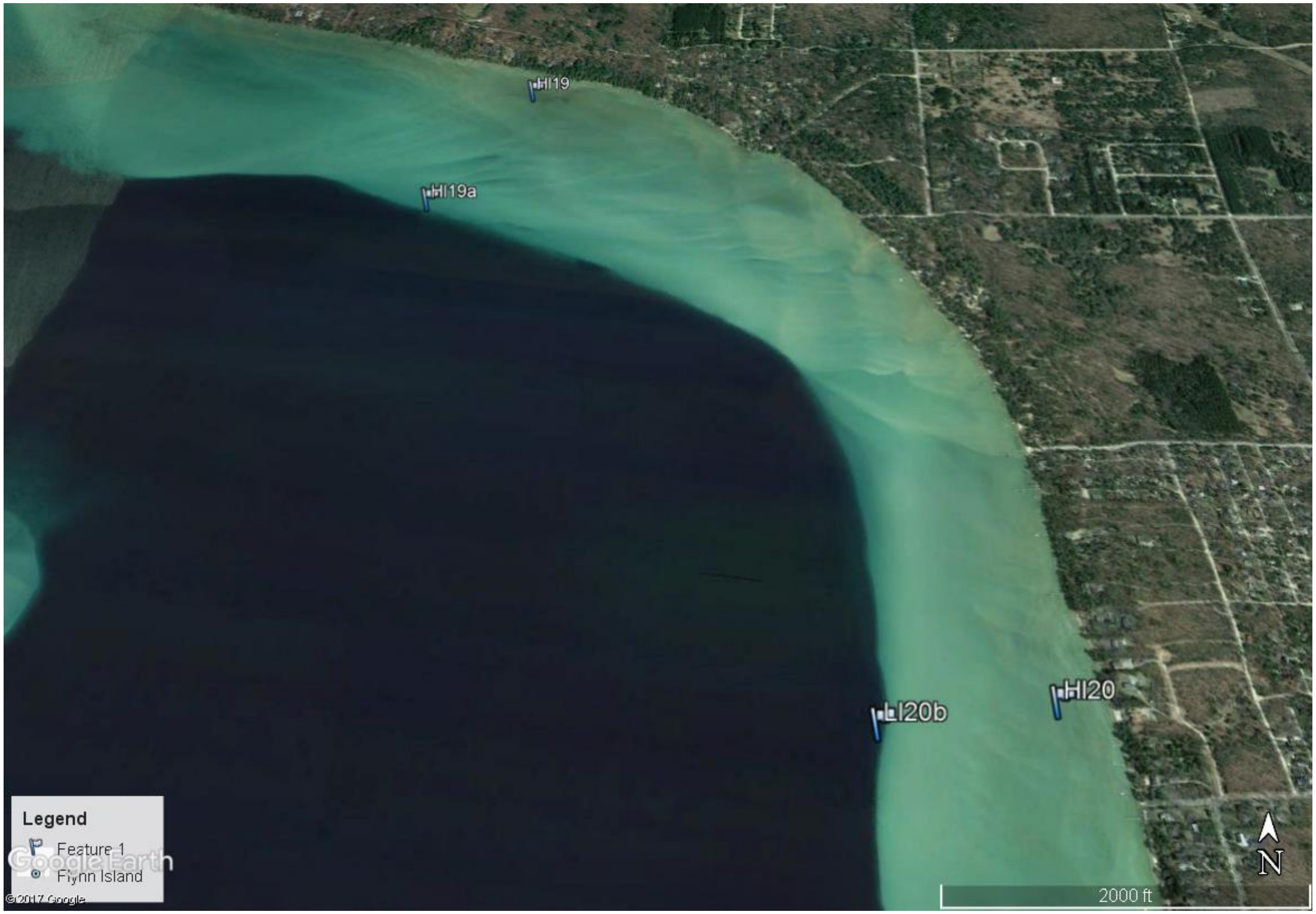

Figure 10. Locations and extent of transects HL19 and HL20.

Figure 11. Locations and extent of transcect HL21.

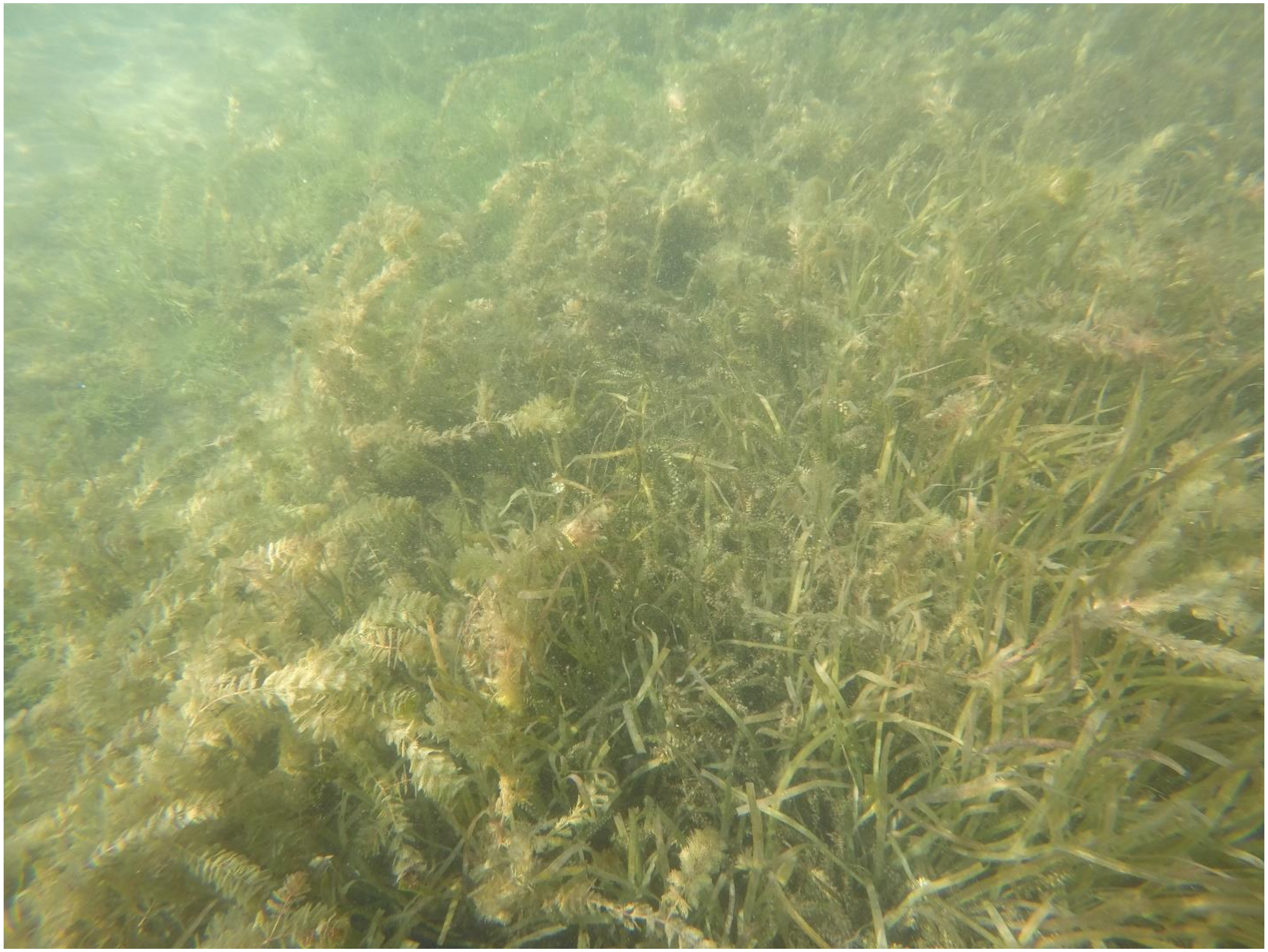
Figure 11. Mixed stand of aquatic macrophytes.

Figure 12. A monospecific stand of EWM.

Figure 13. Small isolated stand of EWM surrounded by *Chara sp*.

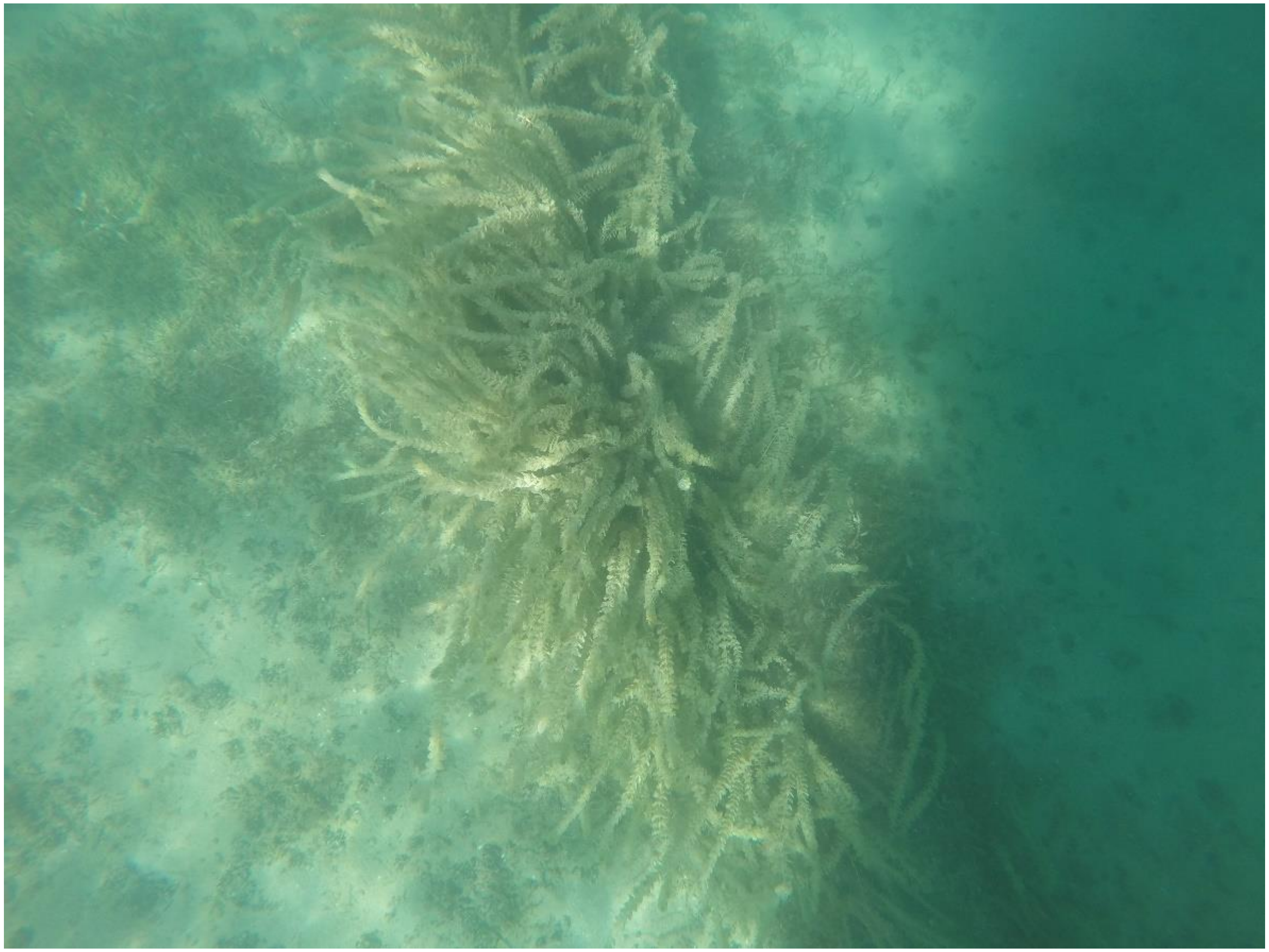
Figure 14. Isolated stand of EWM growing along the length of a submerged log.

Table 1. Relative abundance of aquatic plants along transect HL1.

Distance	Depth	Sand	Chara	Elodea	Heteranthera	Najas flexilis	Potamogeton alpinus	P. gramineus	P. illinoensis	P. oakesianus	P. praelongus	P. richardsonii	Potamogeton sp.	Stuckenia filliformus	Vallisinaria	Blue-green algae	ZM
25 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
50 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
75 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
100 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
125 m	5.25 ft	0%	60%	0%	0%	40%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
150 m	30 ft	20%	40%	0%	0%	40%	0%	0%	0%	0%	0%	0%	0%	0%	0%		

Table 2. Relative abundance of aquatic plants along transect HL2.

Distance	Depth	Sand	Chara	Elodea	Heteranthera	Najas flexilis	Potamogeton alpinus	P. gramineus	P. illinoensis	P. oakesianus	P. praelongus	P. richardsonii	Potamogeton sp.	Stuckenia filliformus	Vallisinaria	Blue-green algae	ZM
25 m	1.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
50 m	1.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
75 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
100 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
125 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
150 m	2.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
125 m	2.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
150 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
200 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
250 m	3.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
300 m	4.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
350 m	8 ft	99%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
400 m	9 ft	90%	10%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
425 m	13 ft	0%	99%	0%	0%	0%	0%	1%	0%	0%	0%	0%	1%	0%	0%		
450 m	48 ft	10%	90%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
tered clumps of EWM south of #2																	

Table 3. Relative abundance of aquatic plants along transect HL3.

Distance	Depth	Sand	Chara	Elodea	Heteranthera	Najas flexilis	Potamogeton alpinus	P. gramineus	P. illinoensis	P. oakesianus	P. praelongus	P. richardsonii	Potamogeton sp.	Stuckenia filliformus	Vallisinaria	Blue-green algae	ZM
25 m	1.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
50 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
75 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
100 m	2.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
125 m	2.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
150 m	2.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
125 m	2.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
150 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
200 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
250 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
300 m	4 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
350 m	4 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
400 m	5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
425 m	5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
450 m	6 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
500 m	6 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
600 m	6 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
645 m	7 ft	100%	sparse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
700 m	11 ft	100%	sparse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
725 m	13 ft	100%	sparse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
740 m	19 ft	20%	80%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
750 m	39 ft	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		

Table 4. Relative abundance of aquatic plants along transect HL4.

Distance	Depth	Sand	Chara	Elodea	Heteranthera	Najas flexilis	Potamogeton alpinus	P. gramineus	P. illinoensis	P. oakesianus	P. praelongus	P. richardsonii	Potamogeton sp.	Stuckenia filliformus	Vallisinaria	Blue-green algae	ZM
25 m	1.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
50 m	1.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
75 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
100 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
125 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
150 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
125 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
150 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
200 m	4 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
250 m	8 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
265 m	50 ft	75%	25%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
umerous Eurasian watermilfoil floating fragments																	

Table 5. Relative abundance of aquatic plants along transect HL5.

Distance	Depth	Sand	Chara	Elodea	Heteranthera	Najas flexilis	Potamogeton alpinus	P. gramineus	P. illinoensis	P. oakesianus	P. praelongus	P. richardsonii	Potamogeton sp.	Stuckenia filliformus	Vallisinaria	Blue-green algae	ZM
25 m	1.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
50 m	1.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
75 m	2 ft	100%	sparse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
100 m	2 ft	100%	sparse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
125 m	3 ft	100%	sparse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
150 m	5 ft	20%	50%	0%	0%	20%	0%	0%	0%	0%	0%	5%	5%	0%	0%		
200 m	9 ft	0%	95%	0%	0%	0%	0%	0%	0%	0%	0%	2%	2%	0%	1%		
225 m	15 ft	0%	95%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%		
275 m	22 ft	4%	95%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%		
300 m	26 ft	2%	98%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
350 m	30 ft	2%	98%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
400 m	30 ft	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
450 m	30 ft	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
500 m	30 ft	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
525 m	40 ft	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
550 m	40 ft	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		

Table 6. Relative abundance of aquatic plants along transect HL6.

Distance	Depth	Sand	Chara	Elodea	Heteranthera	Najas flexilis	Potamogeton alpinus	P. gramineus	P. illinoensis	P. oakesianus	P. praelongus	P. richardsonii	Potamogeton sp.	Stuckenia filliformus	Vallisinaria	Blue-green algae	ZM
25 m	1.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
50 m	1.5 ft	100%	sparse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
75 m	2 ft	100%	sparse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
100 m	2 ft	100%	sparse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
125 m	4.5 ft	100%	sparse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
150 m	6 ft	3%	90%	0%	0%	1%	0%	0%	0%	0%	0%	1%	0%	0%	0%		
175 m	13 ft	3%	90%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
200 m	30 ft	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
250 m	60 ft	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		

Table 7. Relative abundance of aquatic plants along transect HL7.

Distance	Depth	Sand	Chara	Elodea	Heteranthera	Najas flexilis	Potamogeton alpinus	P. gramineus	P. illinoensis	P. oakesianus	P. praelongus	P. richardsonii	Potamogeton sp.	Stuckenia filliformus	Vallisinaria	Blue-green algae	ZM
25 m	1.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
50 m	2 ft	100%	sparse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
75 m	3 ft	100%	sparse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
100 m	4 ft	100%	sparse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
125 m	6 ft	30%	60%	0%	0%	5%	0%	0%		0%	0%	5%	0%	0%	0%		
150 m	18 ft	5%	90%	0%	0%	3%	0%	0%	0%	0%	2%	0%	0%	0%	0%	present	
200 m	37 ft	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		

Table 8. Relative abundance of aquatic plants along transect HL8.

Distance	Depth	Sand	Chara	Elodea	Heteranthera	Najas flexilis	Potamogeton alpinus	P. gramineus	P. illinoensis	P. oakesianus	P. praelongus	P. richardsonii	Potamogeton sp.	Stuckenia filliformus	Vallisinaria	Blue-green algae	ZM
25 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
50 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
75 m	3.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
100 m	7 ft	0%	60%	0%	0%	10%	0%	0%	0%	0%	0%	0%	0%	10%	20%	present	
125 m	25 ft	5%	75%	0%	15%	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
150 m	47 ft	5%	95%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
160 m	60 ft	85%	15%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		

Table 9. Relative abundance of aquatic plants along transect HL9.

Distance	Depth	Sand	Chara	Elodea	Heteranthera	Najas flexilis	Potamogeton alpinus	P. gramineus	P. illinoensis	P. oakesianus	P. praelongus	P. richardsonii	Potamogeton sp.	Stuckenia filliformus	Vallisinaria	Blue-green algae	ZM
25 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		dense
50 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		dense
75 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		dense
100 m	2.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		dense
125 m	2.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		dense
150 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		dense
200 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		dense
225 m	4 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		dense
275 m	5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		dense
300 m	6 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		dense
350 m	10 ft	1.50%	98%	0%	0%	0%	0%	0%	0.50%	0%	0%	0%	0%	0%	0%		
400 m	14 ft	1.50%	98%	0%	0%	0%	0%	0%	0.50%	0%	0%	0%	0%	0%	0%		
425 m	16 ft	1.50%	98%	0%	0%	0%	0%	0%	0.50%	0%	0%	0%	0%	0%	0%		
450 ft	43 ft	25%	75%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		

Table 10. Relative abundance of aquatic plants along transect HL10.

Distance	Depth	Sand	Chara	Elodea	Heteranthera	Najas flexilis	Potamogeton alpinus	P. gramineus	P. illinoensis	P. oakesianus	P. praelongus	P. richardsonii	Potamogeton sp.	Stuckenia filliformus	Vallisinaria	Blue-green algae	ZM	
25 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%			
50 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%			
75 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%			
100 m	2.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%			
125 m	4 ft	100%	sparse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		dense	
150 m	6 ft	100%	0%	0%	0%	sparse	0%	sparse	0%	0%	0%	0%	0%	0%	0%			
200 m	6.5 ft	100%	0%	0%	0%	sparse	0%	sparse	0%	0%	0%	0%	0%	0%	0%			
225 m	7 ft	100%	sparse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%			
250 m	11 ft	1%	98%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%			
300 m	11 ft	1%	98%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%			
325 m	11 ft	1%	98%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%			
350 m	18 ft	99%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%			
350 m	18 ft	47%	50%	0%	0%	0%	0%	0%	0%	0%	3%	0%	0%	0%	0%			50 ft east

Table 11. Relative abundance of aquatic plants along transect HL11.

Distance	Depth	Sand	Chara	Elodea	Heteranthera	Najas flexilis	Potamogeton alpinus	P. gramineus	P. illinoensis	P. oakesianus	P. praelongus	P. richardsonii	Potamogeton sp.	Stuckenia filliformus	Vallisinaria	Blue-green algae	ZM
25 m	1.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
50 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
75 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
100 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
125 m	4 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
150 m	7 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
175 m	9 ft	100%	sparse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
200 m	12 ft	2%	96%	0%	0%	0%	0%	0%	2%?	0%	0%	0%	0%	0%	0%		
250 m	12 ft	2%	98%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
300 m	15 ft	1%	98%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%		
350 m	17 ft	75%	25%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
400 m	20 ft	90%	10%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
500 m	20 ft	40%	60%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
600 m	20 ft	40%	60%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
675 m	20 ft	40%	60%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		

Table 12. Relative abundance of aquatic plants along transect HL12.

Distance	Depth	Sand	Chara	Elodea	Heteranthera	Najas flexilis	Potamogeton alpinus	P. gramineus	P. illinoensis	P. oakesianus	P. praelongus	P. richardsonii	Potamogeton sp.	Stuckenia filliformus	Vallisinaria	Blue-green algae	ZM
25 m	1.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
50 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
75 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
100 m	2.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
125 m	2.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
150 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
175 m	4 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
200 m	5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
250 m	7 ft	100%	sparse	0%	0%	sparse	0%	0%	0%	0%	0%	0%	0%	0%	0%		
275 m	12 ft	25%	75%	0%	0%	0%	0%	sparse	0%	0%	0%	0%	0%	0%	0%		
300 m	30 ft	2%	98%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		

Table 13. Relative abundance of aquatic plants along transect HL13.

Distance	Depth	Sand	Chara	Elodea	Heteranthera	Najas flexilis	Potomogetan alpinus	P. gramineus	P. illinoensis	P. oakesianus	P. praelongus	P. richardsonii	Potamogeton sp.	Stuckenia filliformus	Vallisinaria	Blue-green algae	ZM
25 m	1.5 ft	100%	0%	0%	sparse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	abundant	
50 m	1.5 ft	100%	sparse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	abundant	
75 m	2.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	abundant	
100 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
125 m	4 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
136 m	6 ft	75%	25%	0%	0%	sparse	0%	0%	sparse	0%	0%	0%	0%	0%	0%		
150 m	11 ft	75%	25%	0%	0%	sparse	0%	0%	0%	0%	0%	0%	0%	0%	0%		
160 m	22 ft	7%	90%	0%	0%	0%	0%	0%	0%	0%	3%	0%	0%	0%	0%		

Table 14. Relative abundance of aquatic plants along transect HL14.

Distance	Depth	Sand	Chara	Elodea	Heteranthera	Najas flexilis	Potamogeton alpinus	P. gramineus	P. illinoensis	P. oakesianus	P. praelongus	P. richardsonii	Potamogeton sp.	Stuckenia filliformus	Vallisinaria	Blue-green algae	ZM
25 m	1.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
50 m	1.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
75 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
100 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
125 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
150 m	4 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
175 m	4 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
200 m	5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
225 m	5 ft	100%	sparse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
250 m	7 ft	75%	25%	0%	0%	0%	0%	sparse	sparse	0%	0%	0%	0%	0%	0%		
275 m	15 ft	2.00%	98%	0%	0%	0%	0%	0%	sparse	0%	0%	0%	0%	0%	0%		
300 m	25 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		

Table 15. Relative abundance of aquatic plants along transect HL15.

Distance	Depth	Sand	Chara	Elodea	Heteranthera	Najas flexilis	Potamogeton alpinus	P. gramineus	P. illinoensis	P. oakesianus	P. praelongus	P. richardsonii	Potamogeton sp.	Stuckenia filliformus	Vallisinaria	Blue-green algae	ZM
25 m	1.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
50 m	1.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
75 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
100 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
125 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
150 m	4 ft	100%	sparse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
170 m	15 ft	0%	35%	5%	0%	50%	0%	0%	0%	10%	0%	0%	0%	0%	0%		

Table 16. Relative abundance of aquatic plants along transect HL16.

Distance	Depth	Sand	Chara	Elodea	Heteranthera	Najas flexilis	Potamogeton alpinus	P. gramineus	P. illinoensis	P. oakesianus	P. praelongus	P. richardsonii	Potamogeton sp.	Stuckenia filliformus	Vallisinaria	Blue-green algae	ZM
25 m	1.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
50 m	1.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
75 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
100 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
125 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
150 m	5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
200 m	9 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
225 m	18 ft	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		

Table 17. Relative abundance of aquatic plants along transect HL17.

Distance	Depth	Sand	Chara	Elodea	Heteranthera	Najas flexilis	Potamogeton alpinus	P. gramineus	P. illinoensis	P. oakesianus	P. praelongus	P. richardsonii	Potamogeton sp.	Stuckenia filliformus	Vallisinaria	Blue-green algae	ZM
25 m	1.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
50 m	1.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
75 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
100 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
125 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
150 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
200 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
300 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
400 m	4 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
425 m	6 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
450 m	8 ft	98%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
500 m	10 ft	98%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
550 m	12 ft	96%	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
600 m	22 ft	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		

Table 18. Relative abundance of aquatic plants along transect HL18.

Distance	Depth	Sand	Chara	Elodea	Heteranthera	Najas flexilis	Potamogeton alpinus	P. gramineus	P. illinoensis	P. oakesianus	P. praelongus	P. richardsonii	Potamogeton sp.	Stuckenia filliformus	Vallisinaria	Blue-green algae	ZM
25 m	1.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
50 m	1.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
75 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
100 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
125 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
150 m	3 ft	100%	sparse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
200 m	4 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
300 m	4 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
400 m	4 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
500 m	5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
600 m	6 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
700 m	17 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
710 m	21 ft	95%	3%	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%		

Table 19. Relative abundance of aquatic plants along transect HL19.

Distance	Depth	Sand	Chara	Elodea	Heteranthera	Najas flexilis	Potamogeton alpinus	P. gramineus	P. illinoensis	P. oakesianus	P. praelongus	P. richardsonii	Potamogeton sp.	Stuckenia filliformus	Vallisinaria	Blue-green algae	ZM
25 m	1.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
50 m	1.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
75 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
100 m	2 ft	100%	sparse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
125 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
150 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
200 m	3 ft	100%	sparse	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
300 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
400 m	4 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
500 m	6 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
600 m	7 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
700 m	15 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
725 m	20 ft	4%	95%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%		

Table 20. Relative abundance of aquatic plants along transect HL20.

Distance	Depth	Sand	Chara	Elodea	Heteranthera	Najas flexilis	Potamogeton alpinus	P. gramineus	P. illinoensis	P. oakesianus	P. praelongus	P. richardsonii	Potamogeton sp.	Stuckenia filliformus	Vallisinaria	Blue-green algae	ZM
25 m	1.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
50 m	1.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
75 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
100 m	2 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
125 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
150 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
200 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
300 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
400 m	4 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
425 m	12 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
445 m	42 ft	25%	75%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		

Table 21. Relative abundance of aquatic plants along transect HL21.

Distance	Depth	Sand	Chara	Elodea	Heteranthera	Najas flexilis	Potamogeton alpinus	P. gramineus	P. illinoensis	P. oakesianus	P. praelongus	P. richardsonii	Potamogeton sp.	Stuckenia filliformus	Vallisinaria	Blue-green algae	ZM
25 m	1.5 ft	96%	2%	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
50 m	1.5 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
75 m	3 ft	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
100 m	6 ft	98%	2%	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
125 m	6 ft	98%	2%	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
150 m	7.5 ft	98%	2%	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
200 m	8 ft	98%	2%	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
300 m	10 ft	3%	95%	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
350 m	16 ft	3%	95%	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
400 m	18 ft	3%	95%	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
450 m	23 ft	0%	80%	0%	0%	20%	0%	0%	0%	0%	0%	0%	0%	0%	0%		

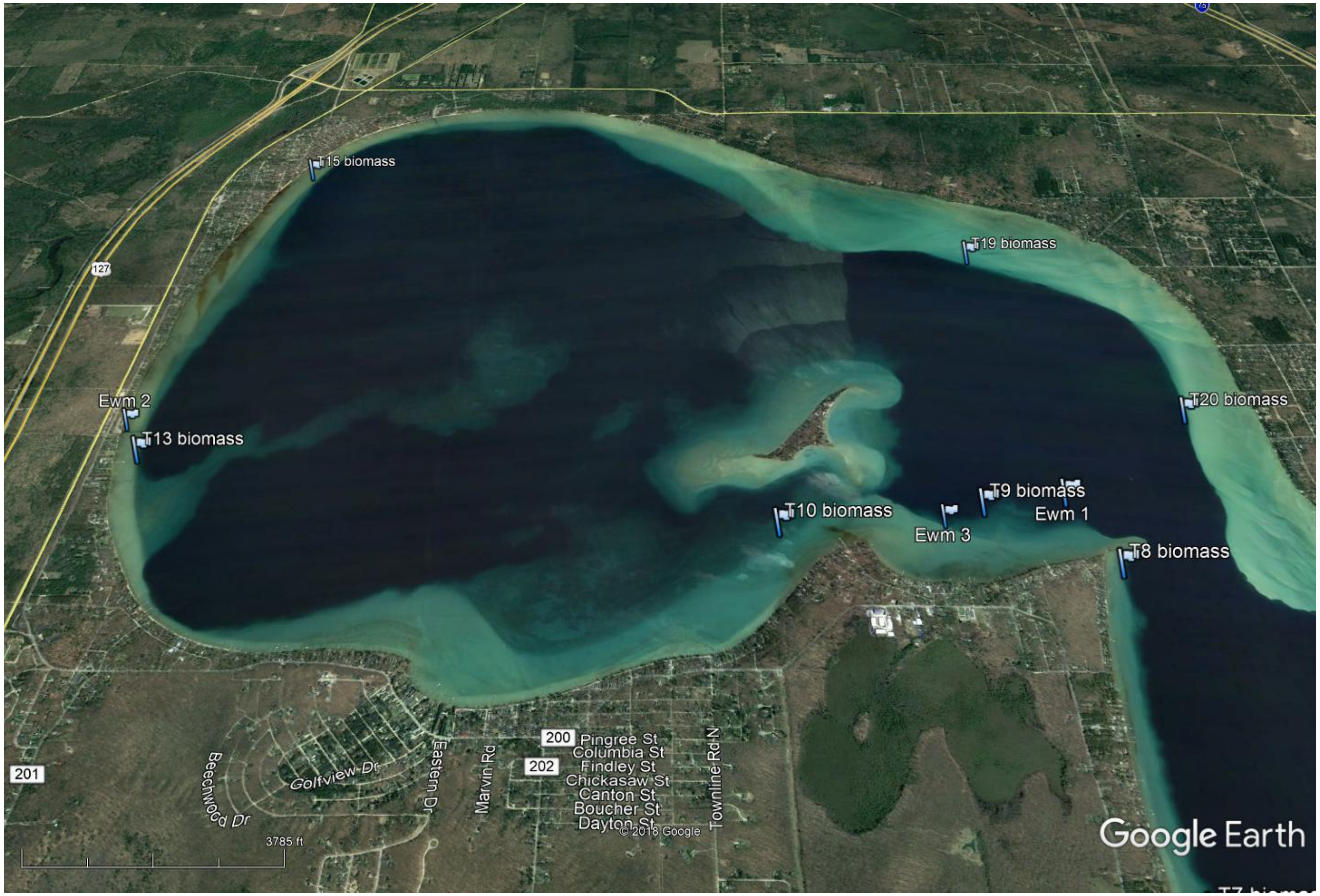

Figure 15. North basin biomass sample locations (Eurasian Watermilfoil = Ewm).

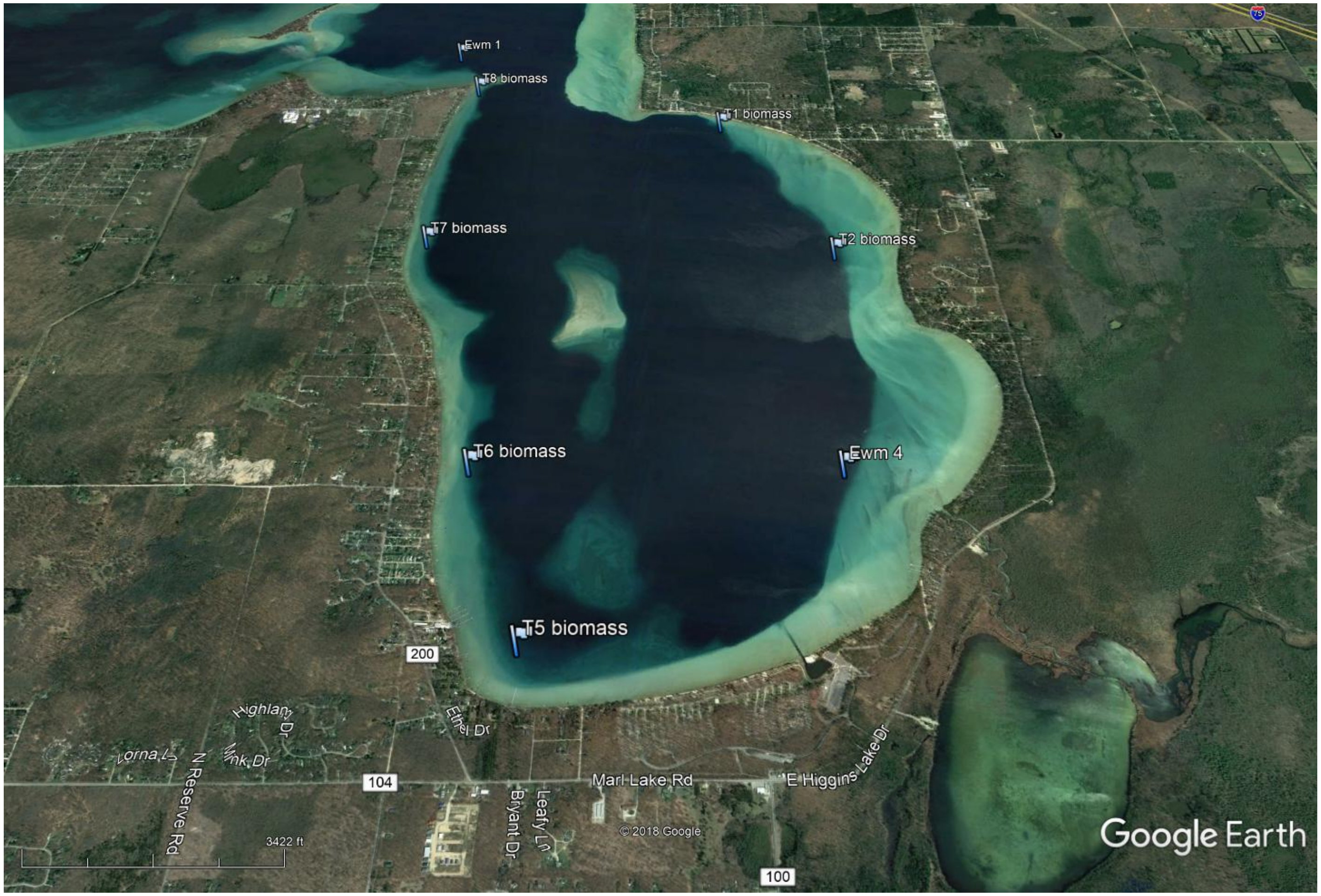

Figure 16. South basin biomass sample locations (Eurasian Watermilfoil = Ewm).

Table 22. Plant biomass collected from survey transects and Eurasian Watermilfoil beds in Higgins Lakes.

Location		Wet Weight (grams/m^2)	Dry Weight (grams/m^2)
Trans 1		2188.57	738.92
Trans 1 125m		3604.70	782.38
Trans 1 150m		5192.48	956.24
Trans 1 175m		3604.70	651.98
Trans 2		3518.87	1043.18
Trans 5		1115.74	217.33
Trans 6		901.17	304.26
Trans 7		2746.43	825.85
Trans 8		2145.65	478.12
HL9B		944.09	347.73
HL10D		2961.00	912.78
HL13B		901.17	260.79
HL13B-2		3948.00	1173.57
HLM14C		1459.04	521.59
HL15b		5149.57	1477.83
HL19a		3862.17	1347.44
HL20b		7080.65	2347.15
Ewm 1		2974.16	316.49
Ewm 2		5540.36	930.40
Ewm 3		1090.44	194.34
Ewm 4		2756.95	361.96