Presque Isle Wilderness Waters Program

Aquatic Plant Management Plan – Little Horsehead Lake

Prepared for:

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This plan is a product of a WDNR Aquatic Invasive Species Control Grant (Subchapter II – Education, Prevention, and Planning Projects) awarded to:

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CHAPTER 1 Introduction

The ***Presque Isle Wilderness Waters Program*** results from the efforts of the Presque Isle Town Lakes Committee, an organization that has been active since 2005. The Lakes Committee views stewardship of lakes as an ongoing endeavor that is integrated, coordinated, and administered by the Lakes Committee. This broader perspective accommodates the appropriate range of geographic scales from which to approach lake stewardship: a discrete "lake specific" focus that goes hand-in-hand with waterscape-wide awareness.

This aquatic plant management plan addresses Little Horsehead Lake. Despite this specificity, it maintains the waterscape perspective crucial to effective lake stewardship. This is especially important when it comes to preventing introduction and establishment of aquatic invasive species (AIS). The closely related ***Wilderness Waters Adaptive Management Plan*** (Premo et al. 2015) provides additional overarching waterscape level examination that allows greater opportunity and efficiency in water resource management and education.

A systematic survey of aquatic plants using the Wisconsin Department of Natural Resources (WDNR) "point-intercept" method was an important underpinning of this aquatic plant management plan. An analysis of the plant data along with water quality and other lake information allowed the preparation of the plan.

Aquatic plants rarely get the respect they merit, although this is slowly changing. We still call an aquatic plant bed a "weed bed." Many aquatic plants have "weed" in their names (e.g., duckweed, pondweed, or musky weed). Likely this term was borrowed from "seaweed" and not intended as derogatory, but in today's use, "weed" connotes an unwanted, aggressively growing plant. Such is not the case for the vast majority of aquatic plants. In fact, aquatic plants are a vital part of a lake ecosystem, recycling nutrients, providing vertical and horizontal structure, and creating habitat for animal life. Invertebrates, including crustaceans and insects, live on or within this "aquatic forest." Fish find food and shelter within aquatic plant beds. Waterfowl eat parts of plants directly as well as feed on invertebrates associated with the plants. Muskrats eat aquatic plants and particularly love cattails and bulrushes. Otter and mink hunt invertebrates and small vertebrates within the shelter of submergent and emergent beds. In shallow water, great blue herons find fishes among the plants.

In lakes that receive an excess of nutrients (particularly from fertilizers or leaking septic tanks), plant growth can become too lush or dominated by only a few species. As these abundant plants die, their decomposition can depress dissolved oxygen levels and diminish suitability for fish. Algae can respond rapidly to nutrient influxes and create nuisance conditions. These phenomena can cause humans to view all aquatic plants in a negative light.

On another negative front, non-native plant species, transported on boats and trailers or dumped from home aquariums, private ponds and water gardens may come to dominate a water body to the exclusion of a healthy diversity of native species. Eurasian water-milfoil (*Myriophyllum spicatum*) is one of the better known examples of these so-called aquatic invasive plant species.

For most lakes, native aquatic plants are an overwhelmingly positive attribute, greatly enhancing the aesthetics of the lake and providing good opportunities for fishing, boating, swimming, snorkeling, sight-seeing, and hunting.

When it comes to aquatic plant management, it is useful to heed the mantra of the medical profession: "First, do no harm." It is both a social and scientific convention that aquatic plant management is more effective and beneficial when a lake is considered as an entire and integrated ecosystem. Anyone involved in aquatic plant management should be aware that a permit may be required to remove, add, or control aquatic plants. In addition, anyone using Wisconsin's lakes must comply with the "Boat Launch Law" that addresses transport of aquatic plants on boat trailers and other equipment. A good review of the laws, permits, and regulations that affect management and behavior surrounding aquatic plants can be found in the WDNR guidelines called ***Aquatic Plant Management in Wisconsin***.[1]

In preparing this plan, we followed guidelines in ***Aquatic Plant Management in Wisconsin***. The resulting plan is an adaptive plan (Walters 1986). Simply put, it will be modified as new information becomes available. The WDNR Guidance document outlines three objectives that may influence preparation of an aquatic plant management plan:

- ***Protection*** - preventing the introduction of nuisance or invasive species into waters where these plants are not currently present;
- ***Maintenance*** - continuing the patterns of recreational use that have developed historically on and around a lake; and

[1] *http://www4.uwsp.edu/cnr/uwexlakes/ecology/APM/APMguideFull2010.pdf*

- ***Rehabilitation*** - controlling an imbalance in the aquatic plant community leading to the dominance of a few plant species, frequently associated with the introduction of invasive non-native species.

During projects with the WDNR Planning Grant Program and through past efforts, Town Lakes Committee has followed the first five steps in the seven-step plan outlined in the Guidance Document for developing an aquatic plant management plan:

1. Goal setting – Getting the effort organized, identifying problems to be addressed, and agreeing on the goals;
2. Inventory – Collecting baseline information to define the past and existing conditions;
3. Analysis – Synthesizing the information, quantifying and comparing the current conditions to desired conditions, researching opportunities and constraints, and setting directions to achieving the goals;
4. Alternatives – Listing possible management alternatives and evaluating their strengths, weaknesses and general feasibility;
5. Recommendations – Prioritizing and selecting preferred management options, setting objectives, drafting the plan;
6. Implementation – Formally adopting the plan, lining up funding, and scheduling activities for taking action to achieve the goals;
7. Monitor & Modify – Developing a mechanism for tracking activities and adjusting the plan as it evolves.

Besides this introductory chapter, this plan is organized in six Chapters. The study area is described in Chapter 2. Chapter 3 states the purpose and goals for the plan. Chapter 4 presents an inventory and analysis of information that pertain to the plan including the results of the aquatic plant surveys. Chapter 5 provides recommendations that support the overall goals and establish the stewardship component of plan. Finally, Chapter 6 presents actions and objectives for implementing the plan. Four appendices complete this document. Appendix A contains literature cited, Appendix B contains tables and figures for the aquatic plant surveys, and Appendix C contains a *Review of Little Horsehead Lake Water Quality*. Appendix D reviews the EPA Littoral and Shoreline Survey.

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CHAPTER 2

Study Area

Presque Isle Township is one of the northern-most townships in Vilas County, Wisconsin. Presque Isle Township's northern border is shared with the State of Michigan. In fact some of the Presque Township lakes lie on the state border. The location of the subject of this APM Plan (Little Horsehead Lake) is shown in Exhibit 1 along with other lakes in Presque Isle Township that have had point-intercept aquatic plant surveys conducted. Exhibit 2 is an aerial view of Little Horsehead Lake.

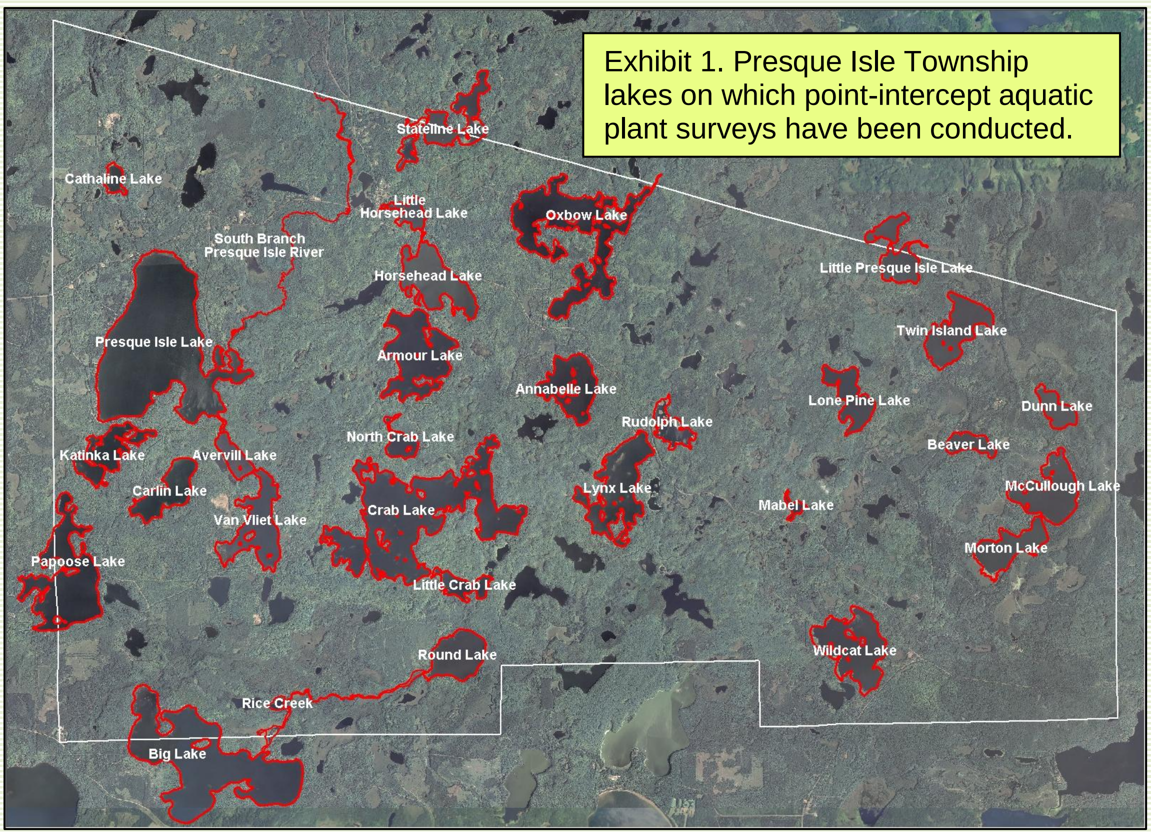

Exhibit 1. Presque Isle Township lakes on which point-intercept aquatic plant surveys have been conducted.

“Almost an island” is the literal translation of the French phrase “Presque Isle.” Early French missionaries, perhaps disoriented by the preponderance of water in this north central Wisconsin landscape applied the name, “Presque Isle” to describe an area where the water seemed to dominate the land. The French visitors and Native Americans certainly recognized this landscape as special. Modern ecologists and recreationist share this view. The region that includes the Township of Presque Isle, Wisconsin is an ecological landscape marvelously rich in surface waters. Aerial photography reveals a concentration of lakes and streams that is unique in North America. Presque Isle Township has eighty-four lakes. The Presque Isle area could as easily be termed a “waterscape” as a “landscape.”

Exhibit 2. Aerial photo of Little Horsehead Lake.

Descriptive parameters for Little Horsehead Lake are in Exhibit 3. It is a drainage lake of about 56 acres and maximum depth of 19 feet. It has a shoreline development index very close to

2. The shoreline development index is a quantitative expression derived from the shape of the lake. It is defined as the ratio of the shoreline length to the length of the circumference of a circle of the same area as the lake. A perfectly round lake would have an index of 1. Increasing irregularity of shoreline development in the form of bays and projections of the shore is shown by numbers greater than 1. For example, fjord lakes with extremely irregularly shaped shorelines sometimes have SDI's exceeding 5. A higher shoreline development index indicates that a lake has relatively more productive littoral zone habitat.

Exhibit 3. Water Body Parameters	
Water Body Name	Little Horsehead
County	Vilas
Township/Range/Section	T43N-R06E-S2,S3; T44N-R06E-S34,S35
Water Body Identification Code	2953000
Lake Type	Drainage
Surface Area (acres)	56
Maximum Depth (feet)	19
Maximum Length (miles)	0.4
Maximum Width (miles)	0.5
Shoreline Length (miles)	2.0
Shoreline Development Index	1.9
Total Number of Piers (2016 EPA Shoreline Survey)	19
Number of Piers / Mile of Shoreline	9.5
Total Number of Homes (2018 aerial)	15
Number of Homes / Mile of Shoreline	7.5

Little Horsehead Lake has a public access site on the lake's south end. We observe a total of 19 piers on the shoreline of Little Horsehead Lake from the 2016 EPA Shoreline Survey or about 9.5 piers per mile of shoreline. The riparian area consists of both upland and wetland areas (Exhibit 4).

Exhibit 4. Topographic Map of Little Horsehead Lake Area.

CHAPTER 3

Purpose and Goal Statements

This plan approaches aquatic plant management with a healthy dose of humility. We do not always understand the causes of environmental phenomena or the effects of our actions to manage the environment. With that thought in mind, we have crafted a statement of purpose and goals for this plan:

> ***Little Horsehead Lake has a native aquatic plant community that was documented by a point-intercept aquatic plant survey. This plant community is essential to, and part of, a high quality aquatic ecosystem that benefits the human community with its recreational and aesthetic features. The purpose of this aquatic plant management plan is to maintain the aquatic plant community in its present high quality state.***

Supporting this purpose, the goals of this aquatic plant management plan are:

(1) Monitor and protect the native aquatic plant community;
(2) Prevent establishment of AIS and nuisance levels of native plants;
(3) Promote and interpret APM efforts; and
(4) Educate riparian owners and lake users on preventing AIS introduction, reducing nutrient inputs that potentially alter the plant community, and minimizing physical removal of native riparian and littoral zone plants.

The purpose and goals are the foundation for the aquatic plant management plan presented in this document. They inform the objectives and actions outlined in Chapter 5 and are the principal motivation of Little Horsehead Lake stewards.

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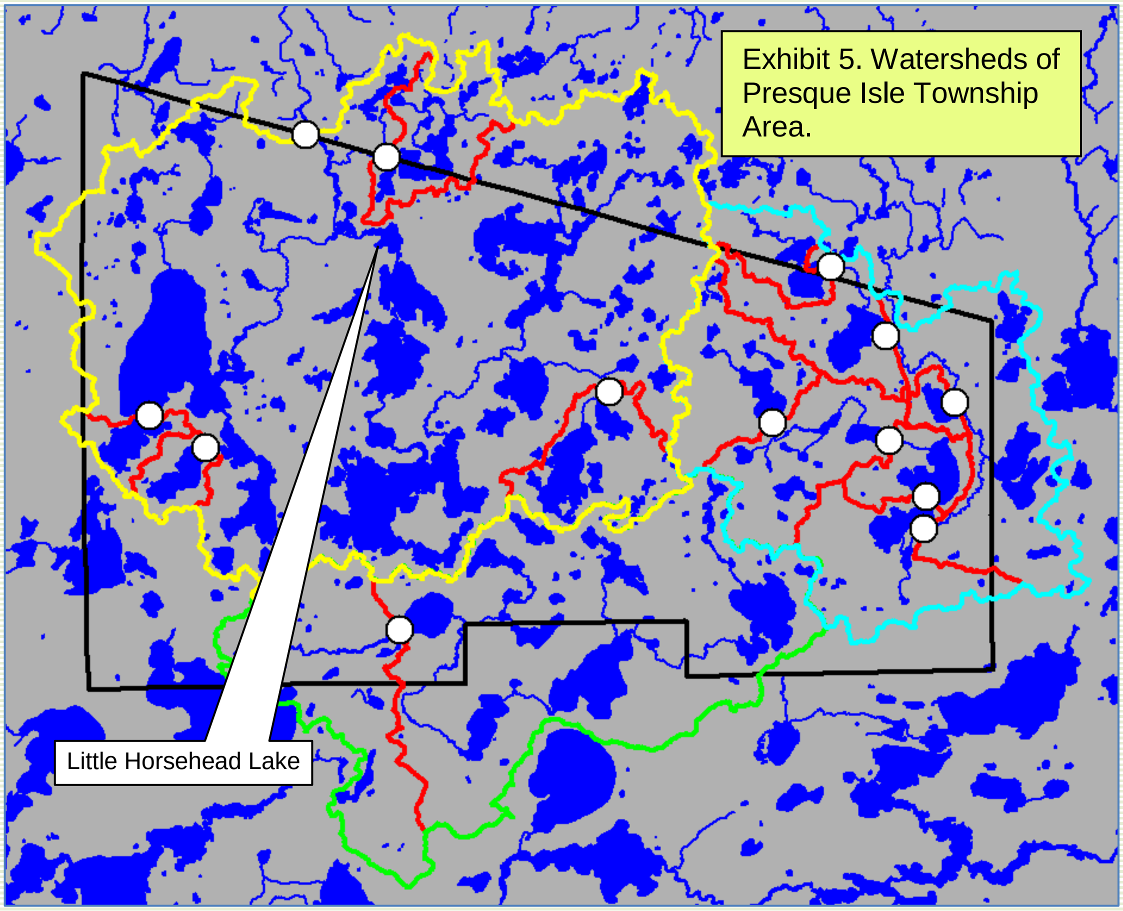
CHAPTER 4

Information and Analysis

Our efforts in the Wilderness Waters Program have compiled information about historical and current conditions of the Little Horsehead Lake ecosystem and its surrounding watershed. Of particular importance to this aquatic plant management plan are the aquatic plant surveys that were conducted using the ***WDNR Protocol for Aquatic Plant Survey, Collecting, Mapping, Preserving, and Data Entry*** (Hauxwell et al., 2010). The results of these comprehensive "point-intercept" surveys along with relevant components of other information are presented in this chapter under nine respective subheadings: watershed, aquatic plant management history, aquatic plant community description, fish community, water quality and trophic status, water use, riparian area, wildlife, and stakeholders.

Part 1. Watershed

The Presque Isle Township waterscape sits on a large-scale watershed divide. Some of the water drains north through the Presque Isle River system and eventually enters Lake Superior. Some of the water drains into the Wisconsin River system to the Mississippi River and to the Gulf of Mexico. In fact there are two federal hydrologic sub-basins (designated by 8-digit HUC codes) that include Presque Isle Township. The Black-Presque Isle Rivers sub-basin (HUC#04020101) drains north to Lake Superior and the Flambeau River sub-basin (HUC#0705002) drains southwesterly to the Mississippi River. The Black-Presque Isle Rivers sub-basin contains two federal hydrologic sub-watersheds within Presque Isle Township: the South Branch Presque Isle River sub-watershed (HUC#040201010303) and the Pomeroy Creek-East Branch Presque Isle River sub-watershed (HUC#040201010301). Little Horsehead Lake is located in the South Branch Presque Isle River sub-watershed. Exhibit 5 illustrates these watersheds and the watersheds of the water bodies subject to the Wilderness Waters Program studies.



Description: Portions of 3 federal hydrologic sub-watersheds are illustrated: (1) S.Br. Presque Isle River (bounded by yellow), (2) Pomeroy Cr-E.Br. Presque Isle River (bounded by blue and yellow), and (3) Rice Cr. (bounded by green, yellow, and blue). Also shown are the smaller watersheds of individual water bodies subject to the Wilderness Waters studies (bounded by red). White dots show outlet points for the smaller watersheds.

The elevation in Presque Isle Township ranges from around 1,550 feet above sea level to 1,750 feet above sea level. A digital elevation model is provided as Exhibit 6 and shows the relative elevations for the area with orange areas of the landscape being the highest elevations and greens and blues being the lowest elevations.

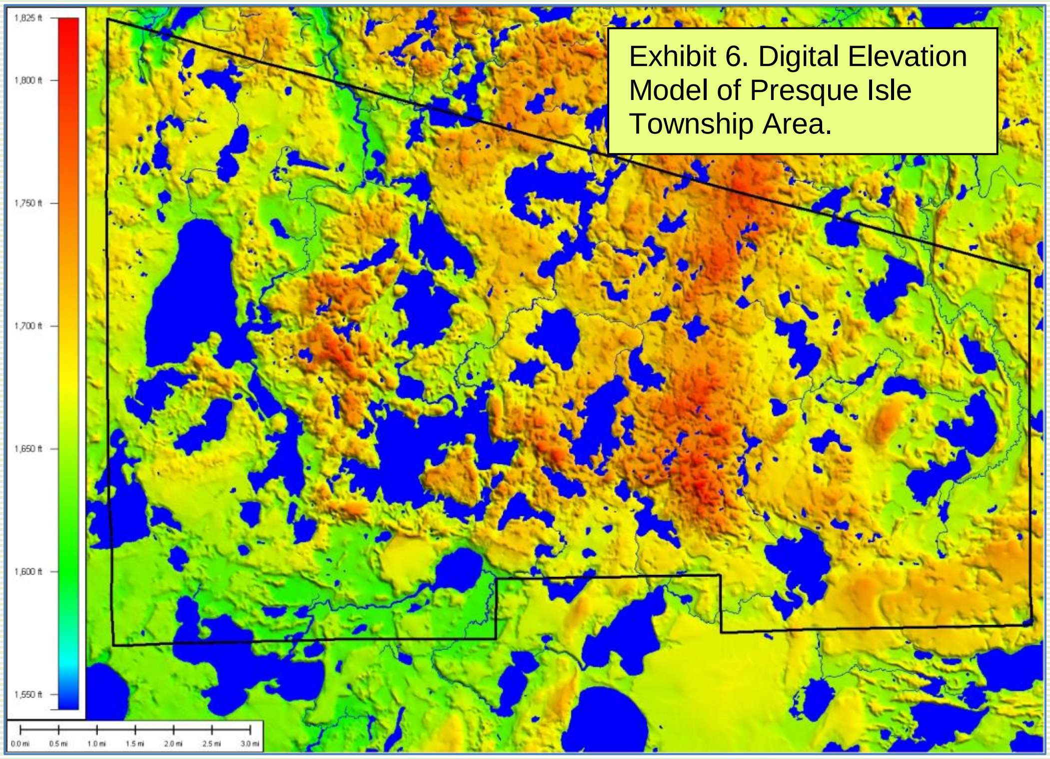


Exhibit 6. Digital Elevation Model of Presque Isle Township Area.

The watershed (drainage basin) is all of the land and water areas that drain toward a particular river or lake. A water body is greatly influenced by its watershed. Watershed size, topography, geology, land use, soil fertility and erodibility, and vegetation are all factors that influence water quality. The Little Horsehead Lake watershed is 15,808 acres. The type of land cover (for example, forest, grassland, agriculture, or residential density) is also an important variable in determining amounts and kinds of materials (like nutrients and sediment) that are carried off the land and into the water. Certain kinds of agriculture (tilled row crops) and urban areas (with their impervious surfaces) have a tendency to give up sediments and nutrients to runoff. In contrast, native vegetation (forests, wetlands, and grasslands), tend to slow runoff of water and nutrients, allowing the soil to absorb them. The cover types in Little Horsehead Lake's watershed are present in Exhibit 7.

Exhibit 7. Cover Types and Soil Groups of the Little Horsehead Lake Watershed.		
Cover Type	Acres	Percent
Agriculture	1.1	0.01
Commercial	0	0
Forest	11026.6	69.8
Grass/Pasture	66.3	0.4
High-density Residential	12.0	0.1
Low-density Residential	933.2	5.9
Water	3768.7	23.8
Total	15807.8	100.0

Soil Group	Acres	Percent	**Hydrologic Soil Groups** - Soils are classified by the Natural Resource Conservation Service into four Hydrologic Soil Groups* based on the soil's runoff potential. The four Hydrologic Soils Groups are A, B, C and D. Where A has the smallest runoff potential and D the greatest.
A	891.8	5.6	**Group A** is sand, loamy sand or sandy loam types of soils. It has low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission.
B	12463.0	78.8	**Group B** is silt loam or loam. It has a moderate infiltration rate when thoroughly wetted and consists chiefly or moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.
C	368.3	2.3	**Group C** soils are sandy clay loam. They have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.
D	2084.7	13.2	**Group D** soils are clay loam, silty clay loam, sandy clay, silty clay or clay. This soil has the highest runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material.

Forest and surface water comprise the largest components. Soil group B is most prevalent; group D is present above 10% and groups A and C are present in percentages at or below 5% of the watershed. Soil group A has a high infiltration capacity whereas D has very low infiltration capacity. The watershed to lake area ratio is 282:1. Water quality often decreases with an increasing ratio of watershed area to lake area. As the watershed to lake area increases there are more sources and amounts of runoff. Little Horsehead Lake seems to be an exception to this rule as it has high water quality. In larger watersheds, runoff water can leach more minerals and nutrients and carry them to the lake. The runoff to a lake (such as after a rainstorm or snowmelt) differs greatly among land uses. Forest cover is the most protective as it exports much less soil (through erosion) and nutrients (such as phosphorus and nitrogen) to the lake than agricultural or urban land use.

Part 2. Aquatic Plant Management History

As far as we can determine, no systematic or large-scale plant management activity has ever taken place in Little Horsehead Lake. Over the years, no particular nuisance issues have demanded control action. In 2007, an aquatic plant survey was conducted on Little Horsehead Lake, and again in 2016. Findings from the 2007 and 2016 surveys are discussed in the next section (Part 3).

Part 3. Aquatic Plant Community Description

Why do lakes need aquatic plants? In many ways, they are underwater forests. Aquatic plants provide vertical and horizontal structure in the lake just like the many forms and variety of trees do in a forest. Imagine how diminished a forest's biodiversity becomes in the advent of a clear-cut. Similarly, a lake's biodiversity in large part depends on a diversity of plants.

Aquatic plants are beneficial in many ways. Areas with plants produce more food for fish (insect larvae, snails, and other invertebrates). Aquatic vegetation offers fish shelter and spawning habitat. Many submerged plants provide food for waterfowl and habitat for insects on which some waterfowl feed. Aquatic plants further benefit lakes by producing oxygen and absorbing nutrients (phosphorus and nitrogen) from runoff. Aquatic plants also protect shorelines and lake bottoms by dampening wave action and stabilizing sediments.

The distribution of plants within a lake is generally limited by light availability, which is, in turn, controlled by water clarity. Aquatic biologists often estimate the depth to which rooted aquatic plants can exist as about two times the average Secchi clarity depth. For example, if the average Secchi depth is eight feet then it is fairly accurate to estimate that rooted plants might exist in water as deep as sixteen feet. At depths greater than that (in our hypothetical example), light is insufficient for rooted plants to grow. In addition to available light, the type of substrate influences the distribution of rooted aquatic plants. Plants are more likely to be found in muddy or soft sediments containing organic matter, and less likely to occur where the substrate is sand, gravel, or rock. Finally, water chemistry influences which plants are found in a body of water. Some species prefer alkaline lakes and some prefer more acidic lakes. The presence of nutrients like phosphorous and nitrogen also influence plant community composition.

As mentioned earlier, non-native invasive plant species can reach high densities and wide distribution within a lake. This diminishes the native plant community and the related habitat. At times, even a native plant species can reach nuisance levels with respect to certain kinds of human recreation. These cases may warrant some kind of plant management.

Aquatic plant surveys have been conducted on Little Horsehead Lake by aquatic plant specialists in 2007 and 2016. In each of these surveys, WDNR point-intercept protocol and methodology was followed. This formal survey assesses the plant species composition on a grid of several hundred points distributed evenly over the lake. Using latitude-longitude coordinates and a handheld GPS unit, scientists navigate to the points and used a rake mounted on a pole or rope to sample plants. Plants are identified, recorded, and put into a dedicated spreadsheet for storage and data analysis. This systematic survey provides baseline data about the lake.

Because Little Horsehead Lake has been surveyed twice, we are able to identify differences in the plant community that have resulted over the course of the six year interval. Changes in a lake environment might manifest as loss of species, change in species abundance or distribution, difference in the relative composition of various plant life forms (emergent, floating leaf, or submergent plants), and/or appearance of an AIS or change in its population size. Monitoring can track changes and provide valuable insight on which to base management decisions. In the remainder of this section (Part 3) we report the findings of the 2016 point-intercept aquatic plant survey and provide a summary of the aquatic plant survey conducted in 2007. Supporting tables and figures for the aquatic plant surveys are provided in Appendix B. Table 3 provides a comparison of statistics from both survey years.

Species richness refers to the total number of species recorded. In 2016, 30 species of aquatic plants were recorded. Of these, 19 were collected at sampling sites and the others were observed from the boat. Table 1 displays summary statistics for the survey. Table 2 provides a list of the species encountered, including common and scientific name along with summarizing statistics.[2] The number of species encountered at any given sample point ranged from 0 to 7 and 66 sample points were found to have aquatic vegetation present. The average number of species encountered at these vegetated sites was 2.30. The actual number of species encountered at each

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[2] *If you are interested in learning more about the plant species found in the lake, visit the University of Wisconsin Steven Point Freckmann Herbarium website at: http://wisplants.uwsp.edu/ or obtain a copy of "Through the Looking Glass (A Field Guide to the Aquatic Plants in Wisconsin)."*

of the vegetated sites is graphically displayed on Figure 1. Plant density is estimated by a "rake fullness" metric (3 being the highest possible density). These densities (considering all species) are displayed for each sampling site on Figure 2.

The maximum depth of plant colonization is 10.5 feet (Table 1 and Figure 3). Rooted vegetation was found at 66 of the 84 sample sites with depth ≤ the maximum depth of plant colonization (78.6% of sites). These sites are displayed as a black dot within a circle on Figure 4. This indicates that although availability of appropriate depth may limit the distribution of plants, it is not the only habitat factor involved. Substrate is another feature that influences plant distribution (e.g., soft substrate often harbors more plants than hard substrate). Figures 5 presents the substrates encountered during the aquatic plant survey (mud, sand, or rock).

Table 2 provides information about the frequency of occurrence of the plant species recorded in the lake. Several metrics are provided, including total number of sites in which each species was found and frequency of occurrence at sites ≤ the maximum depth of rooted vegetation. This frequency metric is standardized as a "relative frequency" (also shown in Table 2) by dividing the frequency of occurrence for a given species by the sum of frequency of occurrence for all plants and multiplying by 100 to form a percentage. The resulting relative frequencies for all species total 100%. The relative frequencies for the plant species collected with a rake are graphically displayed in descending order on Figure 6. This display shows that *Ceratophyllum demersum* (coontail) had the highest relative frequency followed by *Potamogeton robbinsii* (fern pondweed). The lowest relative frequencies are at the far right of the graph. As examples of individual species distributions, we show the occurrences of a few of the most frequently and least frequently encountered plants in Figures 8-20.

Species richness (total number of plants recorded at the lake) is a measure of species diversity, but it doesn't tell the whole story. As an example, consider the plant communities of two hypothetical ponds each with 1,000 individual plants representing ten plant species (in other words, richness is 10). In the first pond each of the ten species populations is comprised of 100 individuals. In the second pond, Species #1 has a population of 991 individuals and each of the other nine species is represented by one individual plant. Intuitively, we would say that first pond is more diverse because there is more "even" distribution of individual species. The "Simpson Diversity Index" takes into account both richness and evenness in estimating diversity. It is based on a plant's relative frequency in a lake. The closer the Simpson Diversity Index is to 1, the more diverse the plant community. The Simpson Diversity Index for Little Horsehead Lake aquatic plants in 2016 is 0.85 (Table 1) which indicates a highly diverse aquatic plant community.

Another measure of floristic diversity and quality is the *Floristic Quality Index* (FQI). Floristic quality is an assessment metric designed to evaluate the closeness that the flora of an area is to that of undisturbed conditions (Nichols 1999). Among other applications, it forms a standardized metric that can be used to compare the quality of different lakes (or different locations within a single lake) and monitor long-term changes in a lake's plant community (an indicator of lake health). The FQI for a lake is determined by using the average *coefficient of conservatism* times the square root of the number of native plant species present in the lake. Knowledgeable botanists have assigned to each native aquatic plant a *coefficient of conservatism* representing the probability that a plant is likely to occur in pristine environments (relatively unaltered from presettlement conditions). The coefficients range from 0 to 10, with 10 being assigned to those species most sensitive to disturbance. As more environmental disturbance occurs, the less conservative species become more prevalent.

Nichols (1999) analyzed aquatic plant community data from 554 Wisconsin Lakes to ascertain geographic (ecoregional) characteristics of the FQI metric. This is useful for considering how the Little Horsehead Lake FQI (26.4) compares to other lakes and regions. The statewide medians for number of species and FQI are 13 and 22.2, respectively. Little Horsehead Lake values are quite high compared to these statewide values. Nichols (1999) determined that there are four ecoregional-lake types groups in Wisconsin: (1) Northern Lakes and Forests lakes, (2) Northern Lakes and Forests flowages, (3) North Central Hardwoods and Southeastern Till Plain lakes and flowages, and (4) Driftless Area and Mississippi River Backwater lakes. Little Horsehead Lake is located in the Northern Lakes and Forests lakes group. Nichols (1999) found species numbers for the Northern Lakes and Forests lakes group had a median value of 13. Little Horsehead Lake data is consistent with that find. Finally, the Little Horsehead Lake FQI (26.4) is slightly higher than the median value for the Northern Lakes and Forests lakes group (24.3). These findings support the contention that the Little Horsehead Lake plant community is healthy and diverse.

Part 4. Fish Community

It was beyond the scope of the current Wilderness Waters project to characterize the fish community and fish habitat of this water body. The WDNR Lake Pages website (http://dnr.wi.gov/lakes/lakepages/) indicates that the bottom is comprised of 50% sand, 10%

gravel, 0% rock, and 40% muck and that fish species present include musky, panfish, largemouth bass, smallmouth bass, and walleye.

Part 5. Water Quality and Trophic Status

Little Horsehead Lake is a 173 acre drainage lake with a maximum depth of 25 feet. Existing water quality information includes data from the WDNR SWIMS database collected in 1985. Secchi depth data was collected from Landsat satellite in 2000, 2004, 2007-2012, 2014-2016, and 2018. Other water quality data was collected by White Water Associates collected in 2016. The water quality information from White Water Associates is briefly summarized in this section, but more fully interpreted in Appendix C.

Temperature and dissolved oxygen showed stratification in the ice-free season. Water clarity was considered fair. Water color was low. The trophic state is mesotrophic. Water quality would be classified as good with respect to phosphorus concentrations. Nitrogen, chloride, sulfate, sodium, and potassium are considered low. The pH of Little Horsehead Lake is neutral.

Part 6. Water Use

Little Horsehead Lake has a public access site, and is used by riparian owners and their guests for a variety of recreational activities. The southern part of the lake is privately owned land while the rest is State of Wisconsin ownership.

Part 7. Riparian Area

Part 1 (Watershed) describes the larger riparian area context of Little Horsehead Lake. The near shore riparian area can be appreciated by viewing Exhibits 2 and 4. The lake is lightly developed with a fairly intact forested riparian zone that extends for hundreds of feet back from the lake. The forest is a mixture of coniferous and deciduous trees and shrubs. Our review of 2018 aerial photography reveals 15 houses on the lake. This intact riparian area provides numerous important functions and values to the lake.

Riparian zones make up the area where aquatic and terrestrial ecosystems converge. The riparian area is a structurally diverse and naturally dynamic ecosystem (Exhibit 8). It is an area where humans put our homes, beaches, and other structures and is quite sensitive to these human-caused changes. Like the littoral zone, the riparian zone provides shelter and food sources for wildlife, and improves water quality by retarding runoff, reducing erosion and absorbing pollutants. Trees that fall into the lake from the riparian zone contribute important habitat elements to the lake. Educating riparian owners as to the value of riparian areas is important to the maintenance of these critical areas.

In a national assessment of lakes, the United States Environmental Protection Agency (USEPA) evaluated hundreds of lakes across the United States assessing water quality, recreational suitability, and ecological integrity (USEPA 2009). Important findings of that assessment included (1) poor lakeshore habitat (riparian vegetation) is the number one stressor of lake ecosystems nation-wide and (2) poor shallow water (littoral zone) habitat is the number two stressor. For the lake steward, by managing for sound lakeshores (both littoral and riparian components), we can make a difference in lake health (biological integrity). This means both development standards (e.g., NR115 and county shoreland ordinances) as well as best management practices (e.g., leave dead wood in place in the lake and refrain from or minimize removal of aquatic vegetation). White Water biologists conducted a littoral and shoreline survey at Little Horsehead Lake in 2016. For results of this survey, see Appendix D.

Part 8. Wildlife

A study of wildlife was beyond the scope of the current study, but would be valuable to study and interpret in future iterations of the plan. This would be especially true of wetland and water oriented wildlife such as frogs, waterfowl, fish-eating birds, aquatic and semi-aquatic mammals, and invertebrate animals. In the future, it would be desirable to monitor indicator species of wildlife such as common loons, bald eagles, and osprey.

Exhibit 8. Shoreline Protection and Restoration Strategy

How can healthy shorelines benefit a lake?

- Help maintain clean water and water quality
- Prevent soil erosion
- Provide wildlife with habitat and food sources

What does a healthy shoreline look like?

- Lots of native vegetation
- Varying heights of vegetation (trees, shrubs, and plants)
- Down dead trees
- Signs of wildlife

How can you maintain a healthy shoreline?

- Minimize runoff /pollution (fertilizers, pesticides, leaky septic systems)
- Protect native plants
- Discourage invasive plants
- Keep dead trees (don't 'clean up' shoreline
- Don't mow right to water's edge
- Continue shoreland monitoring (EPA and WDNR shoreline assessments)

Little Horsehead Lake currently designated a *priority navigable water* (PNW) (WDNR 2017). Priority Navigable Waters meet any of these standards: navigable waterways, or portions thereof, that are considered OWR/EWR or trout streams; lakes less than 50 acres in size; tributaries and rivers connecting to inland lakes containing naturally-reproducing lake sturgeon populations; waters with self-sustaining walleye populations in ceded territories; waters with self-sustaining musky populations; or perennial tributaries to trout streams (WDNR 2017). Little Horsehead Lake is considered a PNW with self-sustaining walleye and musky populations.

The Wisconsin Natural Heritage Inventory (NHI) lists the following plants and animals as rare or sensitive species and/or communities that are considered high-quality and significant natural features (Exhibit 9). They are found in the same town/range is Little Horsehead Lake.

Exhibit 9. Rare Species and Communities located near Little Horsehead Lake.

Common Name	*Scientific Name*	*State Status*[3]	*Group Name*
Fairy slipper	*Calypso bulbosa*	THR	Plant
Downy willow-herb	*Epilobium strictum*	SC	Plant
Smith's melic grass	*Melica smithii*	END	Plant
Sweet colt's foot	*Petasites sagittatus*	THR	Plant
Boreal rich fen		NA	Community
Ephemeral pond		NA	Community
Lake-deep, soft, seepage		NA	Community
Lake-spring		NA	Community
Northern mesic forest		NA	Community
Northern wet forest		NA	Community
Northern wet-mesic forest		NA	Community
Poor fen		NA	Community
Wild rice marsh		NA	Community
Bird rookery		NA	Other

Also of special importance would be monitoring for the presence of aquatic invasive animal species. In 2016, White Water biologists conducted an AIS Early Detection Monitoring Survey. This survey included snorkeling at the boat landing, snorkeling or wading at five sites around the lake, collection of three zooplankton tows, and recording other AIS observed during meandering. No AIS were detected. The zooplankton tows were collected to analyze for spiny

3 **END**=Endangered; **THR**=Threatened; **SC**=Special Concern; **SC/P**=fully protected; **SC/N**=no laws regulating use, possession or harvesting; **SC/H**=take regulated by establishment of open/closed seasons; **SC/FL**=federally protected as endangered or threatened; **SC/M**=fully protected by federal and state laws under Migratory Bird Act.

water flea, however, none were found. The AIS data collected were entered into the WDNR SWIMS database. *Iris* spp. was noted during the aquatic plant survey; however, positive identification could not be made (due to lack of flowers). Follow-up investigation for this species should be conducted at the appropriate time of the year (yellow iris typically blooms in June).

Part 9. Stakeholders

At this juncture in the ongoing aquatic plant management planning process, the Town Lakes Committee has represented the Little Horsehead Lake stakeholders. Additional stakeholders and interested citizens are invited to participate as the plan is refined and updated in order to broaden input, build consensus, and encourage participation in stewardship. No contentious direct plant management actions (for example, harvesting or use of herbicides) are a component of the current plan. The Town Lakes Committee has conducted a township wide lake users' survey that is presented in the overarching ***Wilderness Waters Adaptive Management Plan*** (Premo et al. 2015).

CHAPTER 5

Recommendations, Actions, and Objectives

In this chapter we provide recommendations for specific objectives and associated actions to support the APM Plan's goals stated in Chapter 3 and re-stated here for convenient reference:

> ***(1) Monitor and protect the native aquatic plant community;***
>
> ***(2) Prevent establishment of AIS and nuisance levels of native plants;***
>
> ***(3) Promote and interpret APM efforts; and***
>
> ***(4) Educate riparian owners and lake users on preventing AIS introduction, reducing nutrient inputs that potentially alter the plant community, and minimizing physical removal of native riparian and littoral zone plants.***

Since Little Horsehead Lake is a healthy and diverse ecosystem, we could simply recommend an alternative of "no action." In other words, Little Horsehead Lake continues without any effort or intervention on part of lake stewards. Nevertheless, we consider the "no action" alternative imprudent. Many forces threaten the quality of the lake and Wilderness Waters Program and Town Lakes Committee feels a great responsibility to minimize the threats. We therefore outline in this section a set of actions and related management objectives that will actively engage lake stewards in the process of management.

The actions are presented in tabular form. Each "action" consists of a set of four statements: (1) a declarative "action" statement that specifies the action (2) a statement of the "objective" that the action serves, (3) a "monitoring" statement that specifies the party responsible for carrying out the action and maintaining data, and (4) a "status" statement that suggests a timeline/calendar and indicates status (not yet started, ongoing, or completed).

Recommended Actions for the Little Horsehead Lake APM Plan
Action #1: Formally adopt the 2018 Aquatic Plant Management Plan. ***Objective:*** To continue with long-term native plant community conservation and stewardship and to be prepared for response to AIS introductions. ***Monitoring:*** The Lake Association and Town Lakes Committee oversee activity. ***Status:*** Planned for 2020.
Action #2: Monitor water quality. ***Objective***: Continue with collection and analysis of water quality parameters to detect trends in parameters such as nutrients, chlorophyll *a*, and water clarity. ***Monitoring:*** The Lake Association or Town Lakes Committee oversees activity. ***Status:*** Ongoing.
Action #3: Continue to monitor the lake for aquatic invasive plant species. ***Objective***: To understand the lake's biotic community, provide for early detection of AIS and continue monitoring any existing populations of AIS. ***Monitoring:*** The Lake Association or Town Lakes Committee oversees activity and maintains data. ***Status:*** Ongoing.
Action #4: Continue to monitor the lake for aquatic invasive animal species. ***Objective***: To understand the lake's biotic community, provide for early detection of AIS and continue monitoring any existing populations of AIS. ***Monitoring:*** The Lake Association or Town Lakes Committee oversees activity and maintains data. ***Status:*** Ongoing.
Action #5: Monitor Little Horsehead Lake for the presence of yellow iris during the flowering season (June). ***Objective***: To verify presence of this species. ***Monitoring:*** The Lake Association or Town Lakes Committee oversees activity. ***Status:*** Planned for 2020.

Recommended Actions for the Little Horsehead Lake APM Plan
Action #6: Form an Aquatic Invasive Species Rapid Response Team and interface with the Town Lakes Committee AIS Rapid Response Coordinator. ***Objective:*** To be prepared for AIS discovery and efficient response. ***Monitoring:*** The Lake Association and/or Town Lakes Committee coordinate activity. ***Status:*** Planned for 2020.
Action #7: Conduct quantitative plant survey every five years using WDNR Point-Intercept Methodology. ***Objective:*** To watch for changes in native species diversity, floristic quality, plant abundance, and plant distribution and to check for the occurrence of non-native, invasive plant species. ***Monitoring:*** Town Lakes Committee (Wilderness Waters Program) oversees and maintains data; copies to WDNR. ***Status:*** Anticipated in 2021.
Action #8: Update the APM plan approximately every five years or as needed to reflect new plant information from plant surveys and monitoring. ***Objective:*** To have current information and management science included in the plan. ***Monitoring:*** Lake Association and/or Town Lakes Committee (Wilderness Waters Program) oversees and maintains data; copies to WDNR. ***Status:*** Ongoing.
Action #9: Develop a Citizen Lake Monitoring Network to monitor for invasive species and develop strategies including education and monitoring activities (see http://www.uwsp.edu/cnr/uwexlakes/clmn for additional ideas). ***Objective:*** To create a trained volunteer corps to monitor aquatic invasive species and to educate recreational users regarding AIS. ***Monitoring:*** The Lake Association oversees activity and reports instances of possible introductions of AIS. ***Status:*** Anticipated to begin in 2020.

Recommended Actions for the Little Horsehead Lake APM Plan
Action #10: Become familiar with and recognize the water quality and habitat values of ordinances and requirements on boating, septic, and property development. ***Objective:*** To protect native aquatic plants, water quality, and riparian habitat. ***Monitoring:*** Lake residents and other stakeholders. ***Status:*** Ongoing.
Action #11: Promote adherence to, and enforcement of, the Town of Presque Isle's 200 foot no-wake ordinances (from shoreline and islands). ***Objective:*** To minimize recreational impacts on the aquatic plant community and shoreline habitats, and promote safe boating. ***Monitoring:*** Town Lakes Committee oversees activity and assesses effectiveness. ***Status:*** Ongoing.
Action #12: Create an education plan for the property owners and other stakeholders that will address issues concerning aquatic and riparian plant communities. ***Objective:*** To educate stakeholders about issues and topics that affect the lake's aquatic and riparian plant communities, including topics such as: (1) the importance of the aquatic plant community; (2) no or minimal mechanical removal of plants along the shoreline is desirable and that any plant removal should conform to Wisconsin regulations; (3) the value of a natural shoreline in protecting the aquatic plant community and lake health; (4) nutrient sources to the lake and the role excess nutrients play in degradation of the aquatic plant community; (5) the importance of reducing or eliminating use of fertilizers on lake front property; (6) the importance of minimizing transfer of AIS to the lake by having dedicated watercraft and cleaning boats that visit the lake. ***Monitoring:*** Town Lakes Committee oversees activity and assesses effectiveness. ***Status:*** Anticipated to begin in 2020.
Action #13: Monitor the lake watershed for purple loosestrife. ***Objective:*** Identify purple loosestrife populations before they reach large size. ***Monitoring:*** The Lake Association and/or Town Lakes Committee oversee activity. ***Status:*** Anticipated in 2020.

Recommended Actions for the Little Horsehead Lake APM Plan

Action #14: Assess the conditions of the shoreland and shallow water habitat by using the WDNR *Shoreland and Shallows Habitat Monitoring Protocol.*

Objective: To assess current conditions and guide stewardship actions toward maintenance of healthy status and rehabilitation of areas identified as needing assistance..

Monitoring: Town Lakes Committee oversees activity.

Status: Anticipated to begin in 2025.

Action #15: Consider conditions outlined in the *Shoreland and Shallows Habitat Monitoring Report* and implement protection or rehabilitation initiatives where appropriate.

Objective: To maintain and restore high quality conditions of the riparian and shallow water habitat.

Monitoring: Town Lakes Committee oversees activity and assesses effectiveness.

Status: Anticipated to begin in 2025 or earlier as needed.

Action #16: For those who want to consider long-term protection of special areas, individual landowners should review information on the Northwoods Land Trust, a local land conservancy that serves northern Wisconsin (northwoodslandtrust.org).

Objective: To conserve family lands (especially lake shorelands) for future generations.

Monitoring: Town Lakes Committee stays apprised of properties within the Township that are participating in conservation of lands with the Northwoods Land Trust.

Status: Ongoing.

Action #17: Identify and highlight high quality areas of littoral zone and riparian areas through review of aquatic plant and shoreland assessment data through various reports and online tools.

Objective: To (1) educate lake users on the value of these areas and the importance of good stewardship to their maintenance, (2) recognize landowners who implement good practices (e.g., large percentage of buffer area intact; three vegetative layers intact – herbaceous, shrubs, trees; areas of high native aquatic plant diversity and abundance), and (3) encourage landowners to implement good practices.

Monitoring: Town Lakes Committee and/or lake association promotes and oversees activity.

Status: Ongoing.

Recommended Actions for the Little Horsehead Lake APM Plan
Action #18: Lake leaders should encourage and assist landowners to take on lake shore/shallow water improvement projects to rehabilitate areas identified through formal shoreland/shallow water assessments and/or lake user observations (sites might include areas of active erosion, channelized flow, point source pollution, imperious surfaces, and lawns) *Vilas County Land and Water Conservation* looks for partners in this endeavor and can provide planning and sponsorship of projects. ***Objective:*** To rehabilitate specific areas of shoreland to improve natural functions and values. ***Monitoring:*** Lake groups and lake leaders monitor and report progress to Town Lakes Committee. ***Status:*** Ongoing.
Action #19: As part of an education program, encourage commitment from property owners to adopt practices that maintain/improve health of shoreland areas. In many cases, these are "practices" that mean less or no work (e.g., now mowing, no weed wacking, no leaf blowing, no removing large woody material). ***Objective:*** To engage landowners in simple practices that improve/maintain health of the lake and shoreland. ***Monitoring:*** Each landowner can monitor changes in the shoreland over time by simple means (e.g., annual mid-summer photographs or a catalog of plants and animals seen over time). ***Status:*** Anticipated to begin in 2020.

CHAPTER 6

Contingency Plan for AIS

Unfortunately, sources of aquatic invasive plants and other AIS are numerous in Wisconsin. Some infested lakes are quite close to Presque Isle Township. There is an increasing likelihood of accidental introduction of AIS to Presque Isle Township Lakes through conveyance of life stages by boats, trailers, and other vectors. It is important for the Town Lakes Committee and other lake stewards to be prepared for the contingency of aquatic invasive plant species colonization in a Presque Isle Township water body.

For riparian owners and users of a lake ecosystem, the discovery of AIS is a tragedy that elicits an immediate desire to "fix the problem." Although strong emotions may be evoked by such a discovery, a deliberate and systematic approach is required to appropriately and effectively address the situation. An aquatic plant management plan (one including a contingency plan for AIS) is the best tool by which the process can be navigated. In fact the APM plan is a requirement in Wisconsin for some kinds of aquatic plant management actions. One of the actions outlined in the previous chapter was to establish an Aquatic Invasive Species Rapid Response Team. This team and its coordinator are integral to the management process. It is important for this team to be multi-dimensional (or at least have quick access to the expertise that may be required). AIS invade not just a single lake, but an entire region since the new infestation is an outpost from which the AIS can more easily colonize other nearby water bodies. For this reason it is strategic for the Rapid Response Team to include representation from regional stakeholders.

Exhibit 10 provides a flowchart outlining an appropriate rapid response to the suspected discovery of an aquatic invasive plant species. The response will be most efficient if an AIS Rapid Response Team has already been established and is familiar with the contingency plan. In the remainder of this chapter we further describe the approach.

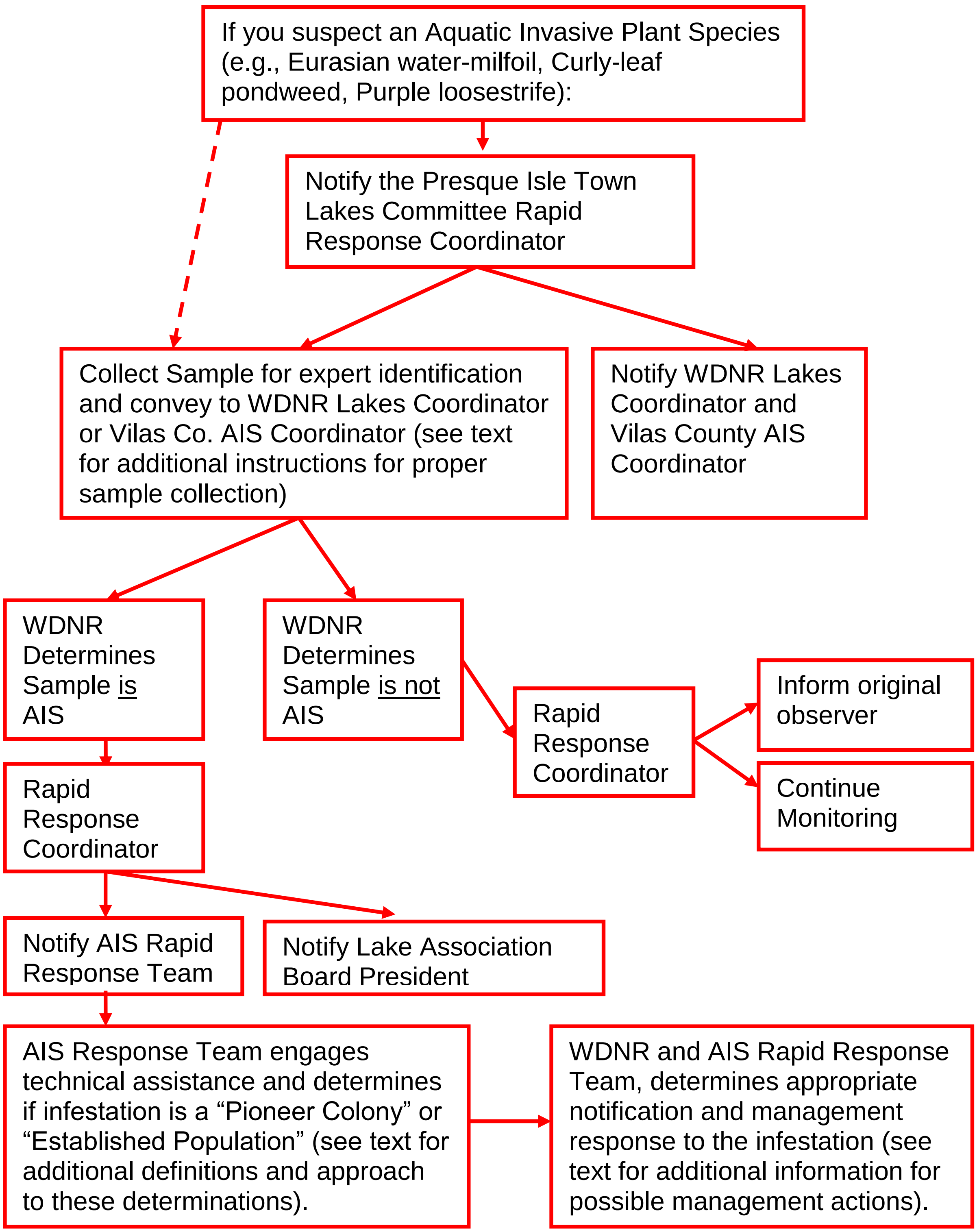
When a suspect aquatic invasive plant species is found, either the original observer or a member of the Rapid Response Team (likely the coordinator) should collect an entire plant specimen including roots, stems, and flowers (if present). The sample should be placed in a sealable bag with a small amount of water to keep it moist. Place a label in the bag written in pencil with date, time, collector's name, lake name, location, town, and county. Attach a lake map to the bag that has the location of the suspect AIS marked and GPS coordinates recorded (if GPS is available). The sample should be placed on ice in a cooler or in a refrigerator. Deliver the sample to the WDNR Water Resource Management Specialist (Kevin Gauthier in Woodruff) or the Vilas County AIS Coordinator (Al Wirt) as soon as possible (at least within three days). The WDNR or their botanical expert(s) will determine the species and confirm whether or not it is an aquatic invasive plant species.

If the suspect specimen is determined to be an invasive plant species, the next step is to determine the extent and density of the population since the management response will vary accordingly. The Rapid Response Team should conduct (or have its consultant conduct) a survey to define the colony's perimeter and estimate density. If less than five acres (or <5% of the lake surface area), it is designated a "Pioneer Colony." If greater than five acres (or >5% of the lake surface area) then it is designated an "Established Population." Once the infestation is characterized, "at risk" areas should also be determined and marked on a map. For example, nearby boat landing sites and areas of high boat traffic should be indicated.

When "pioneer" or "established" status has been determined, it is time to consult with the WDNR Lakes Coordinator to determine appropriate notifications and management responses to the infestation. Determining whether hand-pulling or chemical treatment will be used is an important and early decision. Necessary notifications of landowners, governmental officials, and recreationists (at boat landings) will be determined. Whether the population's perimeter needs to be marked with buoys will be decided by the WDNR. Funding sources will be identified and consultants and contractors will be contacted where necessary. The WDNR will determine if a further baseline plant survey is required (depending on type of treatment). A post treatment monitoring plan will be discussed and established to determine the efficacy of the selected treatment.

Once the Rapid Response Team is organized, one of its first tasks is to develop a list of contacts and associated contact information (phone numbers and email addresses). At a minimum, this contact list should include: the Rapid Response Coordinator, members of the Rapid Response Team, County AIS Coordinator, WDNR Lakes Management Coordinator, Lake Association Presidents (or other points of contact), local WDNR warden, local government official(s), other experts, tribal contacts, chemical treatment contractors, and consultant(s).

Exhibit 10. Aquatic Invasive Plant Species Rapid Response



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Appendix A
Literature Cited

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WHITE WATER ASSOCIATES, INC.

Appendix B

Aquatic Plant Survey Tables and Figures

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Table 1. Summary statistics for the 2016 point-intercept aquatic plant surveys for Little Horsehead Lake.

Summary Statistic	Value	Notes
Total number of sites on grid	235	Total number of sites on the original grid (not necessarily visited)
Total number of sites visited	230	Total number of sites where the boat stopped, even if much too deep to have plants.
Total number of sites with vegetation	66	Total number of sites where at least one plant was found
Total number of sites shallower than maximum depth of plants	84	Number of sites where depth was less than or equal to the maximum depth where plants were found. This value is used for Frequency of occurrence at sites shallower than maximum depth of plants.
Frequency of occurrence at sites shallower than maximum depth of plants	78.57	Number of times a species was seen divided by the total number of sites shallower than maximum depth of plants.
Simpson Diversity Index	0.85	A nonparametric estimator of community heterogeneity. It is based on Relative Frequency and thus is not sensitive to whether all sampled sites (including non-vegetated sites) are included. The closer the Simpson Diversity Index is to 1, the more diverse the community.
Maximum depth of plants (ft.)	10.5	The depth of the deepest site sampled at which vegetation was present.
Number of sites sampled with rake on rope	13	
Number of sites sampled with rake on pole	125	
Average number of all species per site (shallower than max depth)	1.81	
Average number of all species per site (vegetated sites only)	2.30	
Average number of native species per site (shallower than max depth)	1.81	Total number of species collected. Does not include visual sightings.
Average number of native species per site (vegetated sites only)	2.30	Total number of species collected including visual sightings.
Species Richness	19	
Species Richness (including visuals)	30	
Floristic Quality Index (FQI)	26.4	An assessment metric designed to evaluate the closeness that the flora of an area is to that of undisturbed conditions.

Table 2. Summary statistics for the 2007 point-intercept aquatic plant surveys for Little Horsehead Lake.

Summary Statistic	Value	Notes
Total number of sites on grid	235	Total number of sites on the original grid (not necessarily visited)
Total number of sites visited		Total number of sites where the boat stopped, even if much too deep to have plants.
Total number of sites with vegetation		Total number of sites where at least one plant was found
Total number of sites shallower than maximum depth of plants		Number of sites where depth was less than or equal to the maximum depth where plants were found. This value is used for Frequency of occurrence at sites shallower than maximum depth of plants.
Frequency of occurrence at sites shallower than maximum depth of plants	80.58	Number of times a species was seen divided by the total number of sites shallower than maximum depth of plants.
Simpson Diversity Index	0.89	A nonparametric estimator of community heterogeneity. It is based on Relative Frequency and thus is not sensitive to whether all sampled sites (including non-vegetated sites) are included. The closer the Simpson Diversity Index is to 1, the more diverse the community.
Maximum depth of plants (ft.)	12.00	The depth of the deepest site sampled at which vegetation was present.
Number of sites sampled with rake on rope		
Number of sites sampled with rake on pole		
Average number of all species per site (shallower than max depth)	2.58	
Average number of all species per site (vegetated sites only)	3.20	
Average number of native species per site (shallower than max depth)	2.58	Total number of species collected. Does not include visual sightings.
Average number of native species per site (vegetated sites only)	3.20	Total number of species collected including visual sightings.
Species Richness	14	
Species Richness (including visuals)		
Floristic Quality Index (FQI)	23.0	An assessment metric designed to evaluate the closeness that the flora of an area is to that of undisturbed conditions.

Table 3. Plant species recorded and distribution statistics for the 2016 Little Horsehead Lake aquatic plant survey.

Common name	Scientific name	Frequency of occurrence at sites less than or equal to maximum depth of plants	Frequency of occurrence within vegetated areas (%)	Relative Frequency (%)	Number of sites where species found	Number of sites where species found (including visuals)	Average Rake Fullness
Coontail	*Ceratophyllum demersum*	50.00	63.64	27.81	42	44	1.05
Fern pondweed	*Potamogeton robbinsii*	39.29	50.00	21.85	33	34	1.00
White water lily	*Nymphaea odorata*	15.48	19.70	8.61	13	44	1.08
Wild celery	*Vallisneria americana*	13.10	16.67	7.28	11	18	1.00
Slender naiad	*Najas flexilis*	8.33	10.61	4.64	7	10	1.00
Clasping-leaf pondweed	*Potamogeton richardsonii*	8.33	10.61	4.64	7	16	1.00
Flat-stem pondweed	*Potamogeton zosteriformis*	8.33	10.61	4.64	7	13	1.00
Common waterweed	*Elodea canadensis*	7.14	9.09	3.97	6	7	1.00
Large-leaf pondweed	*Potamogeton amplifolius*	5.95	7.58	3.31	5	7	1.00
Spiral-fruited pondweed	*Potamogeton spirillus*	5.95	7.58	3.31	5	10	1.00
Whorled water-milfoil	*Myriophyllum verticillatum*	4.76	6.06	2.65	4	12	1.00
Nitella	*Nitella* sp.	3.57	4.55	1.99	3	4	1.00
Berchtold’s pondweed	*Potamogeton berchtoldii*	2.38	3.03	1.32	2	6	1.00
Water marigold	*Bidens beckii*	1.19	1.52	0.66	1	2	1.00
Slender waterweed	*Elodea nuttallii*	1.19	1.52	0.66	1	1	1.00
Water star-grass	*Heteranthera dubia*	1.19	1.52	0.66	1	1	1.00
Crested arrowhead	*Sagittaria cristata*	1.19	1.52	0.66	1	1	1.00
Softstem bulrush	*Schoenoplectus tabernaemontani*	1.19	1.52	0.66	1	1	1.00
Common bladderwort	*Utricularia vulgaris*	1.19	1.52	0.66	1	1	1.00
Bur-reed 1	*Sparganium* sp. *1*				Visual	11	
Pickerelweed	*Pontederia cordata*				Visual	9	
Swamp loosestrife	*Decodon verticillatus*				Visual	8	
Spatterdock	*Nuphar variegata*				Visual	3	
Ribbon-leaf pondweed	*Potamogeton epihydrus*				Visual	3	

Frequency of occurrence within vegetated areas (%): Number of times a species was seen in a vegetated area divided by the total number of vegetated sites.

Table 3. Continued.

Common name	Scientific name	Frequency of occurrence at sites less than or equal to maximum depth of plants	Frequency of occurrence within vegetated areas (%)	Relative Frequency (%)	Number of sites where species found	Number of sites where species found (including visuals)	Average Rake Fullness
Bur-reed 2	*Sparganium sp. 2*				Visual	3	
Watershield	*Brasenia schreberi*				Visual	1	
Small duckweed	*Lemna minor*				Visual	1	
Common arrowhead	*Sagittaria latifolia*				Visual	1	
Broad-leaved cattail	*Typha latifolia*				Visual	1	
Water horsetail	*Equisetum fluviatile*				Boat Survey	1	

Frequency of occurrence within vegetated areas (%): Number of times a species was seen in a vegetated area divided by the total number of vegetated sites.

Table 4. Plant species recorded and distribution statistics for the 2007 Little Horsehead Lake aquatic plant survey.

Common name	Scientific name	Frequency of occurrence at sites less than or equal to maximum depth of plants	Frequency of occurrence within vegetated areas (%)	Relative Frequency (%)	Number of sites where species found	Number of sites where species found (including visuals)	Average Rake Fullness
Coontail	*Ceratophyllum demersum*	49.51	61.45	19.17	51	--	1.00
Common waterweed	*Elodea canadensis*	37.86	46.99	14.66	39	--	1.00
Small pondweed	*Potamogeton pusillus*	30.10	37.35	11.65	31	--	1.00
Fern pondweed	*Potamogeton robbinsii*	29.13	36.14	11.28	30	--	1.00
Flat-stem pondweed	*Potamogeton zosteriformis*	24.27	30.12	9.40	25	--	1.00
Northern water-milfoil	*Myriophyllum sibiricum*	22.33	27.71	8.65	23	--	1.00
Wild celery	*Vallisneria americana*	18.45	22.89	7.14	19	--	1.00
Clasping-leaf pondweed	*Potamogeton richardsonii*	15.53	19.28	6.02	16	--	1.00
Bushy pondweed	*Najas flexilis*	11.65	14.46	4.51	12	--	1.00
Large-leaf pondweed	*Potamogeton amplifolius*	6.80	8.43	2.63	7	--	1.00
Water marigold	*Bidens beckii*	2.91	3.61	1.13	3	--	1.00
White water lily	*Nymphaea odorata*	2.91	3.61	1.13	3	--	1.00
Pickerelweed	*Pontederia cordata*	2.91	3.61	1.13	3	--	1.00
Nitella	*Nitella* sp.	0.97	1.20	0.38	1	--	1.00

Frequency of occurrence within vegetated areas (%): Number of times a species was seen in a vegetated area divided by the total number of vegetated sites.

Table 5. Comparison of summary statistics for 2007 and 2016 point-intercept aquatic plant surveys in Little Horsehead Lake.

Summary Statistic	2007	2016
Total number of sites on grid	235	235
Total number of sites visited		230
Total number of sites with vegetation		66
Total number of sites shallower than maximum depth of plants		84
Frequency of occurrence at sites shallower than maximum depth of plants	80.58	78.57
Simpson Diversity Index	0.89	0.85
Maximum depth of plants (ft.)	12.00	10.50
Number of sites sampled with rake on rope		13
Number of sites sampled with rake on pole		125
Average number of all species per site (shallower than max depth)	2.58	1.81
Average number of all species per site (vegetated sites only)	3.20	2.30
Average number of native species per site (shallower than max depth)	2.58	1.81
Average number of native species per site (vegetated sites only)	3.20	2.30
Species Richness	14	19
Species Richness (including visuals)		30
Floristic Quality Index (FQI)	23.0	26.4

Figure 1. Number of plant species recorded at Little Horsehead Lake sample sites (2016).

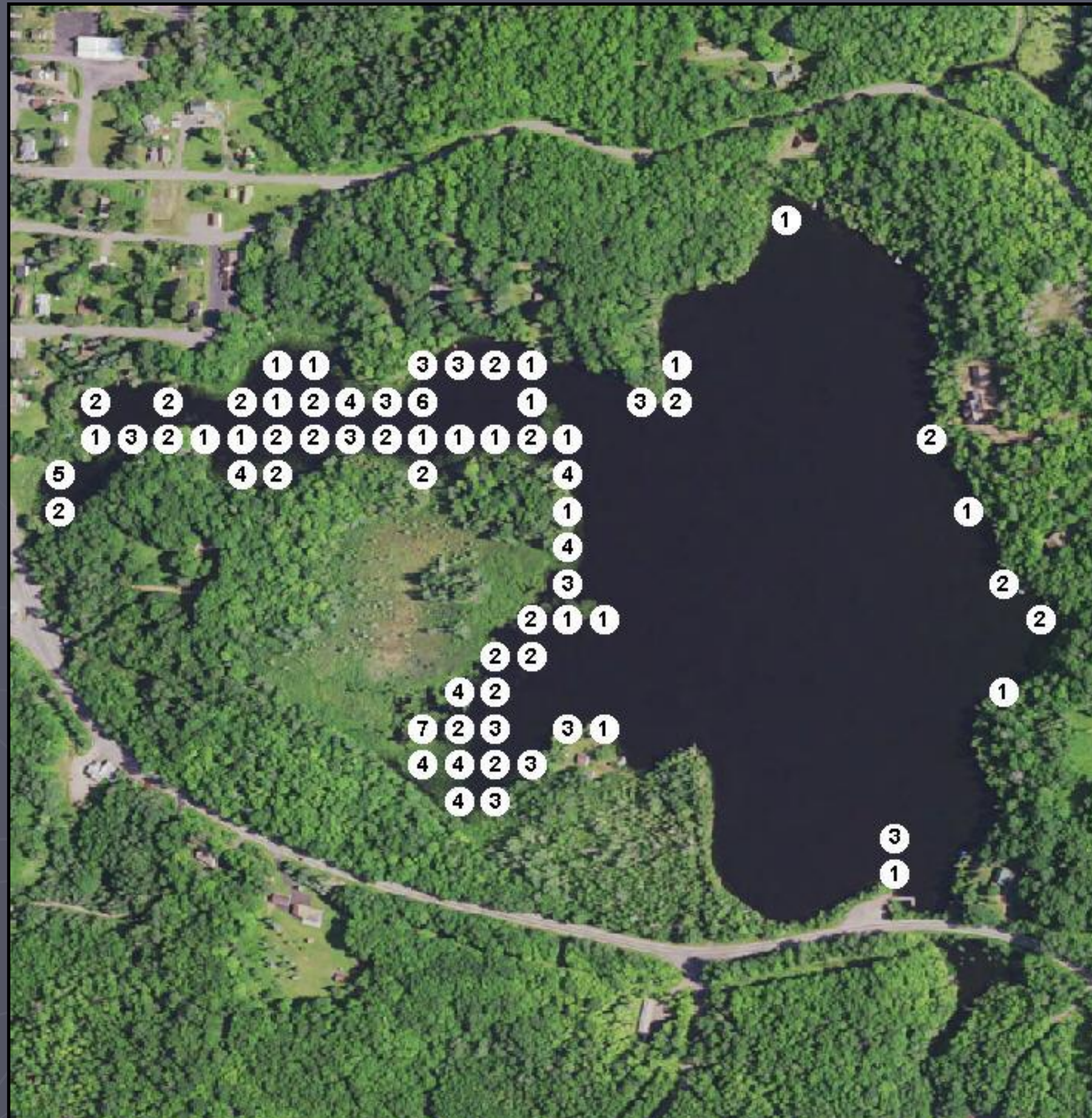
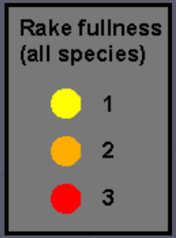


Figure 2. Rake fullness ratings for Little Horsehead Lake sample sites (2016).



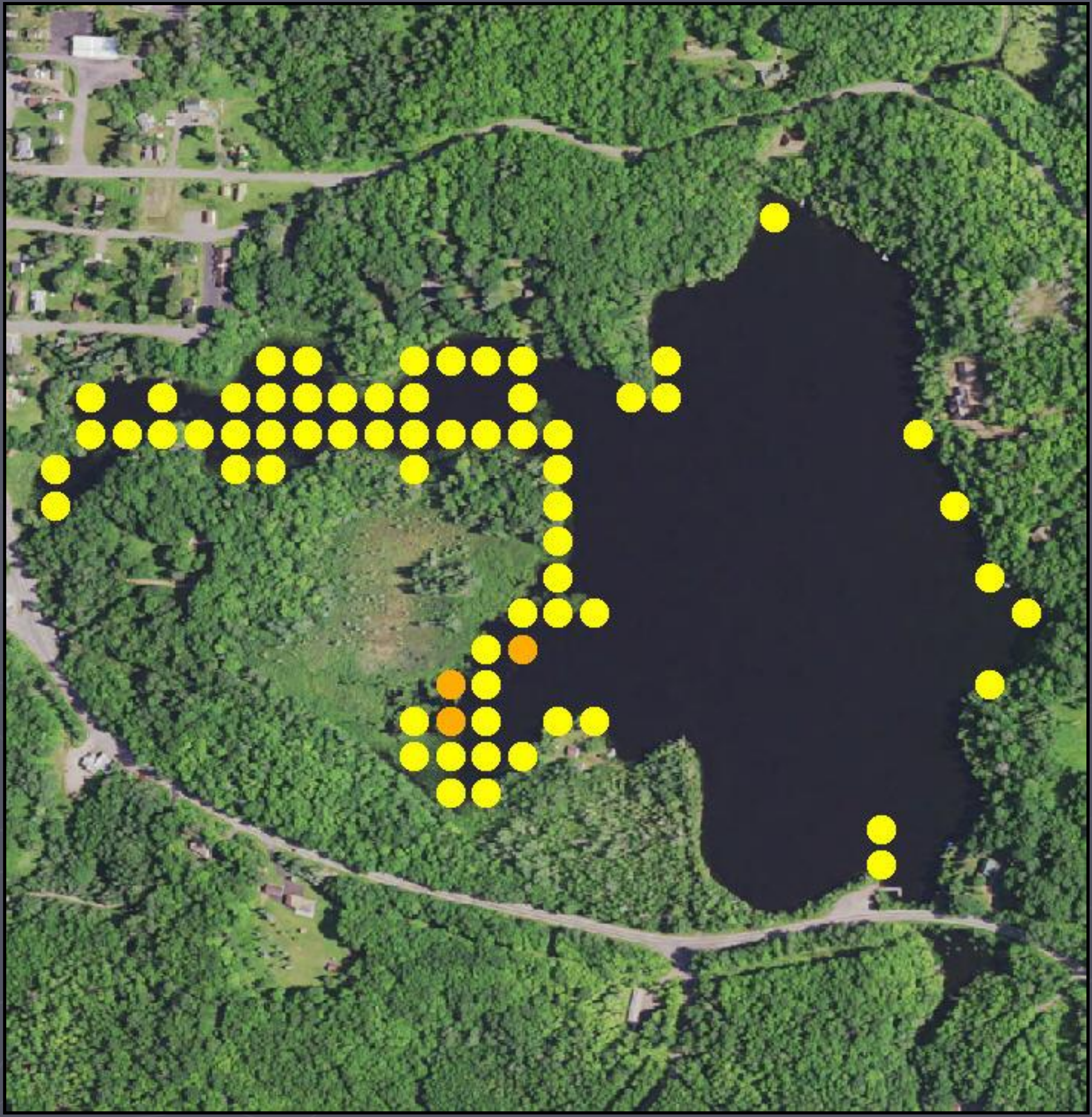


Figure 3. Maximum Depth of Plant Colonization in Little Horsehead Lake.

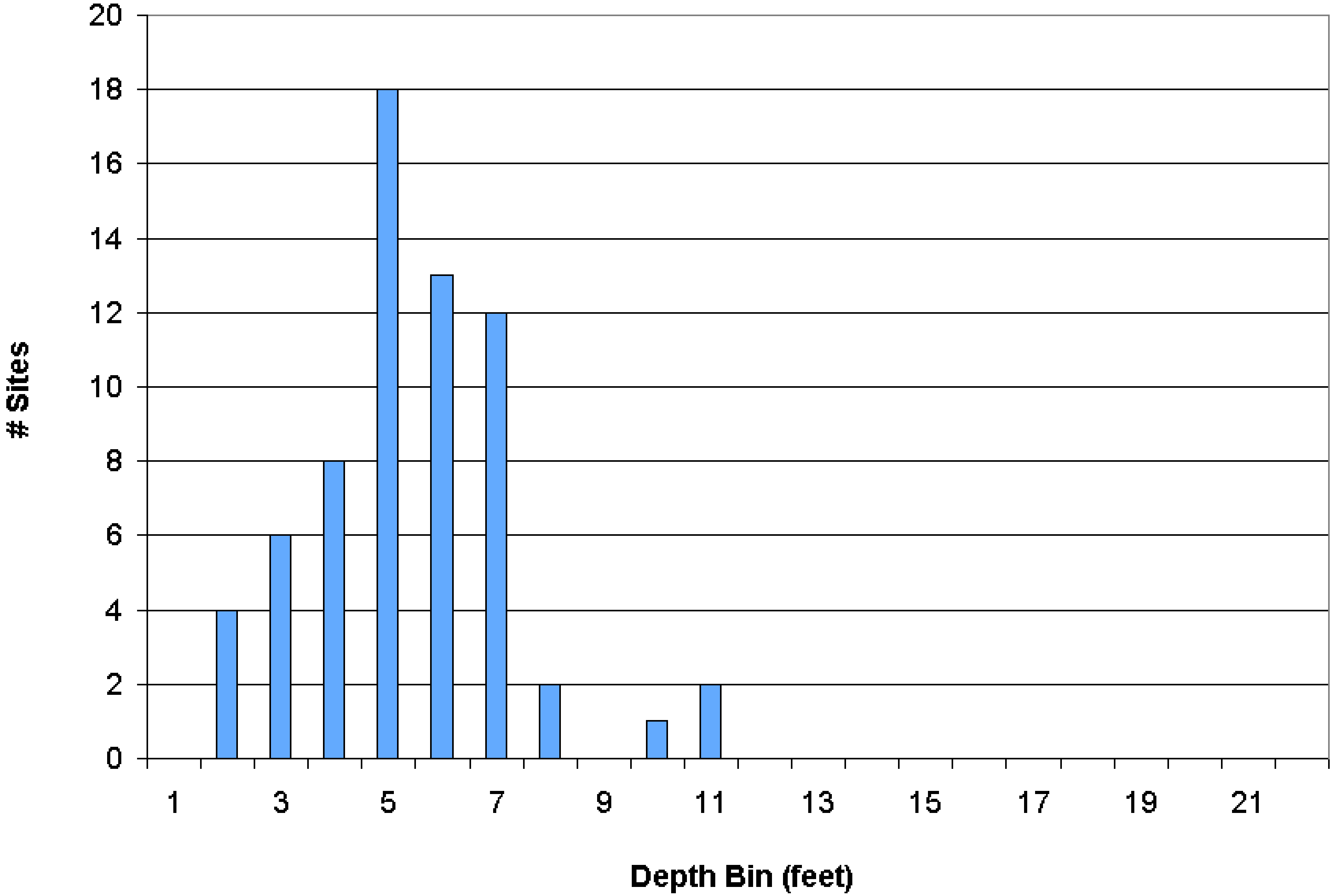


Figure 4. Little Horsehead Lake sampling sites less than or equal to maximum depth of rooted vegetation (2016).

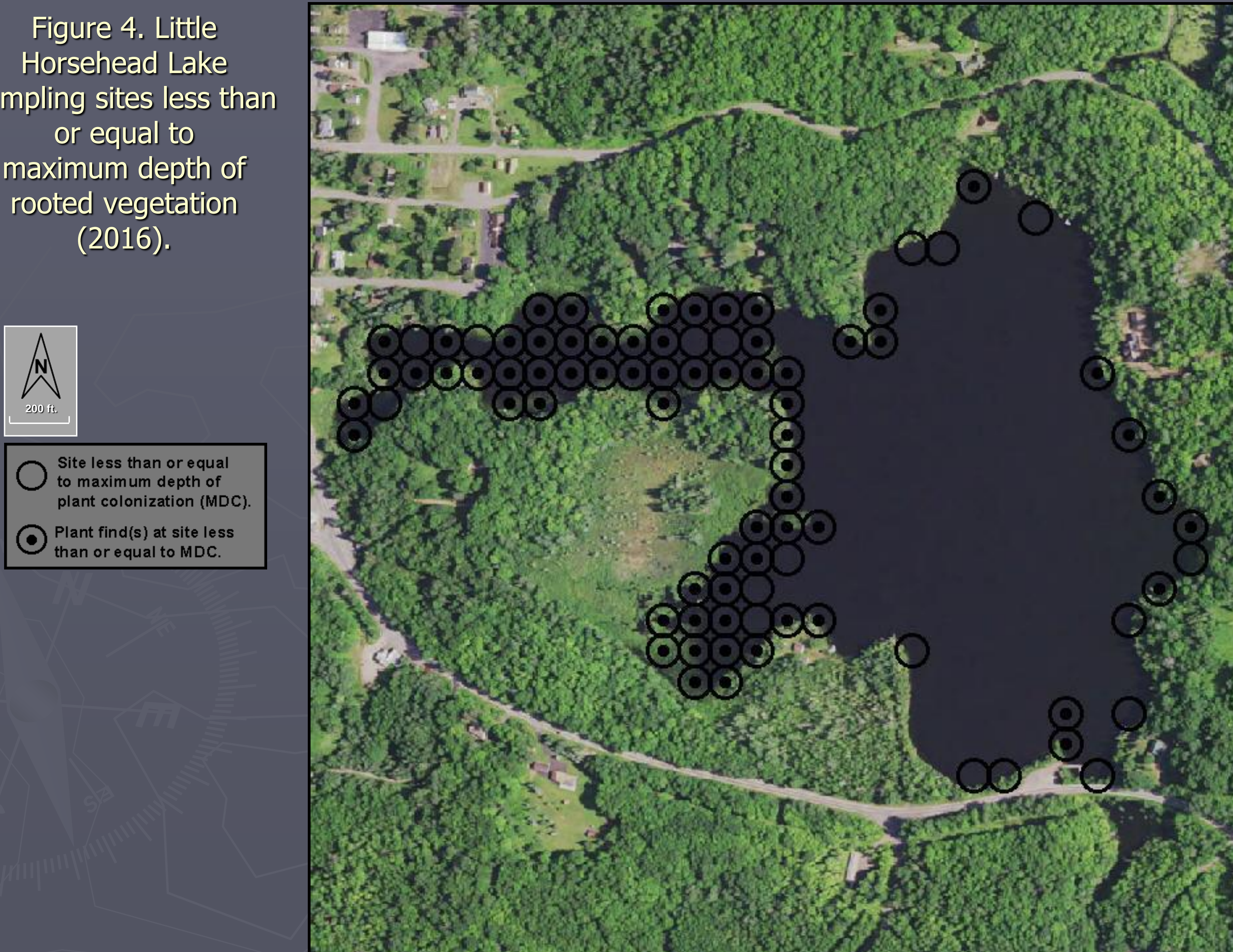


Figure 5. Little Horsehead Lake substrate encountered at point-intercept plant sampling sites (2016).

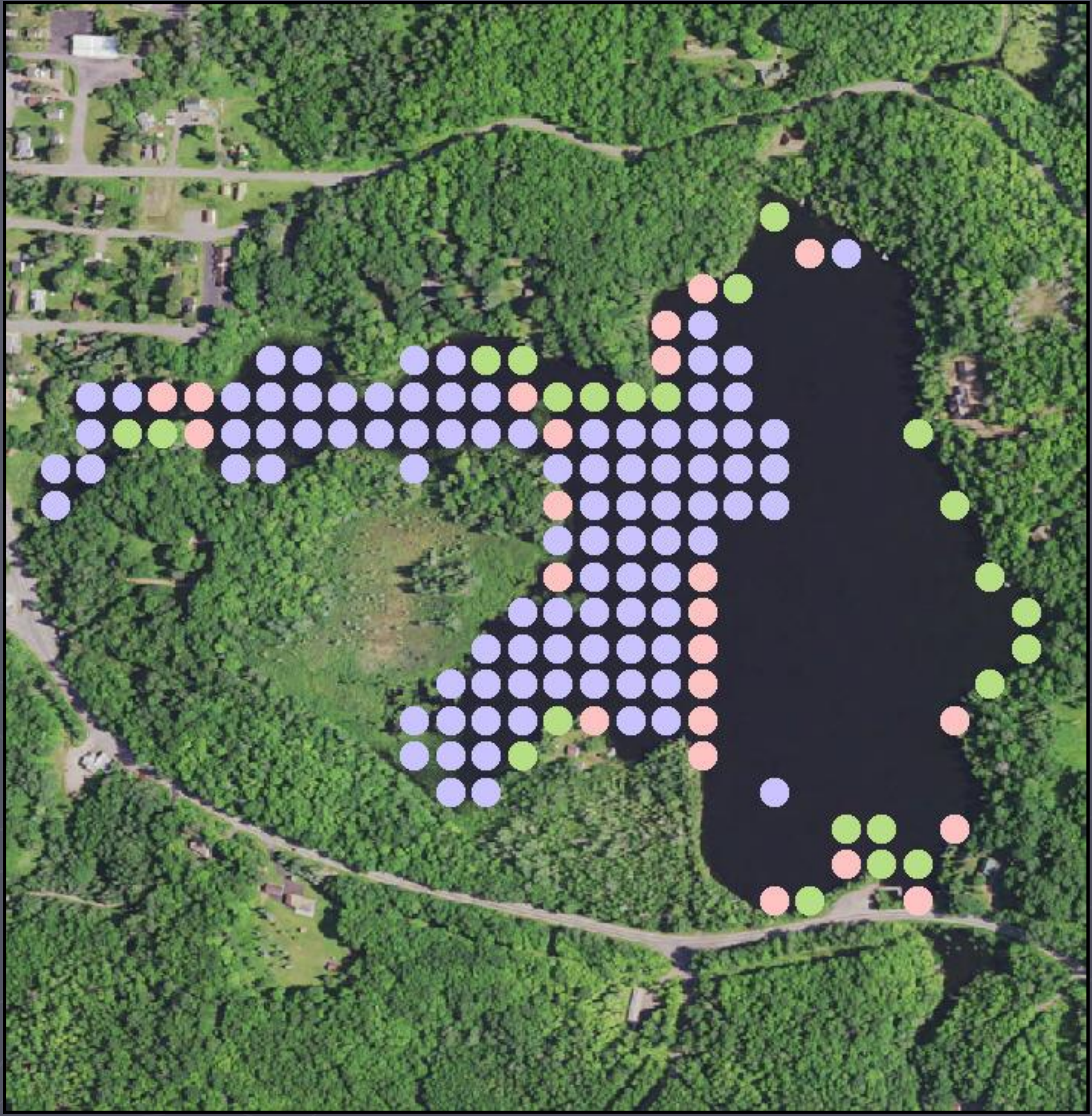


Figure 6. Little Horsehead Lake aquatic plant occurrences for 2016 point-intercept survey data.

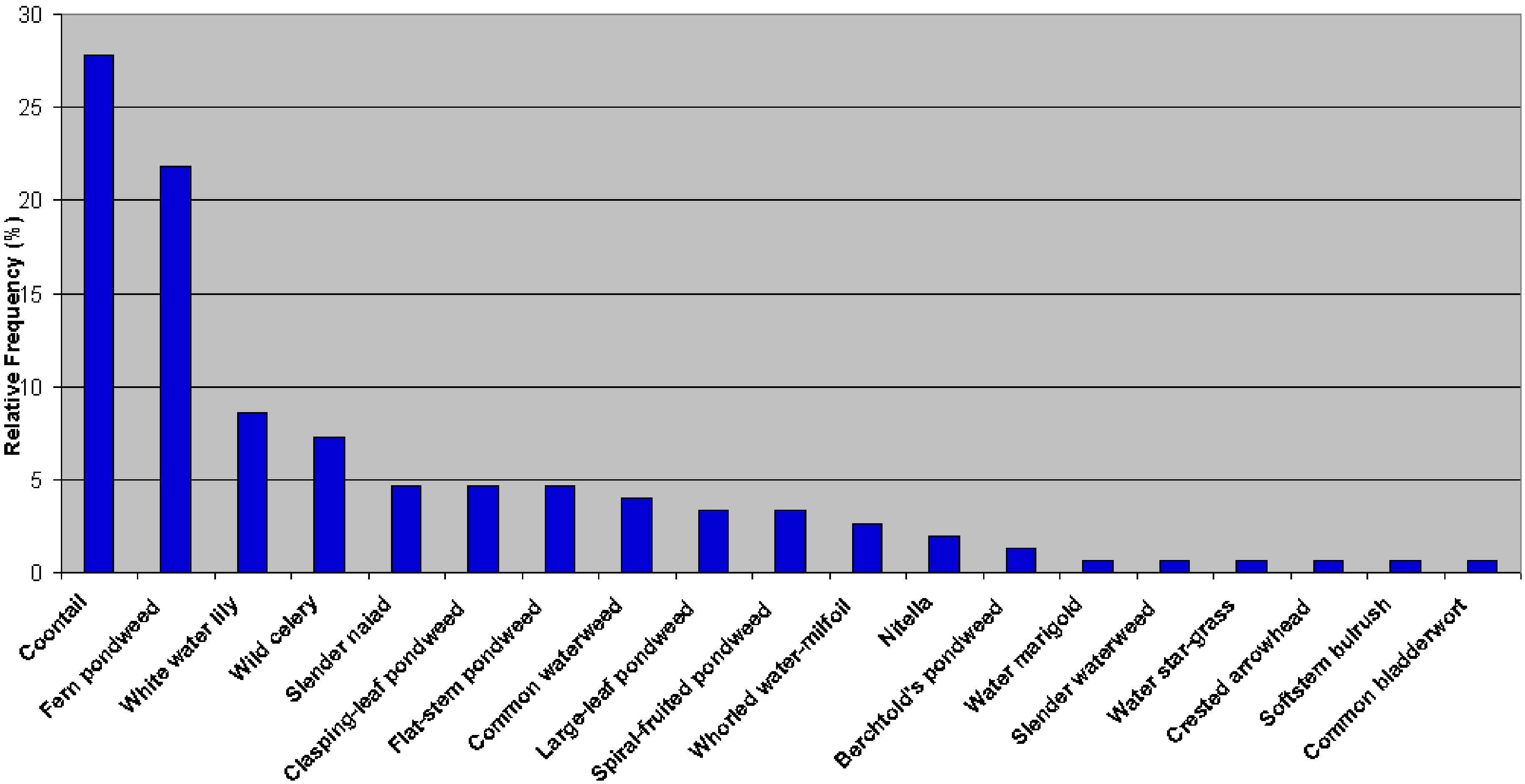


Figure 7. Little Horsehead Lake point-intercept plant sampling sites with emergent and floating aquatic plants (2016).

Figure 8. Distribution of plant species, Little Horsehead Lake (2016).

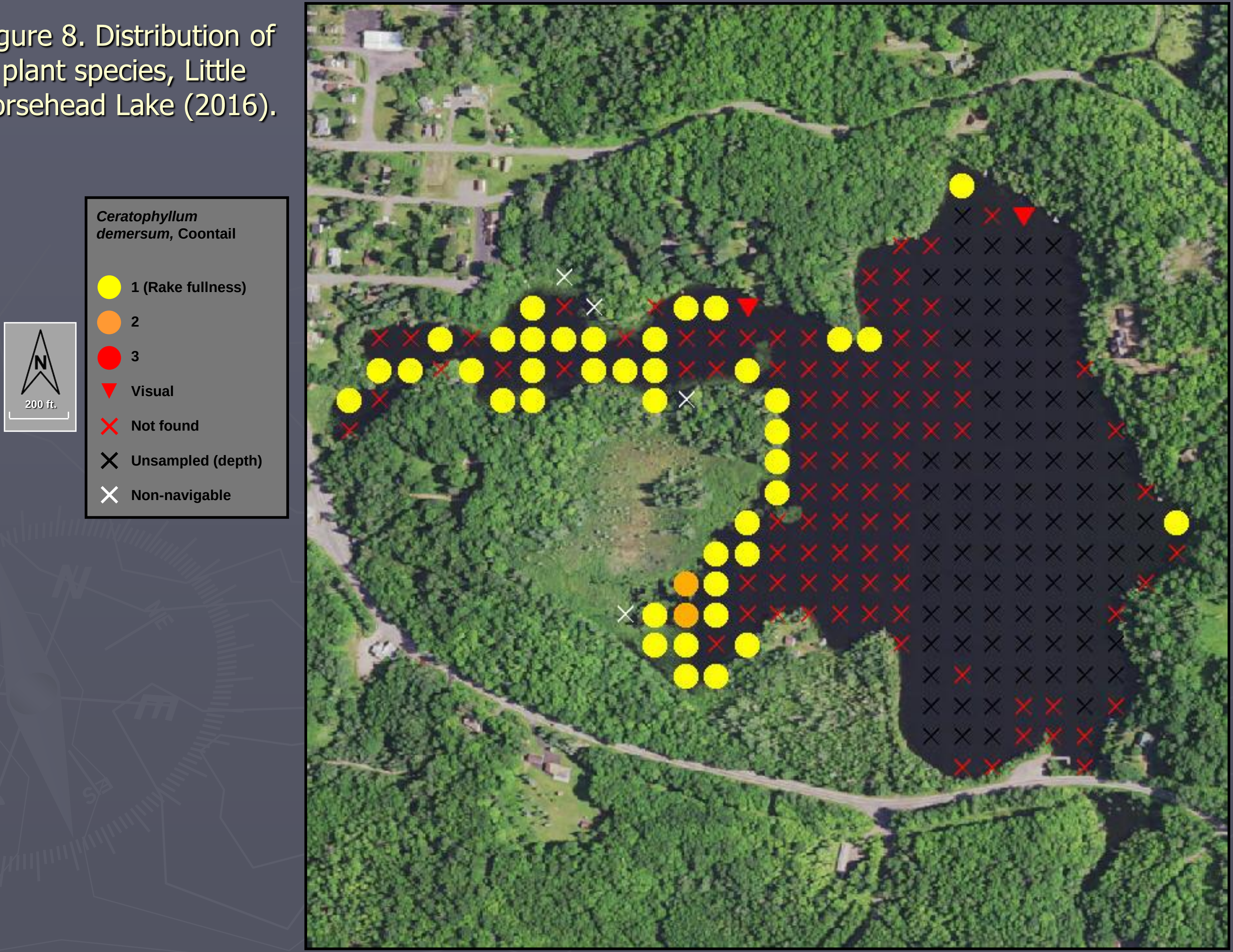


Figure 9. Distribution of plant species, Little Horsehead Lake (2016).

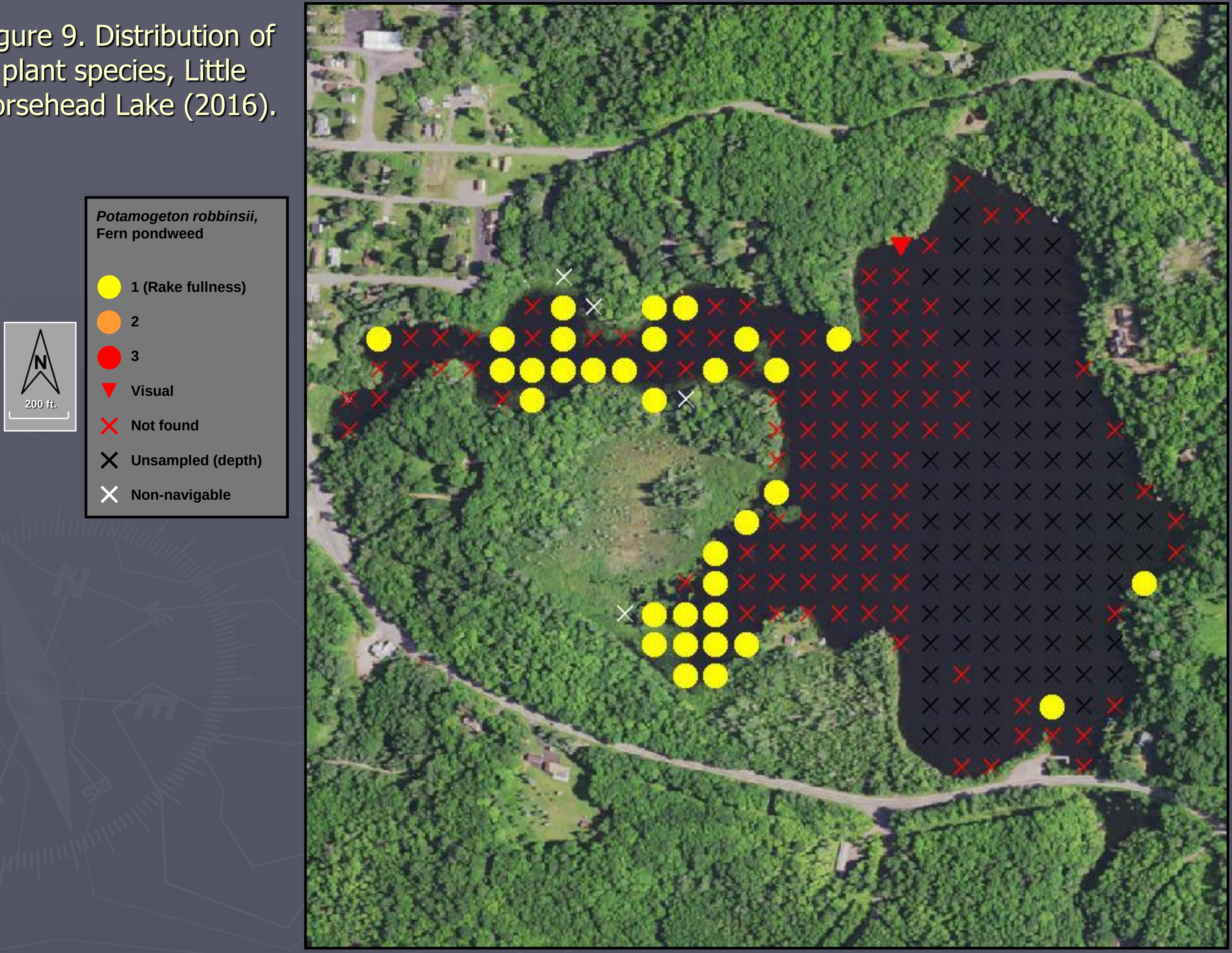


Figure 10. Distribution of plant species, Little Horsehead Lake (2016).

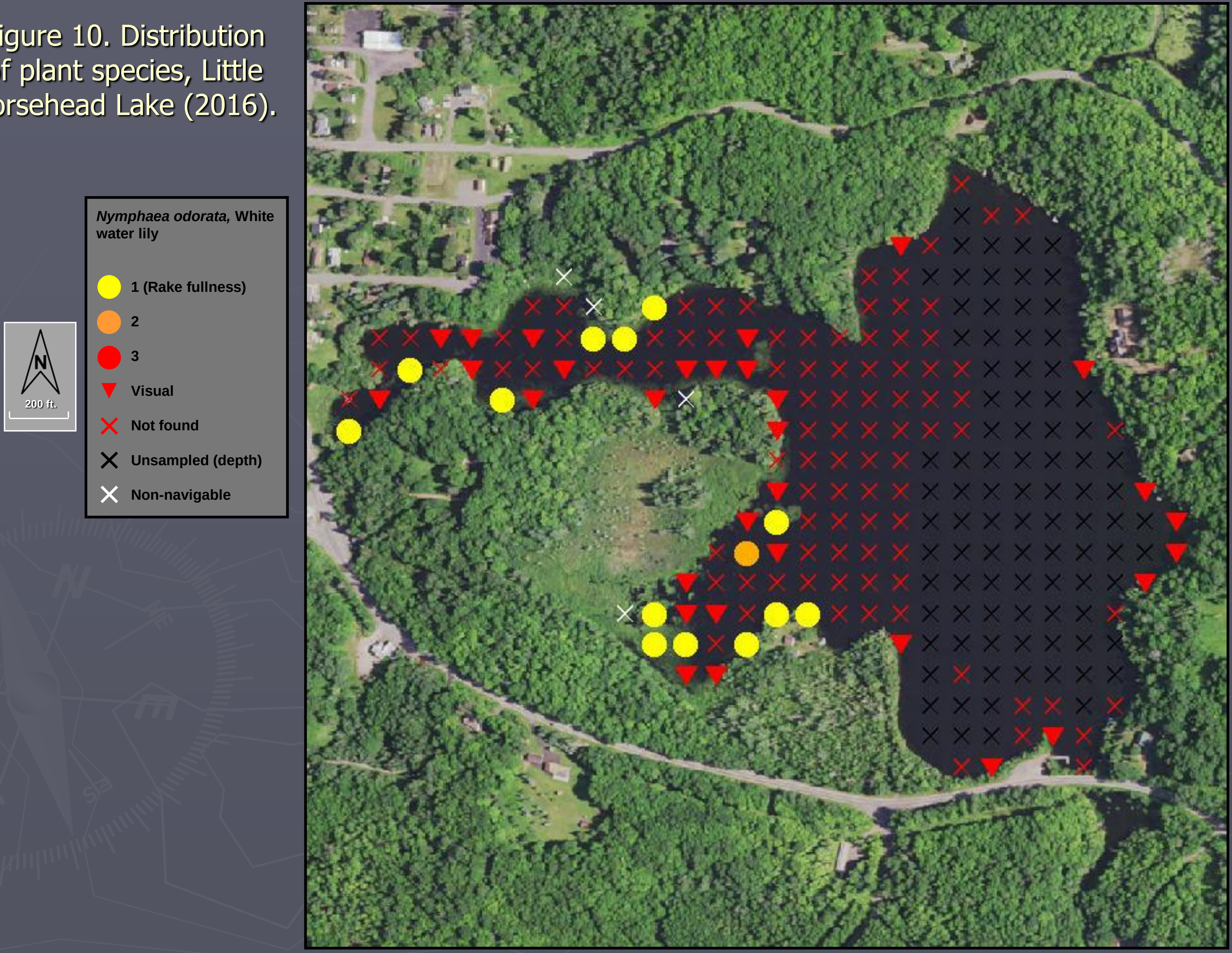


Figure 11. Distribution of plant species, Little Horsehead Lake (2016).

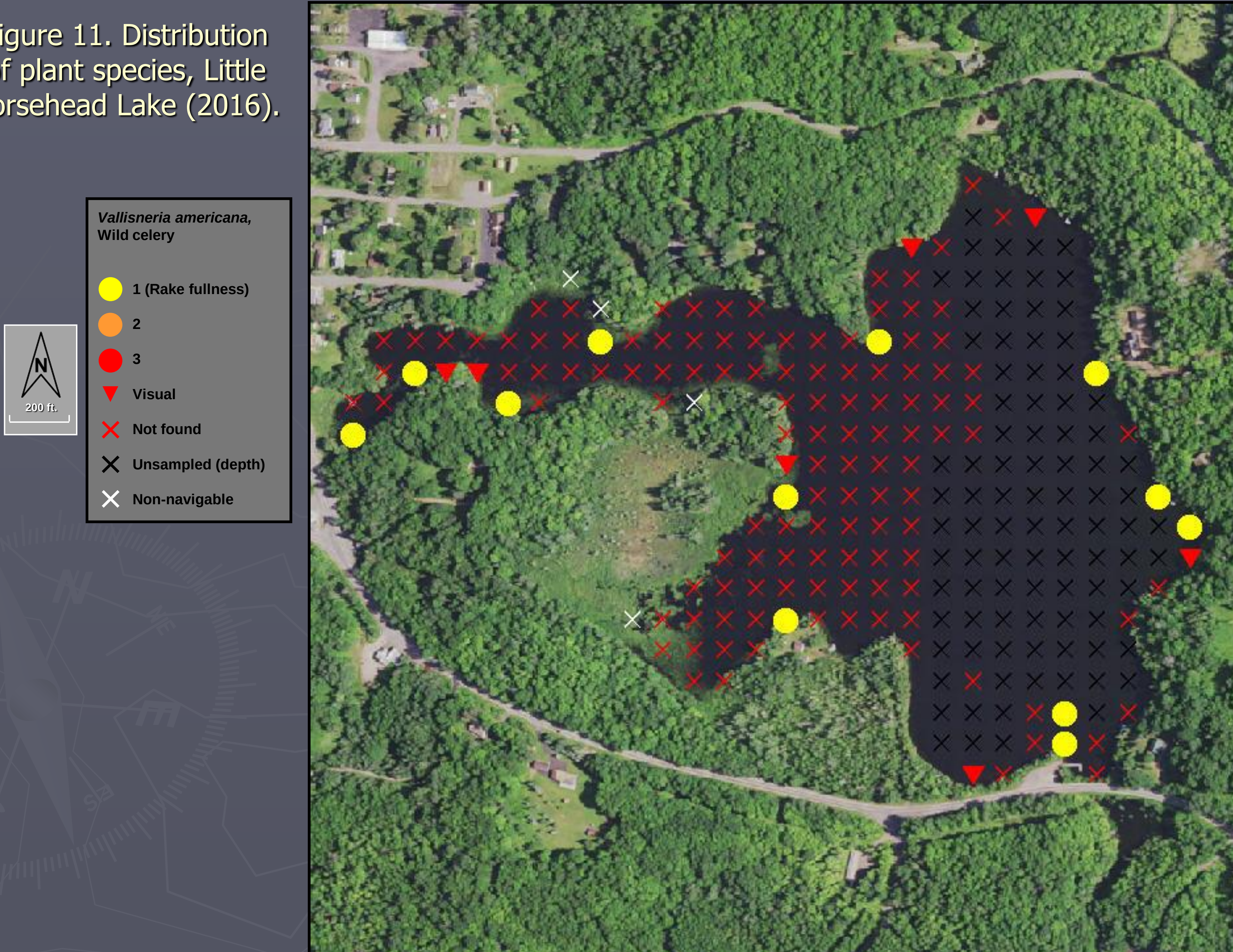
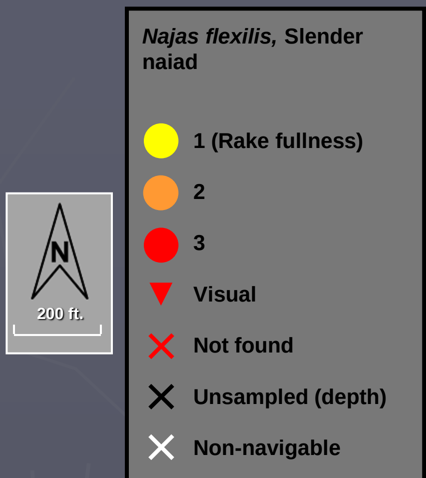


Figure 12. Distribution of plant species, Little Horsehead Lake (2016).



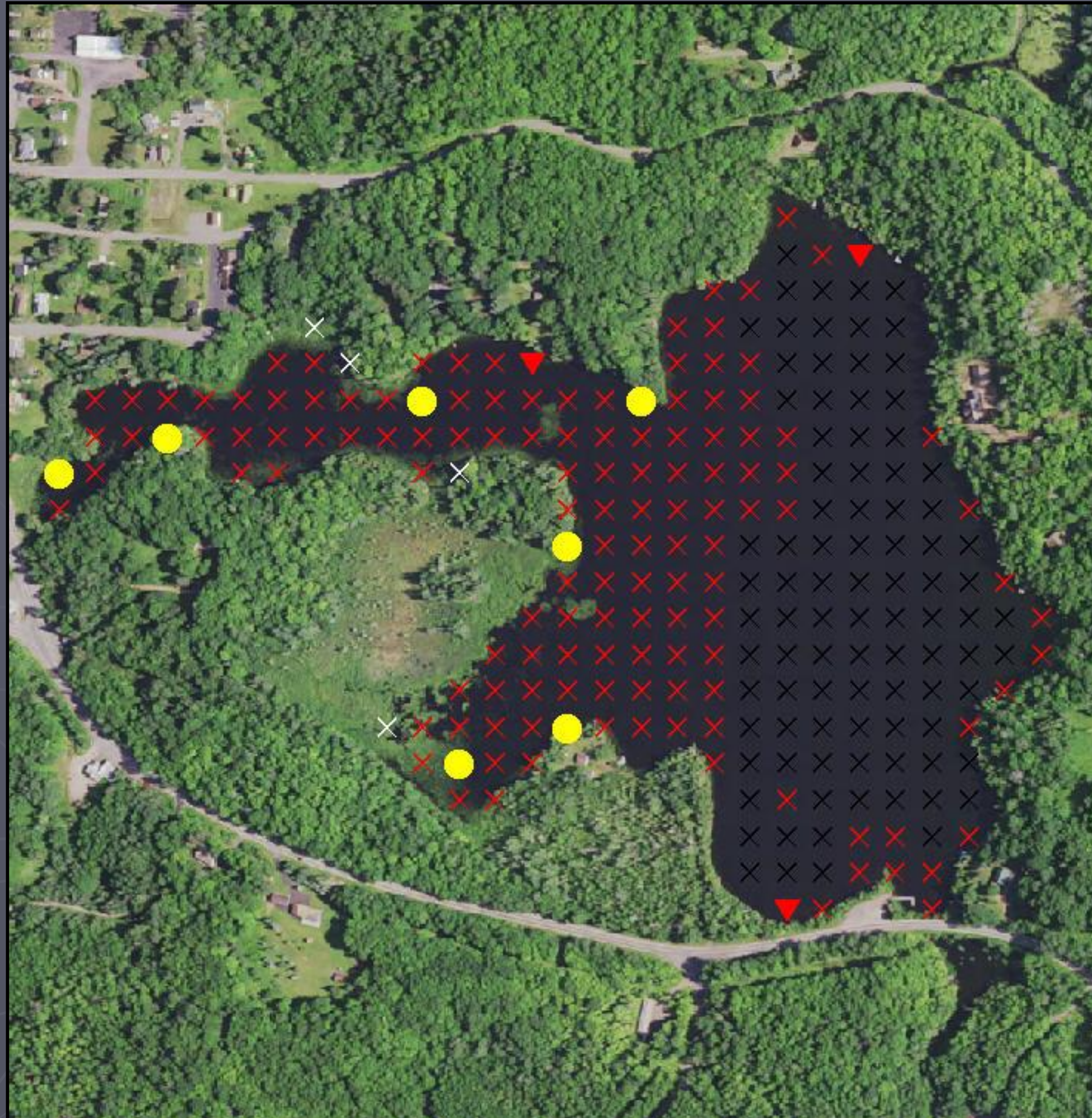


Figure 13. Distribution of plant species, Little Horsehead Lake (2016).

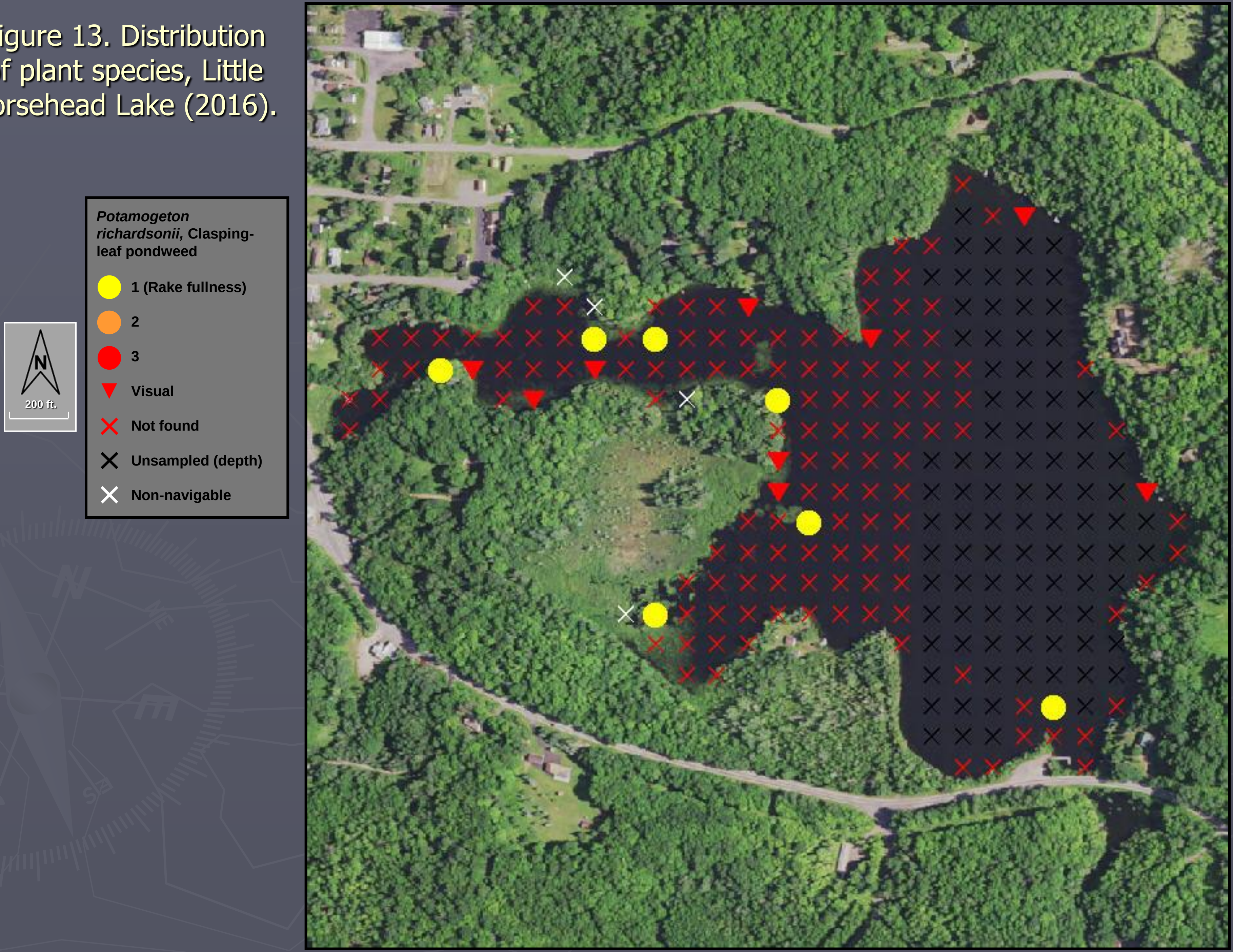


Figure 14. Distribution of plant species, Little Horsehead Lake (2016).

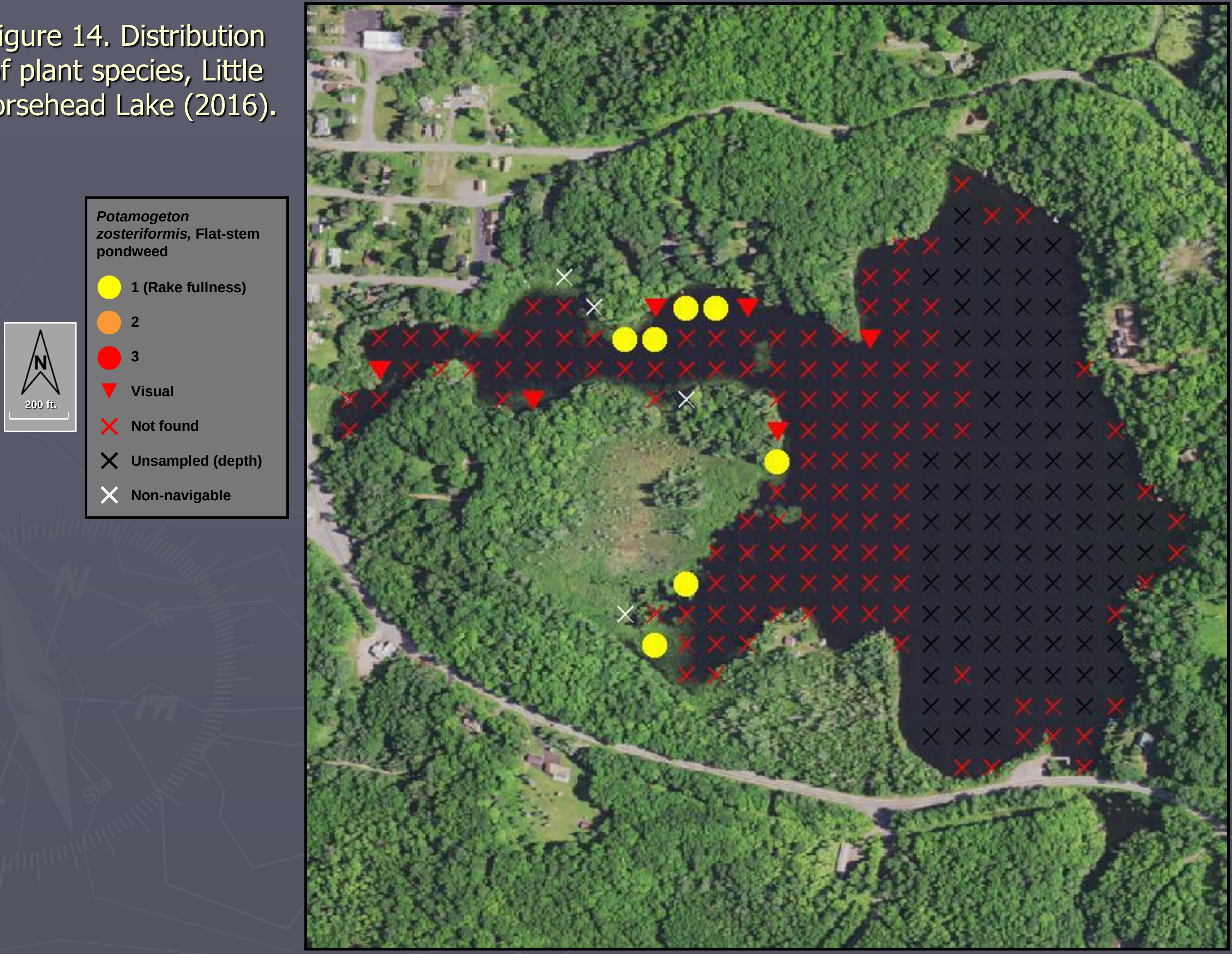


Figure 15. Distribution of plant species, Little Horsehead Lake (2016).

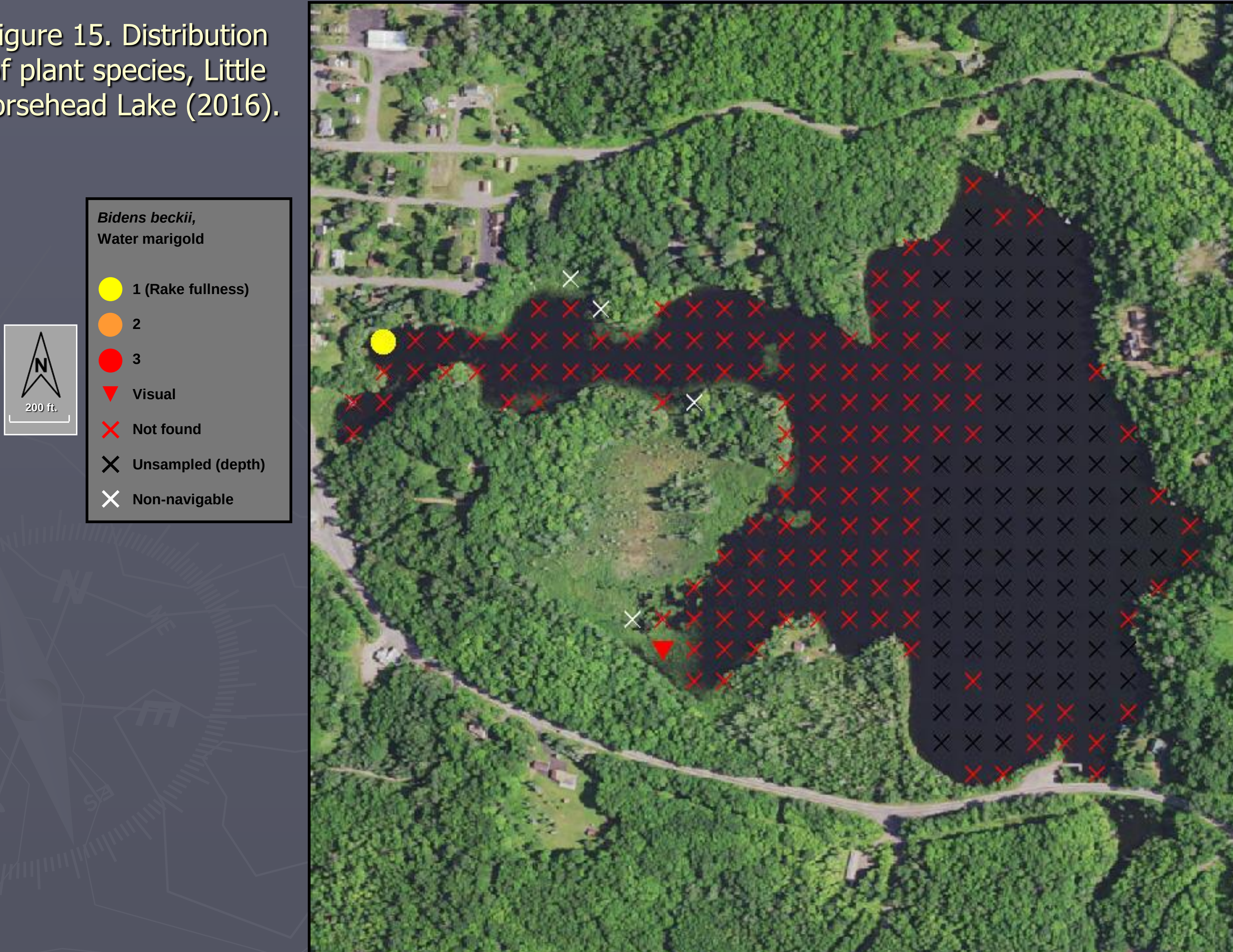


Figure 16. Distribution of plant species, Little Horsehead Lake (2016).

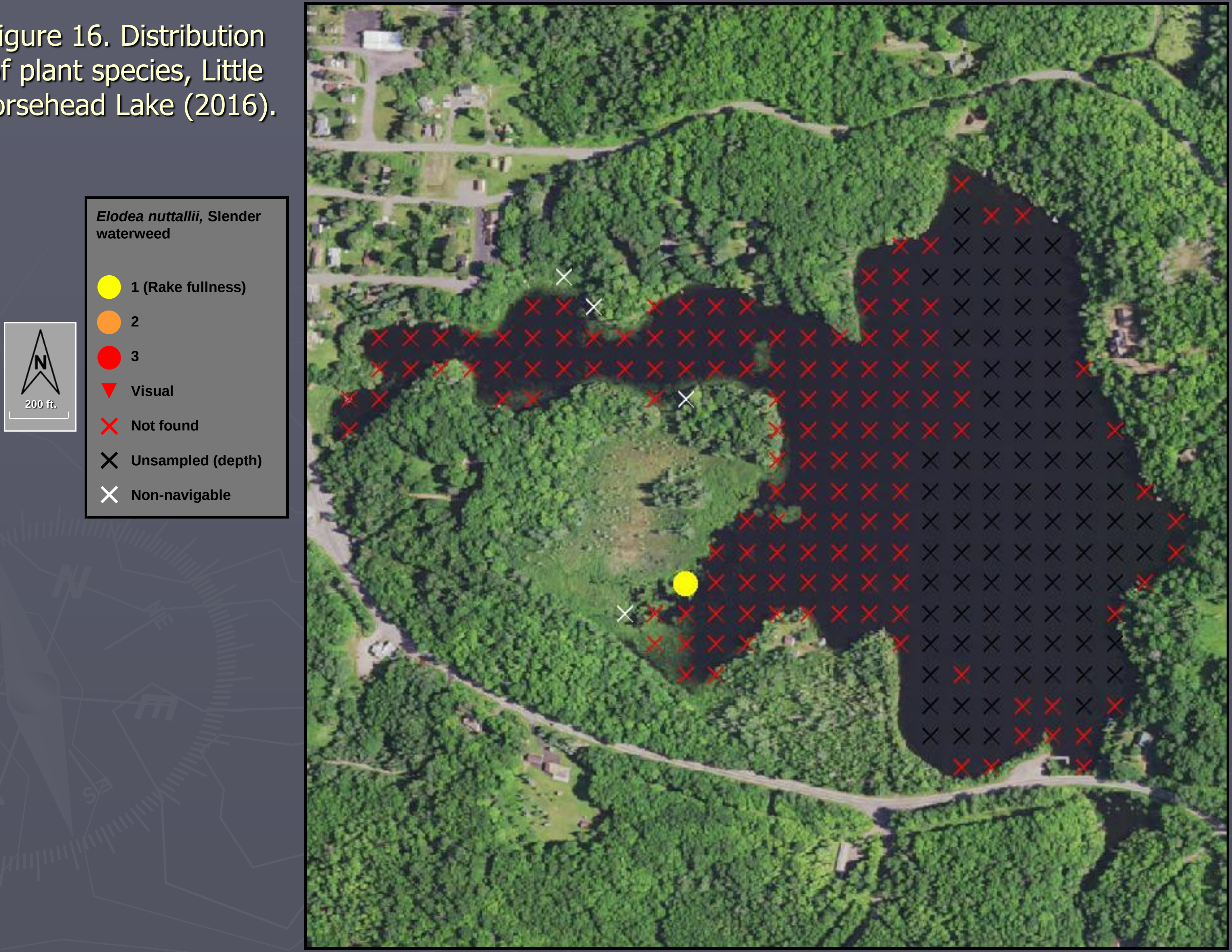


Figure 17. Distribution of plant species, Little Horsehead Lake (2016).

***Heteranthera dubia*, Water star-grass**

- **1 (Rake fullness)**
- **2**
- **3**
- **Visual**
- **Not found**
- **Unsampled (depth)**
- **Non-navigable**

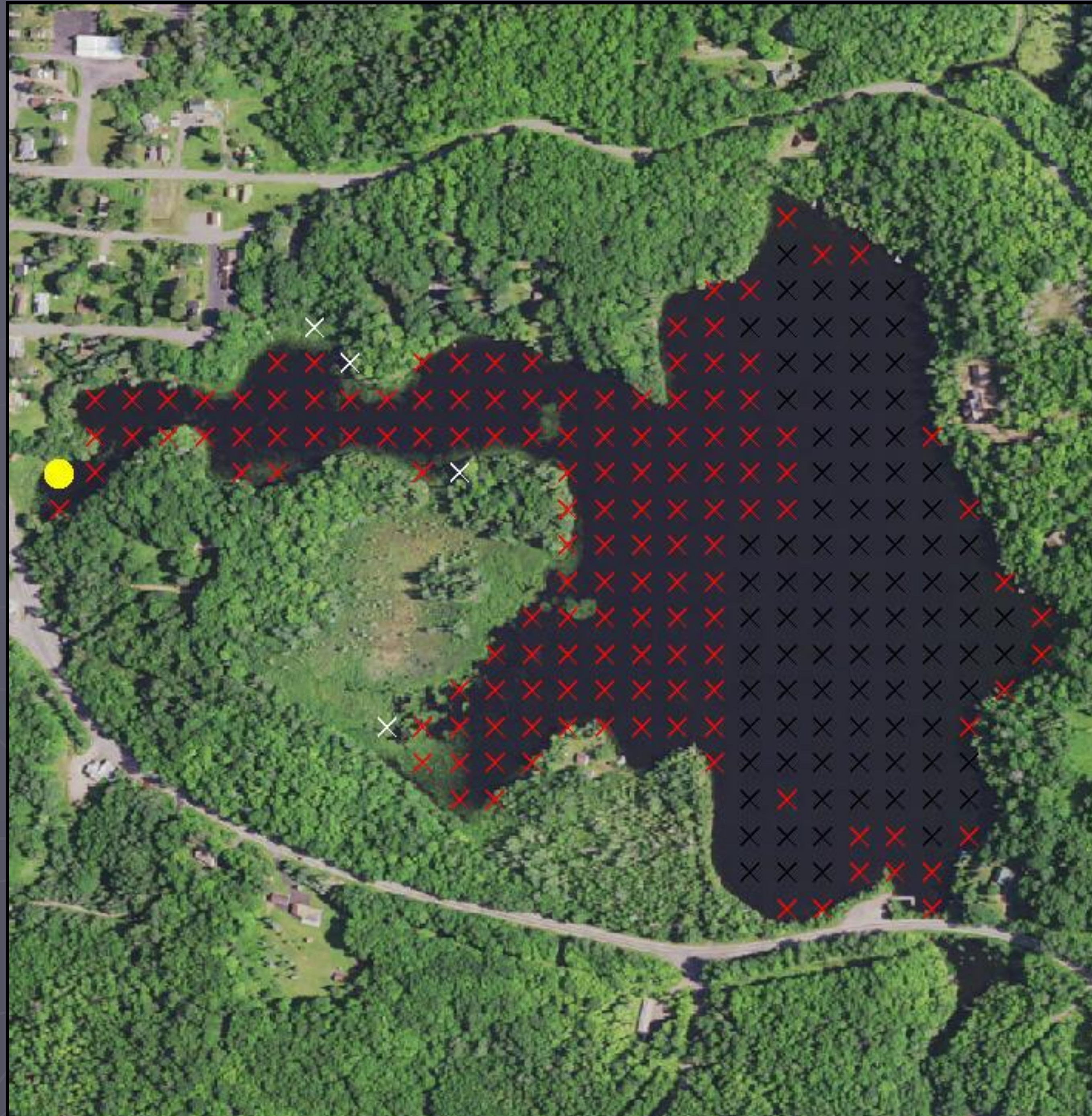


Figure 18. Distribution of plant species, Little Horsehead Lake (2016).

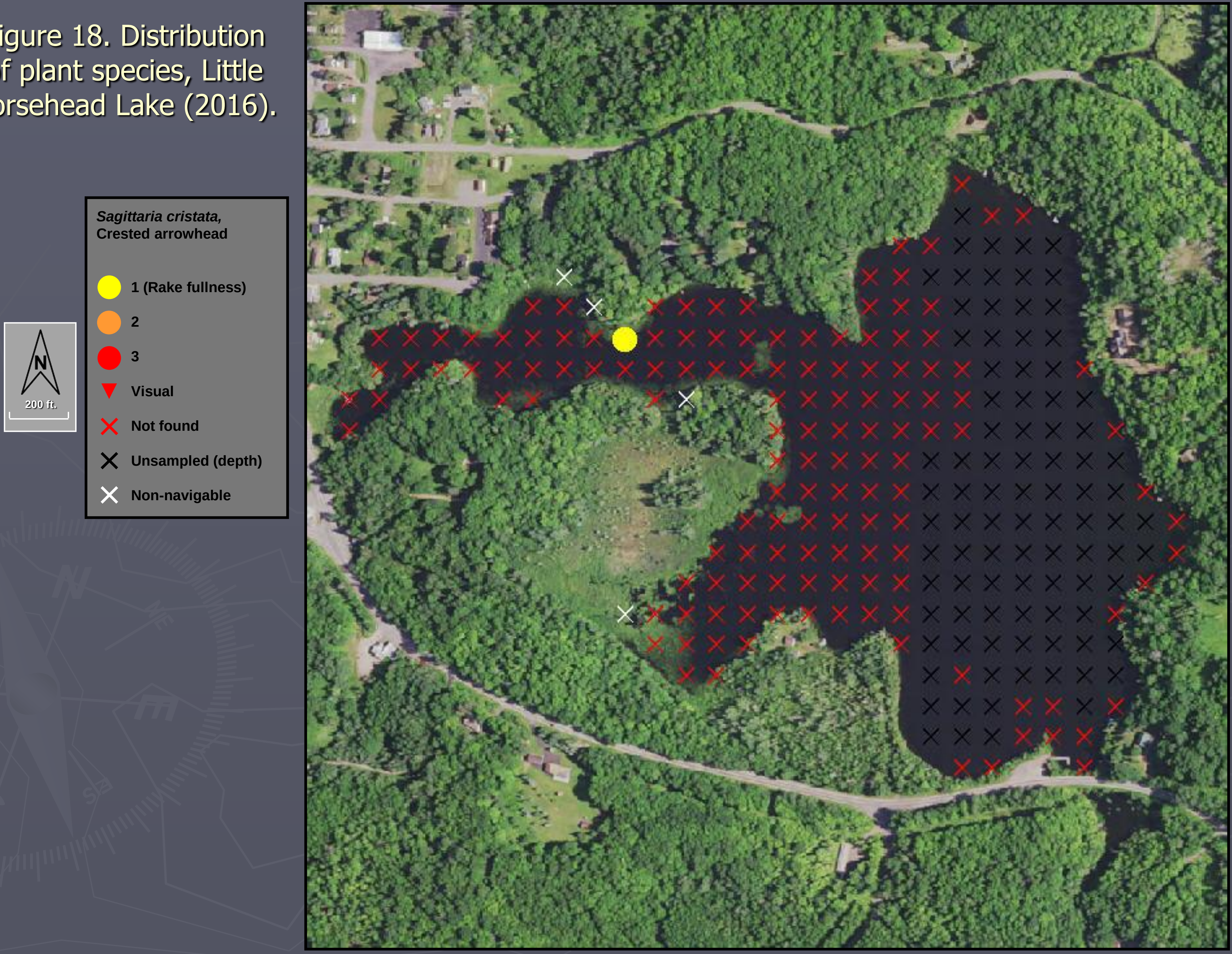


Figure 19. Distribution of plant species, Little Horsehead Lake (2016).

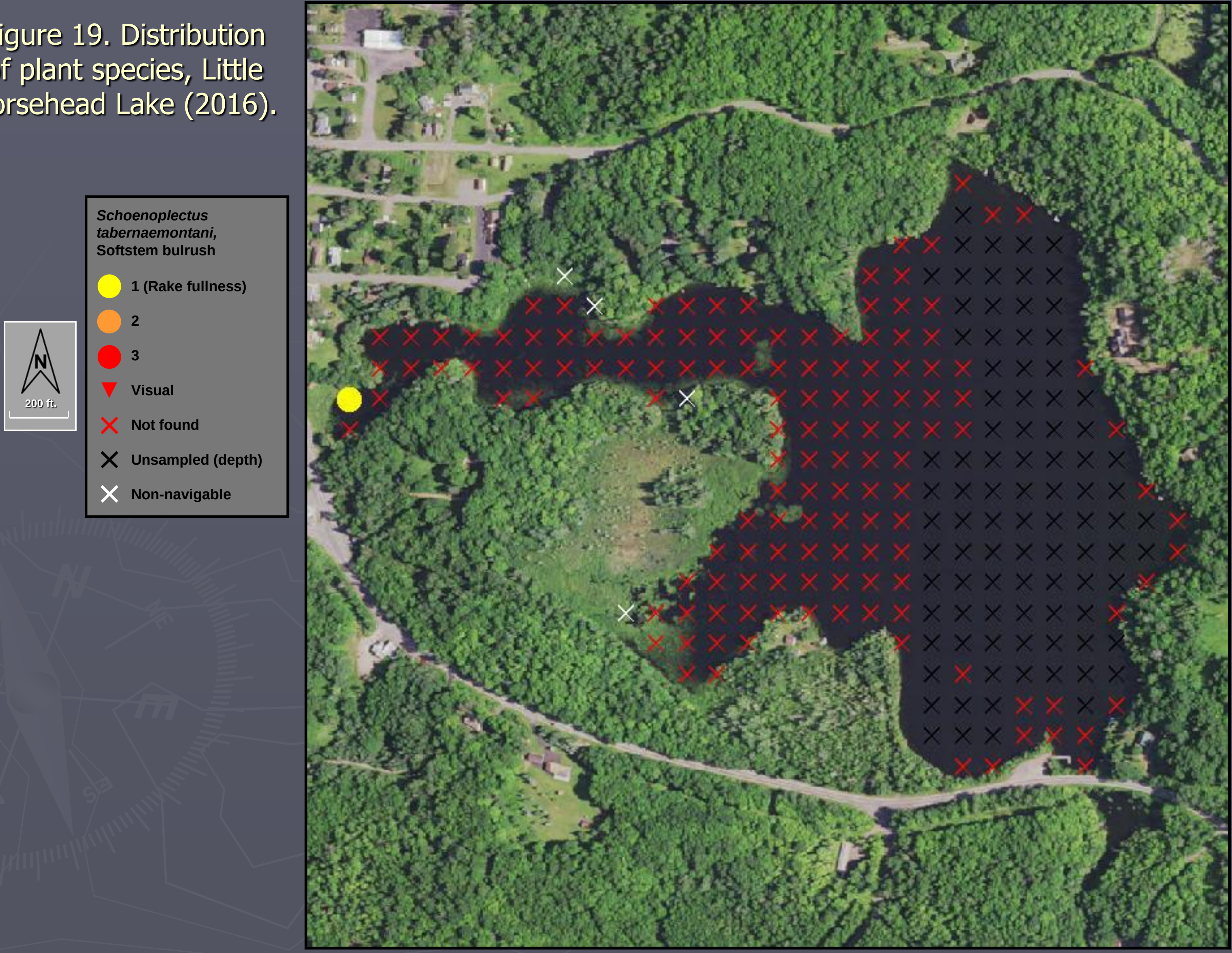
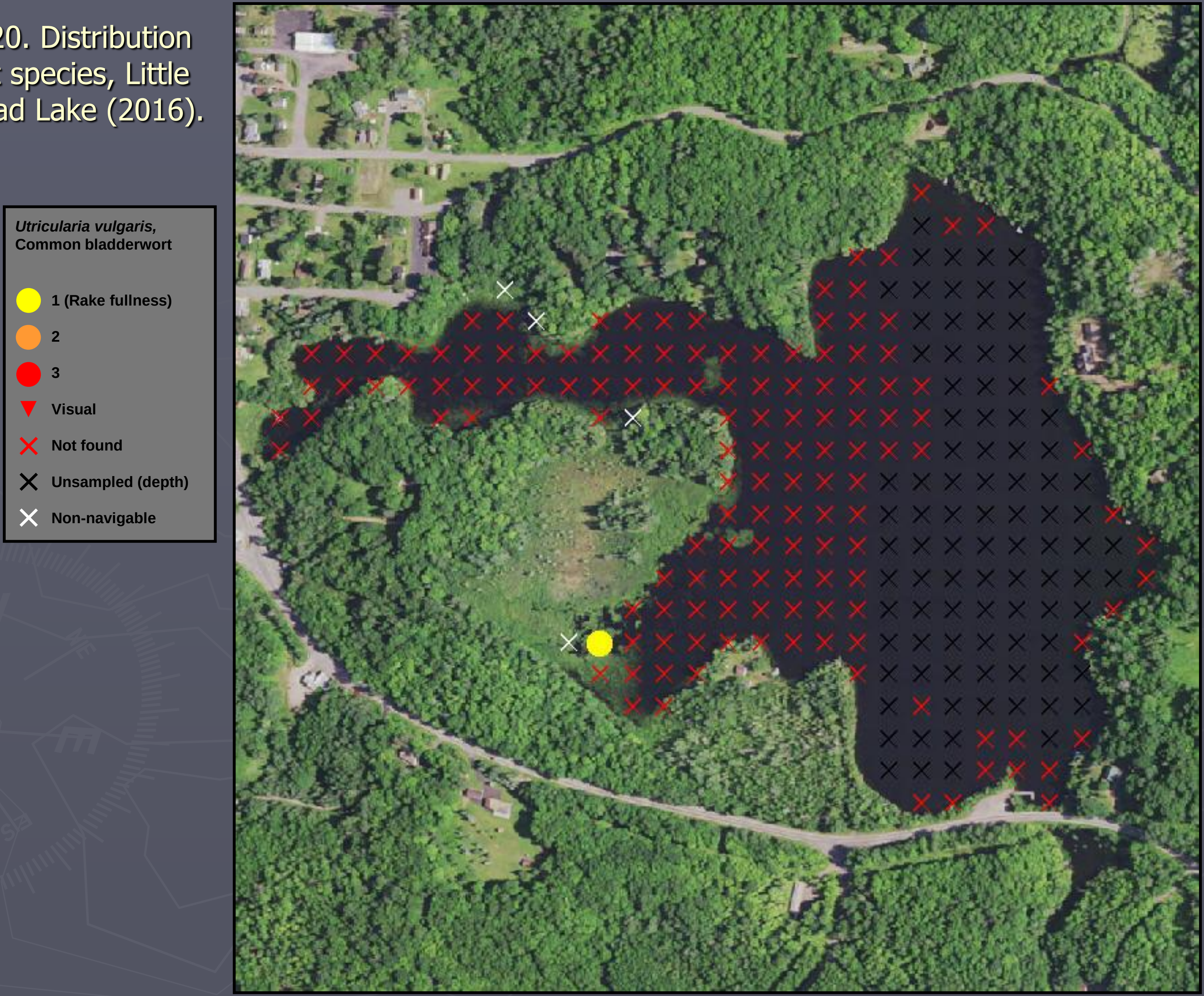


Figure 20. Distribution of plant species, Little Horsehead Lake (2016).



Appendix C

Review of Little Horsehead Lake Water Quality

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WHITE WATER ASSOCIATES, INC.

Appendix C

Review of Lake Water Quality

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WHITE WATER ASSOCIATES, INC.

Review of Little Horsehead Lake Water Quality

Prepared by Angie Stine, B.S., and Caitlin Clarke, B.S., White Water Associates, Inc.

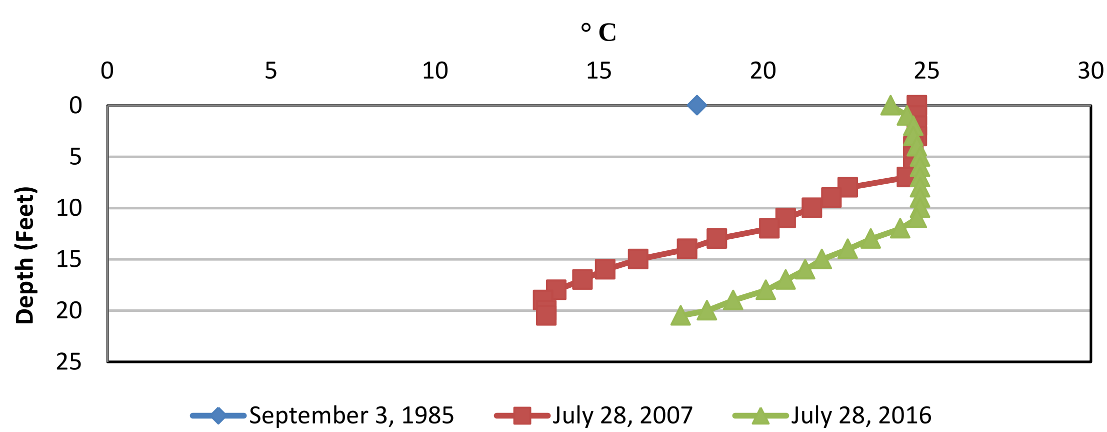
Introduction

Little Horsehead Lake is a 56 acre lake with a maximum depth of 19 feet. The WBIC is 2953000. For the purpose of this review, we took data from the WDNR SWIMS database collected in 1985; Secchi depth data was collected from Landsat satellite in 2000, 2004, 2007, 2008 to 2012, 2014 to 2016 (WDNR 2018); and data from White Water Associates Inc. collected in 2016. Aquatic Invasive Species (AIS) were monitored in July 2016 and September 2017.

Temperature

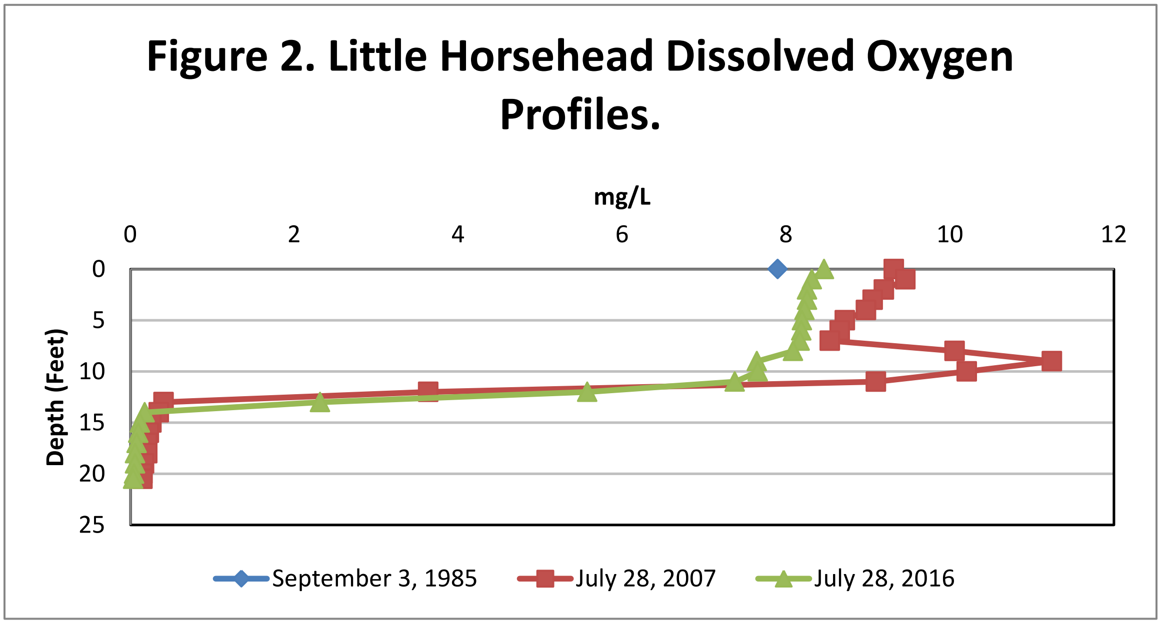
Measuring the temperature of a lake at different depths will determine the influence it has on the physical, biological, and chemical aspects of the lake. Lake water temperature influences the rate of decomposition, nutrient recycling, lake stratification, and dissolved oxygen (D.O.) concentration. Temperature can also affect the distribution of fish species throughout a lake. A surface temperature of 18 °C was taken on September 3, 1985. Temperature profiles were conducted July 28, 2007 and 2016 on Little Horsehead and indicates that the lake stratified around 9 feet in 2007 and around 12 feet in 2016 (Figure 1).

Figure 1. Little Horsehead Temperature Profiles.



Dissolved Oxygen

The dissolved oxygen content of lake water is vital in determining presence of fish species and other aquatic organisms. Dissolved oxygen also has a strong influence on the chemical and physical conditions of a lake. The amount of dissolved oxygen is dependent on the water temperature, atmospheric pressure, and biological activity. Oxygen levels are increased by aquatic plant photosynthesis, but reduced by respiration of plants, decomposer organisms, fish, and invertebrates. The amount of dissolved oxygen available in a lake, particularly in the deeper parts of a lake, is critical to overall health. September 3, 1985 the surface dissolved oxygen was 7.9 mg/L. July 28, 2007 and 2016 a dissolved oxygen profile was taken (Figure 2) indicating adequate D.O. levels until around 13 to 15 feet.



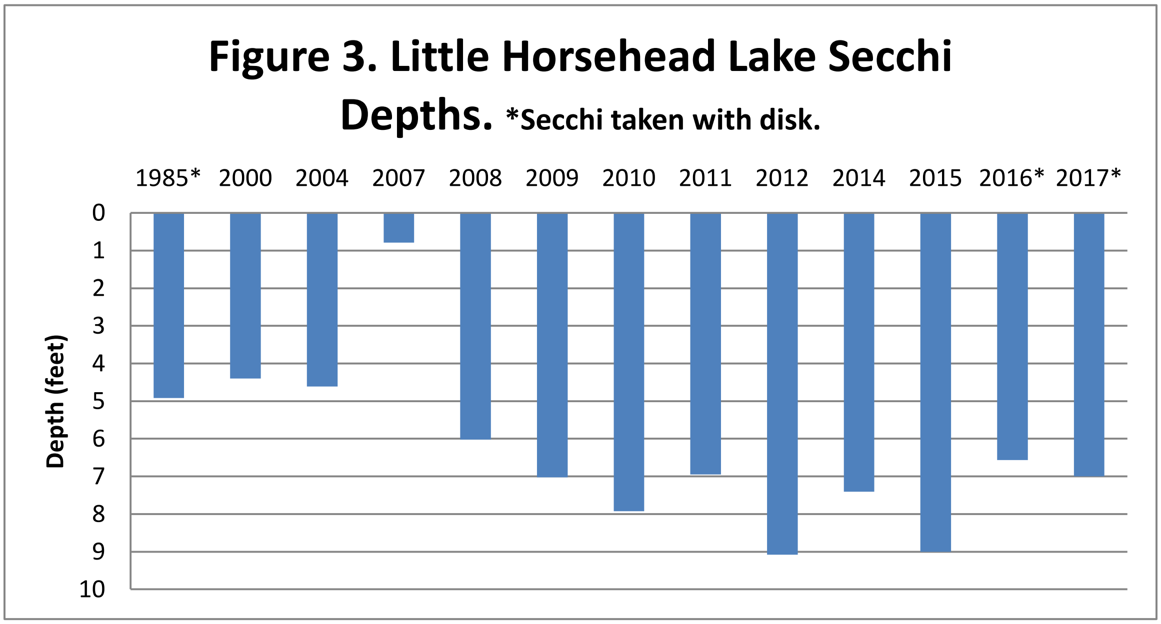
Water Clarity

Water clarity has two main components: turbidity (suspended materials such as algae and silt) and true color (materials dissolved in the water) (Shaw et al., 2004). Water clarity gives an indication of the overall water quality in a lake. Water clarity is typically measured using a Secchi disk (black and white disk) that is lowered into the water column on a tether. In simple terms, the depth at which the disk is no longer visible is recorded as the Secchi depth.

All years Secchi depths were taken from Landsat satellite (WDNR, March 2018) except in 1985, 2016 (White Water Associates, Inc.), and 2017(WDNR AIS Monitoring). Figure 3 indicates that the Secchi depths have varied over the years. In 2016 the mean Secchi disk reading was 6.6 feet which classifies Little Horsehead Lake as "fair" with respect to water clarity (Table 1).

Table 1. Water clarity index (Shaw et al., 2004).

Water clarity	Secchi depth (ft.)
Very poor	3
Poor	5
Fair	7
Good	10
Very good	20
Excellent	32



Turbidity

Turbidity is another measure of water clarity, but is caused by suspended particulate matter rather than dissolved organic compounds (Shaw et al., 2004). Particles suspended in the water dissipate light and reduce the depth at which the light can penetrate. This affects the depth at which plants can grow. Turbidity also affects the aesthetic quality of water. Water that runs off the watershed into a lake can increase turbidity by introducing suspended materials. Turbidity caused by algae is the most common reason for low Secchi readings (Shaw et al., 2004). In terms of biological health of a lake ecosystem, measurements less than 10 Nephelometric Turbidity Units (NTU) represent healthy conditions for fish and other organisms. No turbidity data was collected for Little Horsehead Lake, and future water quality sampling should include measurements of this parameter.

Water Color

Color of lake water is related to the type and amount of dissolved organic chemicals. Its main significance is aesthetics, although it may also influence light penetration and in turn affect aquatic plant and algal growth. Many lakes have naturally occurring color compounds from decomposition of plant material in the watershed (Shaw et al., 2004). Units of color are determined from the platinum-cobalt scale and are therefore recorded as Pt-Co units. Shaw states that a water color between 0 and 40 Pt-Co units is low.

Little Horsehead Lake had a color sample collected on September 3, 1985 and the color level was 20 Pt-Co. Wisconsin Natural Lakes mean for color is 35 units and for Northeastern Wisconsin Lakes it is 46 units.

Water Level

When volunteers collect Secchi depth readings, they also record their perceptions of the lake level as “high,” “normal,” or “low.” Lake level data was not collected for Little Horsehead Lake.

User Perceptions

When Secchi depth readings are collected, the volunteers record their perceptions of the water, based on the physical appearance and the recreational suitability. These perceptions can be compared to water quality parameters to see how the lake user would experience the lake at that time. When interpreting the transparency data, we see that when the Secchi depth decreases, the rating of the lake’s physical appearance also decreases. These perceptions were not recorded for Little Horsehead Lake, so future sampling should include recording of this parameter.

Chlorophyll *a*

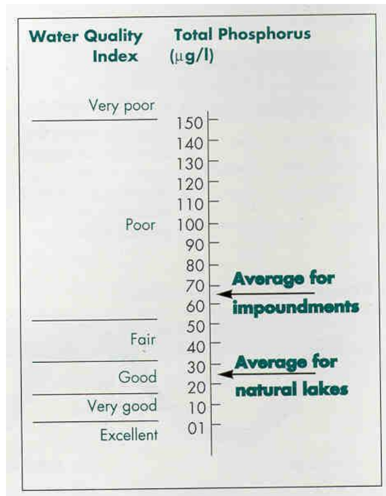
Chlorophyll *a* is the photosynthetic pigment that makes plants and algae green. Chlorophyll *a* in lake water is therefore an indicator of the amount of algae. Chlorophyll *a* concentrations greater than 10 μg/L are perceived as a mild algae bloom, while concentrations greater than 20 μg/L are perceived as a nuisance. Chlorophyll *a* was not recorded for Little Horsehead Lake, so future sampling should include recording of this parameter.

Phosphorus

In more than 80% of Wisconsin’s lakes, phosphorus is the key nutrient affecting the amount of algae and plant growth. If phosphorus levels are high, excessive aquatic plant growth can occur.

Phosphorus originates from a variety of sources, many of which are related to human activities. Major sources include human and animal wastes, soil erosion, detergents, septic systems and runoff from farmland or lawns (Shaw et al., 2004). Phosphorus provokes complex reactions in lakes. An analysis of phosphorus often includes both soluble reactive phosphorus and total phosphorus. Soluble reactive phosphorus dissolves in the water and directly influences plant growth (Shaw et al., 2004). Its concentration varies in most lakes over short periods of time as plants take it up and release it. Total phosphorus is considered a better indicator of a lake’s nutrient status than soluble reactive phosphorus because its levels remain more stable (Shaw et al., 2004). Total phosphorus includes soluble phosphorus and the phosphorus in plant and animal fragments suspended in lake water. Ideally, soluble reactive phosphorus concentrations should be 10 μg/L or less at spring turnover to prevent summer algae blooms (Shaw et al., 2004). A concentration of total phosphorus below 20 μg/L for lakes should be maintained to prevent nuisance algal blooms (Shaw et al., 2004). In September 1985, the total phosphorus was 23 μg/L. Figure 4 classifies Little Horsehead Lake as “good” with respect to phosphorus.

Figure 4. Total phosphorus concentrations for Wisconsin's natural lakes and impoundments (Shaw et al., 2004).



Trophic State

Trophic state is another indicator of water quality (Carlson, 1977). Lakes can be divided into three categories based on trophic state – oligotrophic, mesotrophic, and eutrophic. These categories reflect a lake's nutrient and clarity levels (Shaw et al., 2004).

Figure 5 illustrates the Trophic State Index for Little Horsehead Lake, using Secchi depths and total phosphorus. The TSI shows Little Horsehead Lake to be "mesotrophic" (Table 2).

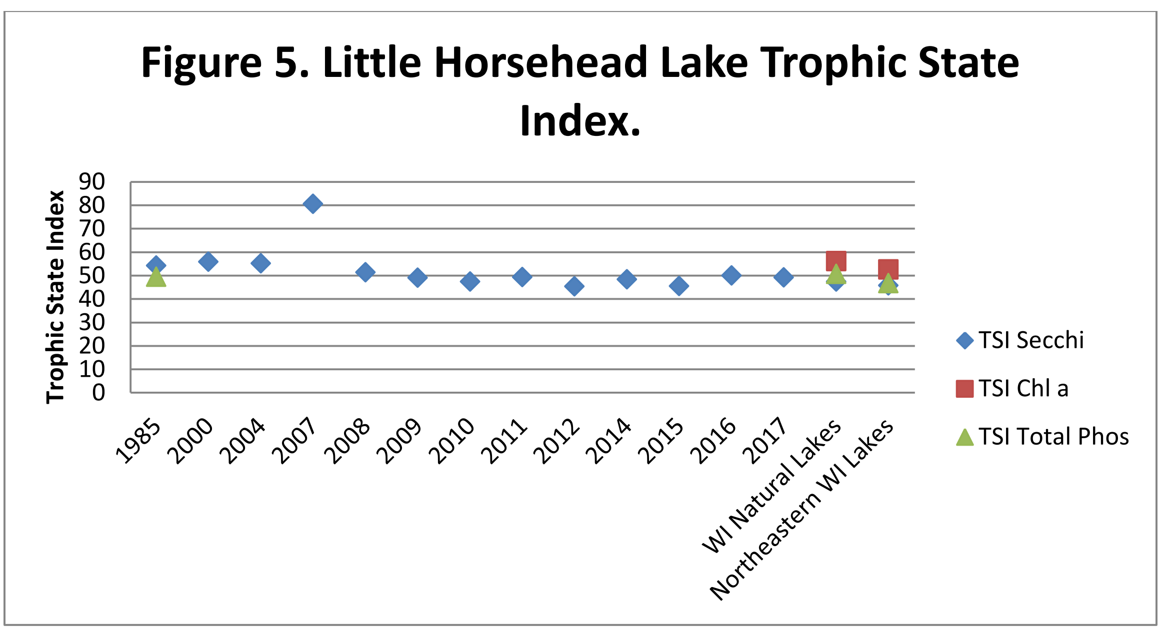


Table 2. Trophic State Index.	
30-40	**Oligotrophic:** clear, deep water; possible oxygen depletion in lower depths; few aquatic plants or algal blooms; low in nutrients; large game fish usual fishery
40-50	**Mesotrophic:** moderately clear water; mixed fishery, esp. panfish; moderate aquatic plant growth and occasional algal blooms; may have low oxygen levels near bottom in summer
50-60	**Mildly Eutrophic:** decreased water clarity; anoxic near bottom; may have heavy algal bloom and plant growth; high in nutrients; shallow eutrophic lakes may have winterkill of fish; rough fish common
60-70	**Eutrophic:** dominated by blue-green algae; algae scums common; prolific aquatic plant growth; high nutrient levels; rough fish common; susceptible to oxygen depletion and winter fishkill
70-80	**Hypereutrophic:** heavy algal blooms through most of summer; dense aquatic plant growth; poor water clarity; high nutrient levels

(WDNR 2018a)

Researchers use various methods to calculate the trophic state of lakes. Common characteristics used to determine the state are: total phosphorus (important for algae growth), chlorophyll *a* (a measure of algae present), and Secchi disk readings (an indicator of water clarity) (Shaw et al., 2004) (Table 3).

Table 3. Trophic classification of Wisconsin Lakes based on chlorophyll *a*, water clarity measurements, and total phosphorus values (Shaw et al., 2004).

Trophic class	Total phosphorus µg/L	Chlorophyll *a* µg/L	Secchi Disk (ft.)
Oligotrophic	3	2	12
	10	5	8
Mesotrophic	18	8	6
	27	10	6
Eutrophic	30	11	5
	50	15	4

Nitrogen

Nitrogen is second only to phosphorus as an important nutrient for aquatic plant and algae growth (Shaw et al., 2004). Human activities on the landscape greatly influence the amount of nitrogen in a lake. Nitrogen may come from lawn fertilizer, septic systems near the lake, or from agricultural activities in the watershed. Nitrogen may enter a lake from surface runoff.

Nitrogen exists in lakes in several forms. Little Horsehead Lake was analyzed for total Kjeldahl Nitrogen on September 3, 1985 (0.4 mg/L); for nitrate-nitrite on September 3, 1985 (0.02 mg/L); and for ammonia on September 3, 1985 (0.05 mg/L). Nitrogen is a major component of all organic (plant and animal) matter. Decomposing organic matter releases ammonia, which is converted to nitrate if oxygen if present (Shaw et al., 2004). All inorganic forms of nitrogen can be used by aquatic plants and algae (Shaw et al., 2004). If inorganic forms of nitrogen exceed 0.3 mg/L in spring, there is sufficient nitrogen to support summer algae blooms (Shaw et al., 2004). Elevated concentrations of ammonium, nitrate, and nitrite, derived from human activities, can stimulate or enhance the development, maintenance and proliferation of primary producers (phytoplankton, benthic algae, marcrophytes), contributing to the widespread phenomenon of the cultural eutrophication of aquatic ecosystems (Camargo et al., 2007). The nutrient enrichment can cause important ecological effects on aquatic communities, since the overproduction of organic matter, and its subsequent decomposition, usually lead to low dissolved oxygen concentrations in bottom waters, and sediments of eutrophic and hypereutrophic aquatic ecosystems with low turnover rates (Camargo et al., 2007).

Chloride

The presence of chloride (Cl^-) where it does not occur naturally indicates possible water pollution (Shaw et al., 2004). Chloride does not affect plant and algae growth and is not toxic to aquatic organisms at most of the levels found in Wisconsin (Shaw et al., 2004). Little Horsehead Lake was analyzed for chloride on September 3, 1985, with a value of 0.8 mg/L. Chloride concentrations in Little Horsehead Lake are well below the generalized distribution gradient of chloride found in surface waters in Wisconsin.

Sulfate

Sulfate in lake water is primarily related to the types of minerals found in the watershed, and to acid rain (Shaw et al., 2004). Sulfate concentrations are noted to be less than 10 mg/L in Vilas County (Lillie and Mason, 1983). The sample taken in September 3, 1985 indicates that sulfate concentrations in Little Horsehead Lake are low (3.0 mg/L).

Conductivity

Conductivity is a measure of the ability of water to conduct an electric current. Conductivity is reported in micromhos per centimeter **(**µmhos/cm) and is directly related to the total dissolved inorganic chemicals in the water. Usually, values are approximately two times the water hardness, unless the water is receiving high concentrations of human-induced contaminants (Shaw et al., 2004). Conductivity in Little Horsehead Lake was 77 µmhos/cm September 3, 1985.

pH

The acidity level of a lake's water regulates the solubility of many minerals. A pH level of 7 is considered neutral. The pH level in Wisconsin lakes ranges from 4.5 in acid, bog lakes to 8.4 in hard water, marl lakes (Shaw et al., 2004). Natural rainfall in Wisconsin averages a pH of 5.6. Some minerals become available under low pH (especially aluminum, zinc, and mercury) and can inhibit fish reproduction and/or survival. Mercury and aluminum are not only toxic to many kinds of wildlife, but also to humans (especially those that eat tainted fish). The pH scale is logarithmic, so every 1.0 unit change in pH increases the acidity tenfold. Water with a pH of 6 is 10 times more acidic than water with pH of 7. A lake's pH level is important for the release of potentially harmful substances and affects plant growth, fish reproduction and survival. A lake with neutral or slightly alkaline pH is a good lake for fish and plant survival. Little Horsehead Lake has had only one pH sample analyzed (September 3, 1985) with a value of 7.65 is alkaline (pH higher than 7).

Alkalinity

Alkalinity levels in a lake are affected by the soil minerals, bedrock type in the watershed, and frequency of contact between lake water and these materials (Shaw et al., 2004). Alkalinity is important in a lake to buffer the effects of acidification from the atmosphere. Acid rain has long been a problem with lakes that have low alkalinity levels and high potential sources of acid deposition. Alkalinity has not been tested on Little Horsehead Lake, so future sampling should include recording of this parameter. Table 4 shows alkalinity values sensitive to acid rain.

Table 4. Sensitivity of Lakes to Acid Rain (Shaw et al., 2004)

Sensitivity to acid rain	***Alkalinity value (mg/L or ppm $CaCO_3$)***
High	0-2
Moderate	2-10
Low	10-25
Non-sensitive	>25

Hardness

Hardness levels in a lake are affected by the soil minerals, bedrock type in the watershed, and frequency of contact between lake water and these materials (Shaw et al., 2004). One method of evaluating hardness is to test for calcium carbonate ($CaCO_3$). Little Horsehead Lake was analyzed for total hardness on in September, 1985 and had a value of 37.32 mg/L $CaCO_3$. The surface water of Little Horsehead Lake can be categorized as "soft water" (Table 5).

Table 5. Categorization of hardness mg/L of calcium carbonate ($CaCO_3$) (Shaw et al., 2004).

Soft water	0-60
Moderately hard water	61-120
Hard water	121-180
Very hard water	>180

Calcium and Magnesium Hardness

The carbonate system provides acid buffering through two alkaline compounds: bicarbonate and carbonate. These compounds are usually found with two hardness ions: calcium and magnesium (Shaw et al., 2004). Calcium is the most abundant cation found in Wisconsin lakes. Its abundance is related to the presence of calcium-bearing minerals in the lake watershed (Shaw et al., 2004). Aquatic organisms such as native mussels use calcium in their shells. The aquatic invasive zebra mussel tends to need calcium levels greater than 20 mg/L to maintain shell growth. Little Horsehead Lake's calcium level was 10 mg/L on September 3, 1985. The University of Wisconsin-Madison's Aquatic Invasive Species Smart Prevention program classifies Little Horsehead Lake as "borderline suitable" for zebra mussels, based on calcium and conductivity levels found in the lake (UW-Madison). One magnesium level was recorded September 3, 1985 for Little Horsehead Lake at 3 mg/L.

Sodium and Potassium

Sodium and potassium are possible indicators of human pollution in a lake, since naturally occurring levels of these ions in soils and water are very low. Sodium is often associated with chloride and gets into lakes from road salting, fertilizations, and human and animal waste (Shaw et al., 2004). Potassium is the key component of commonly-used potash fertilizer, and is abundant in animal waste. Both of these elements are held by soils to a greater extent than is chloride or nitrate; therefore, they are not as useful as indicators of pollution impacts (Shaw et al., 2004). Although not normally toxic themselves, they provide a strong indication of possible contamination by more damaging compounds (Shaw et al., 2004). Sodium (1 mg/L) and potassium (1 mg/L) were tested on September 3, 1985.

Dissolved Organic Carbon

Dissolved Organic Carbon (DOC) is a food supplement, supporting growth of microorganisms, and plays an important role in global carbon cycle through the microbial loop (Kirchman et al., 1991). In general, organic carbon compounds are a result of decomposition processes from dead organic matter such as plants. When water contacts highly organic soils, these components can drain into rivers and lakes as DOC. DOC is also extremely important in the transport of metals in aquatic systems. Metals form extremely strong complexes with DOC, enhancing metal solubility while also reducing metal bioavailability. Baseflow concentrations of DOC in undisturbed watersheds generally range from 1 to 20 mg/L carbon. Because DOC was not tested for Little Horsehead Lake, future water quality sampling should include measurement of this parameter.

Silica

The earth's crust is abundant with silicates or other compounds of silicon. The water in lakes dissolves the silica and pH can be a key factor in regulating the amount of silica that is dissolved. Silica concentrations are usually within the range of 5 to 25 mg/L. The silica level in Little Horsehead Lake was not collected, and should be included in the next sampling of water quality.

Aluminum

Aluminum occurs naturally in soils and sediments. In low pH (acidic) environments aluminum solubility increases greatly. With a low pH and increased aluminum values, fish health can become impaired. This can have impacts on the entire food web. Aluminum also plays an important role in phosphorus cycling in lakes. When aluminum precipitates with phosphorus in lake sediments, the phosphorus will not dissolve back into the water column as readily. On September 3, 1985 aluminum was 39 µg/L.

Iron

Iron also forms sediment particles that bind with and store phosphorus when dissolved oxygen is present. When oxygen concentration gets low (for example, in winter or in the deep water near sediments) the iron and phosphorus dissolve in water. This phosphorus is available for algal blooms. Because iron levels are not known for Little Horsehead Lake, future water sampling should include measurement of this parameter.

Manganese

Manganese is a mineral that occurs naturally in rocks and soil. In lakes, manganese is usually in particulate form. When the dissolved oxygen levels decrease, manganese can convert from an insoluble form to soluble ions. A manganese concentration of 0.05 mg/L can cause color and staining problems. Because manganese levels are not known for Little Horsehead Lake, future water sampling should include measurement of this parameter.

Sediment

Lake bottom sediments are sometimes analyzed for chemical constituents that they contain. This is especially true for potentially toxic metals such as mercury, chromium, selenium, and others. Lake sediments also tend to record past events as particulates settle down and become part of the sediment. Biological clues for the historic conditions in the lake can be gleaned from sediment samples. Examples include analysis of pollen or diatoms that might help understand past climate or trophic states in the lake. Sediment data was not collected for Little Horsehead Lake, and future sampling should include this parameter.

Total Suspended Solids

Total suspended solids are all particles suspended in lake water. Silt, plankton, and wastes are examples of these solids and can come from runoff of agricultural land, erosion, and can be produced by bottom-feeding fish. As the suspended solid levels increase, they absorb heat from sunlight which can increase the water temperature. They can also block the sunlight that plants need for photosynthesis. These events can in turn affect the amount of dissolved oxygen in the lake. Lakes with total suspended solids levels less than 20 mg/L are considered “clear,” while levels between 40 and 80 mg/L are “cloudy.” Total suspended solids have not been tested in Little Horsehead Lake. Future water quality sampling should include this parameter.

Aquatic Invasive Species

On July 25, 2016, AIS monitoring was conducted by White Water Associates Biologists in search of various aquatic invasive species and no AIS were found. September 13, 2017 the WDNR conducted an AIS Early Detection Survey and no AIS were noted to be found.

Resources

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Appendix D

Little Horsehead Lake EPA Littoral and Shoreline Survey

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Appendix D
Little Horsehead EPA Littoral and Shoreline Survey

Introduction

Little Horsehead's littoral and shoreline zones were assessed in 2016 by White Water field biologists using the US Environmental Protection Agency's (EPA) National Lakes Assessment (NLA) protocol and the Wisconsin Department of Natural Resources (WDNR) Supplemental Lakeshore Assessment protocol. The intention of the National Lakes Assessment (NLA) project was to provide a comprehensive assessment for lakes, ponds, and reservoirs across the United States (USEPA, 2009). This assessment at Little Horsehead will stand as a baseline against which future changes can be measured and can be used to compare Little Horsehead with other lakes measured using the same protocols.

Methods

Ten physical habitat (P-Hab) stations were spaced equidistantly around the lake (Figure 1 and 2). At each site, biologists recorded information about the littoral zone bottom substrate, littoral zone aquatic macrophytes (plants), littoral zone fish cover, riparian zone canopy, understory and ground cover, shoreline substrates, human influences, classification of fish habitat, bank features, any invasive species observed (terrestrial or aquatic), land cover, human development and the number of piers between sites.

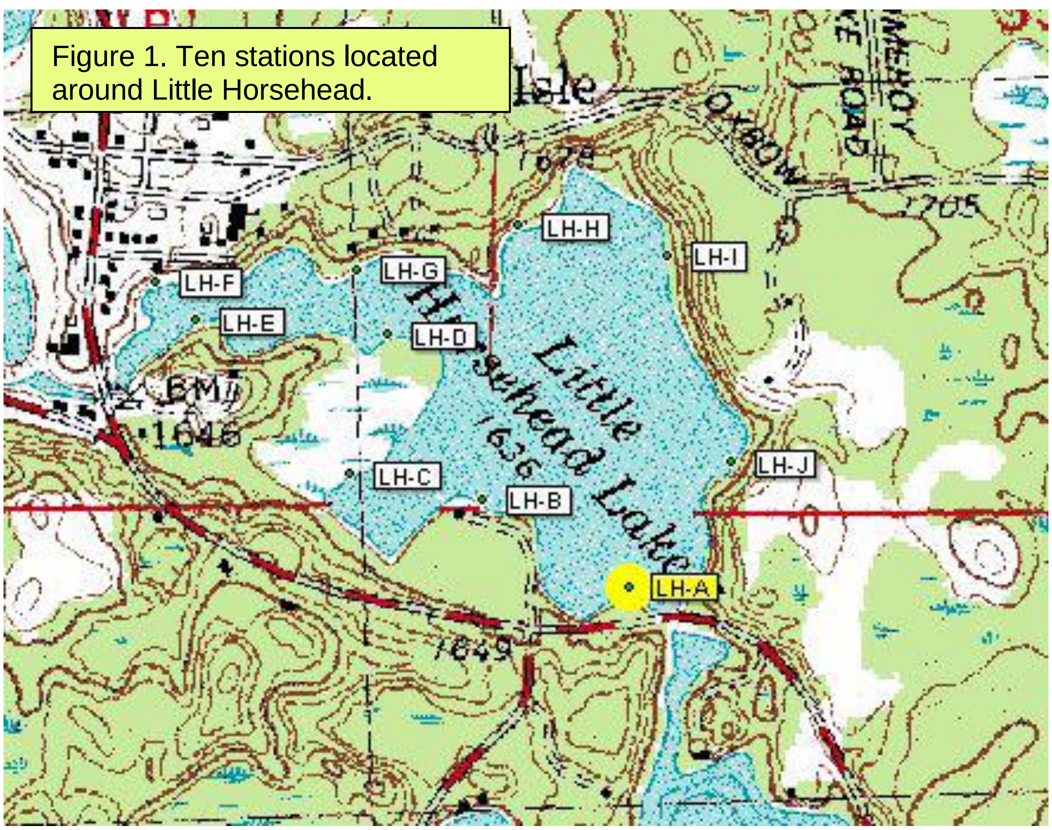

Figure 1. Ten stations located around Little Horsehead.

At each P-Hab site, biologists collected macroinvertebrates for later identification. A fecal indicator sample was collected at one site to be analyzed for levels of *E. coli*.

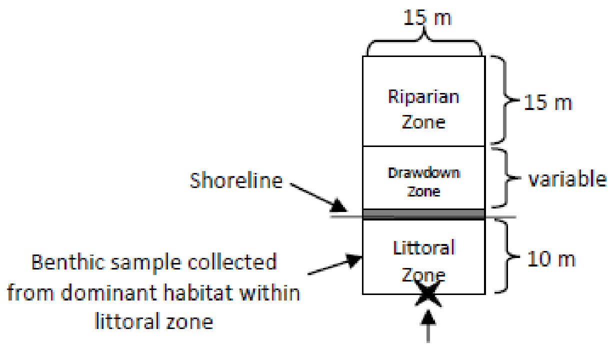

Figure 2. Dimensions and layout of a P-Hab station.

Results

The average depth of the ten stations was 8.95 feet (the range was from 3 to 16 feet). Pollen was observed at any of the seven stations.

Table 1 contains the littoral zone bottom substrate data collected from the ten Little Horsehead sampling stations. Bedrock was not observed as a bottom substrate at any station. Boulders were present at four of the ten stations. Cobble was present at six stations. Gravel was present at six stations. Sand was present at seven stations. Silt, clay and muck were encountered at all ten stations. Woody debris was present at all ten stations. The color of the sediment appeared brown at all ten stations. No odor was detected at eight stations and was anoxic at two stations.

Table 1. USEPA Habitat Characterization – Littoral Zone Bottom Substrate.

Station	A	B	C	D	E	F	G	H	I	J
Bedrock	0	0	0	0	0	0	0	0	0	0
Boulders	0	0	0	0	0	2	1	1	0	1
Cobble	1	1	0	0	0	2	0	1	1	1
Gravel	2	2	0	0	1	0	0	1	1	2
Sand	4	4	0	3	0	0	2	1	3	2
Silt, Clay, Muck	4	3	4	3	4	4	3	4	2	3
Woody Debris	3	2	1	2	2	4	2	2	2	4
Color	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown
Odor	None	None	None	None	Anoxic	Anoxic	None	None	None	None

Bedrock (>4000mm); Boulders (250-4000mm); Cobble (64-250mm); Gravel (2-64mm); Sand (0.02-2mm); Silt, Clay, or Muck (<0.06mm, not gritty). 0=Absent (0%); 1=Sparse (<10%); 2=Moderate (10-40%); 3=Heavy (40-75%); 4=Very Heavy (>75%)

Table 2 presents the observations made on aquatic macrophytes in the littoral zone. Submergent aquatic plants were observed at seven stations. Emergent macrophytes were observed at all ten stations. Nine of the ten stations had floating macrophytes present. Total macrophyte cover had moderate (three stations), heavy (four stations), and very heavy (three stations) coverage. Macrophytes extended lakeward at seven of the ten stations.

Table 2. USEPA Habitat Characterization – Littoral Zone Aquatic Macrophytes.

Station	A	B	C	D	E	F	G	H	I	J
Submergent	0	0	2	1	1	2	3	2	0	3
Emergent	3	2	3	4	2	4	3	3	2	2
Floating	0	2	3	2	1	2	2	2	1	1
Total Aquatic Macrophyte Cover	3	2	3	4	3	4	3	4	2	2
Do macrophytes extend lakeward from plot?	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No

0=Absent (0%); 1=Sparse (<10%); 2=Moderate (10-40%); 3=Heavy (40-75%); 4=Very Heavy (>75%)

Littoral zone fish cover observations are presented in Table 3. Aquatic and/or inundated herbaceous vegetation was observed at all ten stations, having coverage's of sparse (one station), moderate (four stations), and very heavy (five stations). Woody debris and snags greater than 0.3 meters in diameter were observed at all ten stations and had sparse (four stations), moderate (two stations) and heavy (one station) coverage. Woody brush/woody debris less than 0.3 meters in diameter was found at all ten stations and had sparse (two stations), moderate (five stations), and heavy (three stations) coverage. Inundated live trees (greater than 0.3 meters in diameter) were observed at six stations with sparse (four stations) and moderate (two stations) coverage. Overhanging vegetation within one meter of the surface was observed at all ten stations with sparse (three stations), moderate (one station), heavy (four stations) and very heavy (two stations). Ledges or sharp drop-offs and boulders were observed at one station and were sparse. Boulders were observed at five stations with sparse (four stations) and moderate (one station) coverage. Finally, human structures (such as docks, landings, etc.) were not observed three stations with sparse (two stations) and moderate (one station) coverage.

Table 3. USEPA Habitat Characterization – Littoral Zone Fish Cover.										
Station	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Aquatic & Inundated Herbaceous Cover	4	2	4	4	2	4	2	4	1	2
Woody Debris/Snags >0.3 m dia.	1	1	1	0	1	3	0	2	0	2
Woody Brush/ Woody Debris <0.3 m dia.	3	1	2	2	2	2	1	3	2	3
Inundated Live Trees >0.3 m dia.	1	0	2	0	0	0	1	1	2	1
Overhanging veg. w/in 1 m of surface	4	3	4	1	3	1	1	3	2	3
Ledges or Sharp Drop-offs	1	0	0	0	0	0	0	0	0	0
Boulders	1	0	0	0	0	2	1	1	0	1
Human Structures (docks, landings, etc.)	0	2	0	0	0	1	1	0	0	0
0=Absent (0%); 1=Sparse (<10%); 2=Moderate (10-40%); 3=Heavy (40-75%); 4=Very Heavy (>75%)										

Table 4 shows observations made at the riparian zone canopy (>5 meters high), understory (0.5 to 5 meters), and ground cover (<0.5 meters). Mixed (conifer and deciduous) canopy type was observed at six of the ten stations and deciduous canopy type was observed at three stations. The coverage of big trees (>0.3 meters diameter) was observed at nine stations with sparse (five stations), moderate (three stations) and heavy (one station). The coverage of small trees (<0.3 meters diameter) was sparse (three stations), moderate (two stations), and heavy (two stations). In the understory, mixed coverage type (six stations), deciduous type (three stations), and Coniferous (one station) were observed. Coverage of understory woody shrubs and saplings was sparse (three stations), moderate (two stations), heavy (two stations) and very heavy (three stations). Understory tall herbs, grasses, and forbs were present at four stations with sparse (one station), moderate (two stations) and very heavy (one station) coverage. Ground cover of woody shrubs and saplings were observed at nine stations with coverages of sparse (four stations), moderate (two stations), and heavy (three stations). Groundcover herbs, grasses, and forbs were observed at all ten stations with sparse (one station), moderate (three stations), heavy (two stations), and very heavy (four stations) coverage. Standing water or inundated vegetation was observed at one station with very heavy coverage. Barren, bare dirt or buildings were observed at two stations having sparse coverage.

Table 4. USEPA Habitat Characterization – Riparian Zone.										
Station	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
CANOPY (>5 m high)										
Type	Mix	Mix	None	Dec	Mix	Mix	Dec	Mix	Mix	Dec
Big Trees (Trunk >0.3 m dia.	1	1	0	2	2	3	2	1	1	1
Small Trees (Trunk <0.3 m dia.	2	1	0	1	4	1	3	3	4	0
UNDERSTORY (0.5 to 5 m high)										
Type	Dec	Mix	Dec	Mix	Con	Dec	Mix	Mix	Mix	Mix
Woody Shrubs and Saplings	2	1	1	4	3	1	2	4	3	4
Tall Herbs, Grasses, Forbes	2	1	4	0	0	2	0	0	0	0
GROUND COVER (<0.5 m high)										
Woody Shrubs and Saplings	1	2	3	3	1	0	1	1	2	3
Herbs, Grasses and Forbes	2	2	4	2	1	4	4	4	3	3
Standing Water/ Inundated Veg.	0	0	4	0	0	0	0	0	0	0
Barren, Bare Dirt, or Buildings	0	0	0	0	1	1	0	0	0	0
0=Absent (0%); 1=Sparse (<10%); 2=Moderate (10-40%); 3=Heavy (40-75%); 4=Very Heavy (>75%); Mix = Mixed conifer and deciduous; Dec = Deciduous										

Table 5 presents observations recorded on the riparian shoreline substrate zone. Bedrock was not observed at any of the ten stations. Boulders were found at four stations with sparse (three stations) and moderate (one station) coverage. Cobble substrate was observed at three stations with sparse coverage. Gravel substrate was observed at six stations with sparse (two stations), moderate (three stations), and heavy (one station) coverage. Sand substrate was observed at six stations with sparse (one station), moderate (two stations), and heavy (three stations) coverage. Silt, clay, or muck substrate was observed at all ten stations and had sparse (one station), moderate (one station), heavy (four stations) and very heavy (four stations) coverage. Woody debris was observed at nine stations with moderate (four stations), heavy (one station), and very heavy (six stations) coverage. Vegetation or other was observed at all ten stations with moderate (three stations), heavy (one station), and very heavy (six stations) coverage.

Table 5. USEPA Habitat Characterization – Riparian Zone – Shoreline Substrate Zone.										
Station	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Bedrock	0	0	0	0	0	0	0	0	0	0
Boulders	0	0	0	0	0	2	1	1	0	1
Cobble	0	0	0	0	0	0	0	1	1	1
Gravel	3	2	0	0	0	0	1	1	2	2
Sand	3	3	0	0	0	0	2	1	3	2
Silt, Clay, Muck	2	3	4	4	4	4	3	3	1	3
Woody Debris	3	2	0	4	2	3	2	4	2	4
Vegetation or other	4	2	4	4	2	4	4	4	2	3
0=Absent (0%); 1=Sparse (<10%); 2=Moderate (10-40%); 3=Heavy (40-75%); 4=Very Heavy (>75%)										

Observations of human influence in the riparian zone are shown in Table 6. Human influence was low. Buildings were observed outside and inside the plot at four stations and inside the plot at one station. Park facilities/manmade beach were located inside and outside the plot at one station. Docks or boats were observed outside the plot at four stations and inside the plot at two stations. Landfill/trash was present outside the plot at one location and inside the plot at one location. Roads or railroads were observed outside the plot at two stations. Lawn was found outside the plot at two stations and was present inside the plot at one location. All other human influences (commercial development, walls, dykes, revetments, row crops, pasture/range/hayfield, and orchards) were not observed at any of the ten stations.

Table 6. USEPA Habitat Characterization – Riparian Zone – Human Influence Zone.										
Station	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Buildings	0	PC	0	0	0	P	P	0	P	0
Commercial	0	0	0	0	0	0	0	0	0	0
Park Facilities/ manmade beach	PC	0	0	0	0	0	0	0	0	0
Docks/Boats	P	PC	0	0	0	P/C	P	0	0	0
Walls, dykes, revetments	0	0	0	0	0	0	0	0	0	0
Landfill/Trash	0	0	0	0	0	P	0	0	C	0
Roads or Railroad	P	0	0	0	0	P	0	0	0	0
Row crops	0	0	0	0	0	0	0	0	0	0
Pasture/Range/Hayfield	0	0	0	0	0	0	0	0	0	0
Orchard	0	0	0	0	0	0	0	0	0	0
Lawn	0	PC	0	0	0	P	0	0	0	0
0 = Not Present; P = Present outside plot; C = Present within plot										

Table 7 reports the observations made on littoral fish macrohabitat classification. Human disturbance was observed at four stations. Cover class was patchy (four stations) and continuous (six stations). Cover type was recorded as woody (seven stations), vegetated (ten stations) and boulders (four stations). Substrate was sand/gravel at two stations and mud/muck at eight stations.

Table 7. USEPA Habitat Characterization – Littoral Zone Macrohabitat Classification.										
Station	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Human Disturbance	Low	Mod	None	None	None	Low	Low	None	None	None
Cover Class	Cont	Patchy	Cont	Cont	Patchy	Cont	Cont	Cont	Patchy	Patchy
Cover Type	Woody Veg	Veg	Veg	Woody Veg	Veg	Bould Woody Veg	Bould Woody Veg	Bould Woody Veg	Woody Veg	Bould Woody Veg
Dominant Substrate	S/G	M/M	M/M	M/M	M/M	M/M	M/M	M/M	S/G	M/M
Mod = Moderate; Cont = Continuous Cover; Art = Artificial; No/Lit = No or Little Cover; Bould = Boulder; Veg = Vegetation; M/M = Mud/Muck; C/B = Cobble/Boulder; S/G = Sand/Gravel										

Plot bank features are presented in Table 8. Bank angle was considered flat at one station, gradual at five stations, and steep at four stations. The vertical height from waterline to the high water mark was 0.05 or 0.10 meters. The horizontal distance from waterline to the high water mark was considered zero at all sites.

Table 8. USEPA Habitat Characterization – Within Plot Bank Features.										
Station	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Angle	Grad	Steep	Flat	Grad	Steep	Grad	Steep	Grad	Steep	Grad
Vertical Height (m) to HWM	0.05	0.07	0.07	0.07	0.07	0.06	0.08	0.08	0.10	0.08
Horizontal Distance (m) to HWM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HWM = High Water Mark; Flat = <5 º; Grad = Gradual (5-30 º); Steep (30-75 º); NV= Near Vertical/undercut (>75º)										

Table 9 displays the invasive plant and invertebrate species found in Little Horsehead. Stations H had the presence of a Yellow Iris and Japanese Barberry. The other nine stations had no presence of invasives.

Table 9. USEPA Habitat Characterization – Invasive Plant and Invertebrate Species.										
Station	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Target Invasive Species in Littoral Plot	None	None	None	None	None	None	None	Yellow Iris	None	None
Target Invasive Species in Shore-line/Riparian Plot	None	None	None	None	None	None	None	Japanese Barberry	None	None
Target Invasive Species include: Zebra or Quagga Mussel, Eurasian Water-milfoil, Hydrilla, Curly Pondweed, African Waterweed, Brazilian Waterweed, European Water Chestnut, Water Hyacinth, Parrot Feather, Yellow Floating Heart, Giant Salvinia, Purple Loosestrife, Knotweed (Giant or Japanese), Hairy Willow Herb, Flowering Rush, Other Japanese Barberry, Banded Mystery Snail (BMS) and Chinese Mystery Snail (CMS)										

The WDNR Supplemental Methodology data are presented in Tables 10 and 11. Table 10 shows 181 pieces of small woody material (>5cm diameter) were counted at nine stations. One-hundred and thirty-nine pieces of large woody material were found at nine stations. None of the five target invasive species (Japanese stiltgrass, reed canary grass, Phragmites, cattails) were observed except at Station H where the Yellow Iris was present.

Table 10. WDNR Supplemental Methodology– Wood and Invasive Plant Species.										
Station	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Wood: >5cm diameter	14	19	0	13	19	24	17	31	22	22
Wood: >10cm diameter	15	12	0	13	15	10	10	24	19	21
Invasive: Japanese stiltgrass	No	No	No	No	No	No	No	No	No	No
Invasive: Reed canary grass	No	No	No	No	No	No	No	No	No	No
Invasive: Phragmites	No	No	No	No	No	No	No	No	No	No
Invasive: Cattails	No	No	No	No	No	No	No	No	No	No
Invasive: Yellow Iris	No	No	No	No	No	No	No	2	No	No

Table 11 tabulates the land cover, human development, and piers. Seawall, rip rap, and artificial beach were not found. Lawns were observed in the riparian plot at one site and the upland plot at two stations. Pavement was present at one station in the upland and riparian plot. Residences were observed in the riparian plot of one station and at four stations in the upland plot. Commercial buildings were not observed. Structures were observed in the upland plot at four stations and inland plot one station. There were no boat lifts or swim rafts at any of the stations. There were docks in the riparian plot at one station. The WDNR protocol called for counting piers between each of the ten stations. Nineteen piers were counted between stations on the perimeter of Little Horsehead.

Table 11. WDNR Supplemental Methodology– Land cover, Human Development, and Piers. (1 number given for riparian plot; if 2 numbers, 1st for riparian plot & 2nd for upland plot)										
Station	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
LANDCOVER Key: 0 (0-1%), 1 (>1-10%), 2 (>10-40%), 3 (>40-75%), 4 (>75%)										
Seawall	0	0	0	0	0	0	0	0	0	0
Rip Rap	0	0	0	0	0	0	0	0	0	0
Artificial beach	0	0	0	0	0	0	0	0	0	0
Lawn	0	0/4	0	0	0	1/1	0	0	0	0
Pavement	2/2	0	0	0	0	0	0	0	0	0
HUMAN DEVELOPMENT										
Residences	0	1/2	0	0	0	0/1	0	0/1	0/1	0
Commercial buildings	0	0	0	0	0	0	0	0	0	0
Structures (sheds/boat houses)	0	1/1	0	0	0	0/1	0	0/1	0/1	0
Boat lifts	0	0	0	0	0	0	0	0	0	0
Swim rafts	0	0	0	0	0	0	0	0	0	0
Docks	0	1/0	0	0	0	0	0	0	0	0
NUMBER OF PIERS BETWEEN STATIONS										
From:	A-B	B-C	C-D	D-E	E-F	F-G	G-H	H-I	I-J	J-A
Count	2	2	0	1	1	2	4	2	3	2

The USEPA protocol called for a composite sample of aquatic benthic macroinvertebrates, combining net sweeps from each station into one sample. Table 12 provides the identified invertebrate taxa and counts of individuals by taxa for the composite sample. A total of twenty-one taxa and 775 individual organisms were identified.

Table 12. Composite Benthic Macroinvertebrate Sample from Little Horsehead.				
Taxon	**Count**		**Taxon**	**Count**
Nematomorpha	2		Hemiptera (aquatic bugs): Corixidae (109), Gerridae (1), and Nepidae (1)	111
Annelida: Hirudinea (1),Oligochaeta (30)	31		Trichoptera (caddisflies): Lepidostomatidae (1) and Leptoceridae (3)	4
Crustacea: Amphipoda (13), Isopoda (147)	160		Coleoptera (aquatic beetles): Dytiscidae (3 larvae), Haliplidae (2 adults and 2 larvae), and Psephenidae (1 adult)	8
Arachnoidea: Hydracarina	9		Diptera (true flies): Ceratopogonidae (17), Chaoboridae (4), Chironomidae (294), and Tabanidae (2)	317
Ephemeroptera (mayflies): Baetidae (1), Caenidae (36), Ephemerellidae (7), Heptageniidae (2), and Siphlonuridae (1)	47		Mollusca: Gastropoda: Ancylidae (2), Bithyniidae (12), Physidae (10), and Planorbidae (6)	30
Anisoptera (dragonflies): Aeshnidae (3), and Libellulidae (9)	12		Mollusca: Pelecypoda: Sphaeriidae	39
Zygoptera (damselflies): Coenagrionidae	5		**Total Taxa**	**775**

Finally, the USEPA protocol called for a fecal indicator sample at the final sampling station (Station J). The collected sample was analyzed for *Escherichia coli* (*E. coli)*. The *E. coli* analysis resulted in 10 CFU (Colony Forming Units) per 100 milliliters of sample. To place this value in context, the USEPA recommends a water quality advisory (for swimming) when a level of the indicator bacterium *E. coli* exceeds a limit is 235 CFU per 100 milliliters of water.

Table 13 indicates the coordinates of Stations A-J. A photo was taken at each of the ten stations. The station photos are displayed below.

Table 13. Little Horsehead USEPA & WDNR Physical Habitat Locations.		
Station	*Latitude*	*Longitude*
A	46.2418547	-89.7191594
B	46.2429327	-89.7218173
C	46.2432557	-89.7241813
D	46.2450127	-89.7235243
E	46.2451897	-89.7269931
F	46.2456707	-89.7277091
G	46.2458407	-89.7240903
H	46.2463807	-89.7211454
I	46.2460137	-89.7184535
J	46.2434047	-89.7173015

Station A – Little Horsehead

Photograph taken 6/15/2016, White Water Associates, Inc.

Station B – Little Horsehead

Photograph taken 6/15/2016, White Water Associates, Inc.

Station C – Little Horsehead

Photograph taken 6/15/2016, White Water Associates, Inc.

Station D – Little Horsehead

Photograph taken 6/15/2016, White Water Associates, Inc.

Station E – Little Horsehead

Photograph taken 6/15/2016, White Water Associates, Inc.

Station F – Little Horsehead

Photograph taken 6/15/2016, White Water Associates, Inc.

Station G – Little Horsehead

Photograph taken 6/15/2016, White Water Associates, Inc.

Station H – Little Horsehead

Photograph taken 6/15/2016, White Water Associates, Inc.

Station I – Little Horsehead

Photograph taken 6/15/2016, White Water Associates, Inc.

Station J – Little Horsehead

Photograph taken 6/15/2016, White Water Associates, Inc.

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