Note: Methodology, explanation of analysis and biological background on Manitowish Lake studies are contained within the Manitowish Waters Chain of Lakes-wide Management Plan document.

8.8 Manitowish Lake

An Introduction to Manitowish Lake

Manitowish Lake, Vilas County, is a deep, lowland drainage lake with a maximum depth of 61 feet, a mean depth of 23 feet, and a surface area of approximately 496 acres. Manitowish Lake is considered to be mesotrophic and its watershed encompasses approximately 53,720 acres. In 2016, 55 aquatic plant species were found in the lake, of which wild celery (*Vallisneria americana*) the most common. Two non-native shoreland plants, pale-yellow iris and purple loosestrife, were found during surveys.

Field Survey Notes

Of all the lakes in the Chain, Manitowish Lake was found to have the highest species richness (number of different aquatic plant species). One of the species found was Vasey's pondweed, a state-listed special concern plant, which requires a high-quality environment to live.

Photo 8.8. Manitowish Lake, Vilas County

Lake at a Glance* – Manitowish Lake

Morphology	
Acreage	496
Maximum Depth (ft)	61
Mean Depth (ft)	23
Volume (acre-feet)	11,632
Shoreline Complexity	8.7
Vegetation	
Curly-leaf Survey Date	June 28-29, 2016
Comprehensive Survey Date	July 18-19, 2016
Number of Native Species	53
Threatened/Special Concern Species	Vasey's pondweed
Exotic Plant Species	Pale-yellow iris & Purple loosestrife
Simpson's Diversity	0.91
Average Conservatism	6.6
Water Quality	
Wisconsin Lake Classification	Deep, Lowland Drainage
Trophic State	Oligo-mesotrophic
Limiting Nutrient	Phosphorus
Watershed to Lake Area Ratio	107:1

**These parameters/surveys are discussed within the Chain-wide portion of the management plan.*

8.8.1 Manitowish Lake Water Quality

Water quality data was collected from Manitowish Lake on six occasions in 2016/2017. Onterra staff sampled the lake for a variety of water quality parameters including total phosphorus, chlorophyll-*a*, Secchi disk clarity, temperature, and dissolved oxygen. Please note that the data in these graphs represent concentrations and depths taken during the growing season (April-October), summer months (June-August) or winter (February-March) as indicated with each dataset. Furthermore, unless otherwise noted the phosphorus and chlorophyll-*a* data represent only surface samples. In addition to sampling efforts completed in 2016/2017, any historical data was researched and are included within this report as available.

Very little historical data exist for two water quality parameters of interest – total phosphorus and chlorophyll-*a*. In 2016, average summer phosphorus concentrations (14.7 µg/L) were less than the median value (23.0 µg/L) for other deep, lowland drainage lakes in the state (Figure 8.8.1-1). This value is also lower than the value for other lakes within the Northern Lakes and Forests ecoregion. A weighted summer value from all available data ranks as *Excellent* for a deep, lowland drainage lake.

Total phosphorus surface values from 2016-2017 are compared with bottom-lake samples collected during this same time frame in Figure 8.8.1-2. Concentrations from the epilimnion were found to be lower to those in the hypolimnion during these time periods. As explained in the Chainwide Report (Water Quality Section Primer), sediments within a lake often release phosphorus under anoxic conditions. When mixing occurs in the lake, these nutrients may be transported to the upper water column for use by algae or aquatic plants. The data in Figure 8.8.1-2 indicate that phosphorus is being released from the sediments in Manitowish Lake; however, the near-bottom phosphorus concentrations are relatively low, and internal phosphorus loading is not a significant source of phosphorus in Manitowish Lake.

Similar to what has been observed with the total phosphorus dataset, summer average chlorophyll-*a* concentrations (1.4 µg/L) were slightly lower than the median value (7.0 µg/L) for other lakes of this type (Figure 8.7.1-3), as well as lower than the median for all lakes in the ecoregion. Both of these parameters, total phosphorus and chlorophyll-*a*, rank within a TSI category of *Excellent*, indicating the lake has enough nutrients for production of aquatic plants, algae, and other organisms but not so much that a water quality issue is present. During 2016 visits to the lake, Onterra ecologists recorded field notes describing stained water but good conditions overall.

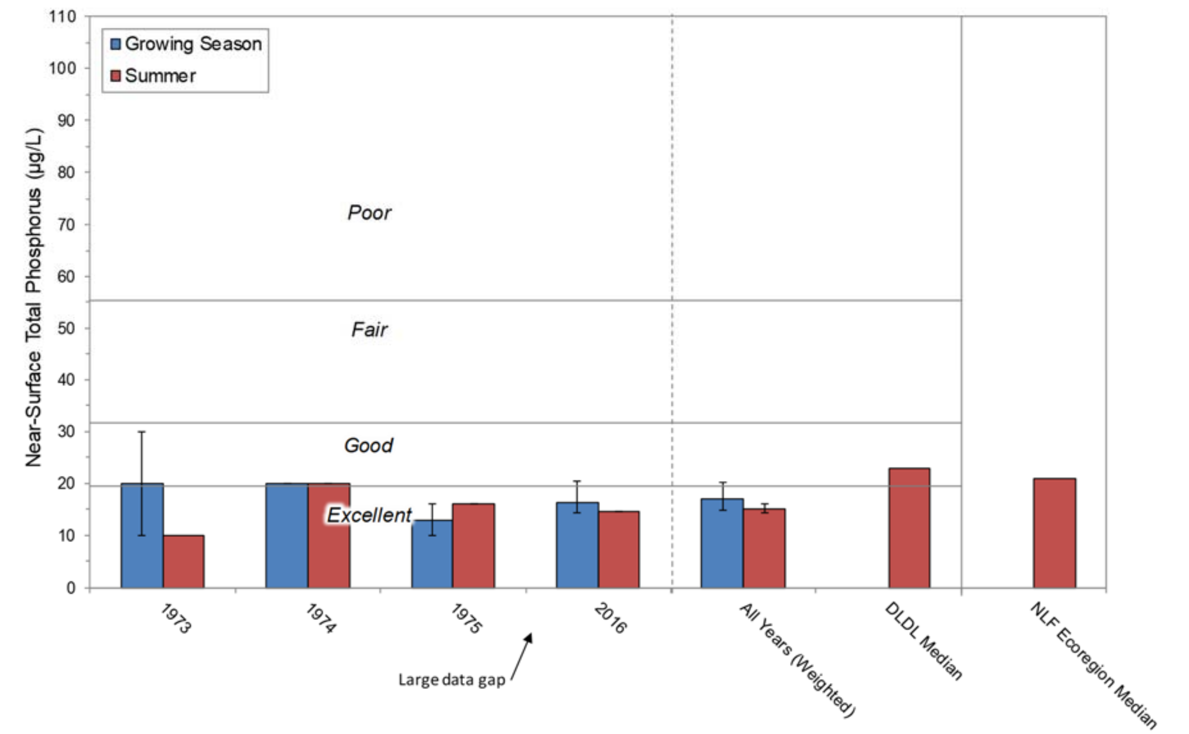


Figure 8.8.1-1. Manitowish Lake, state-wide deep, lowland drainage lakes, and regional total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

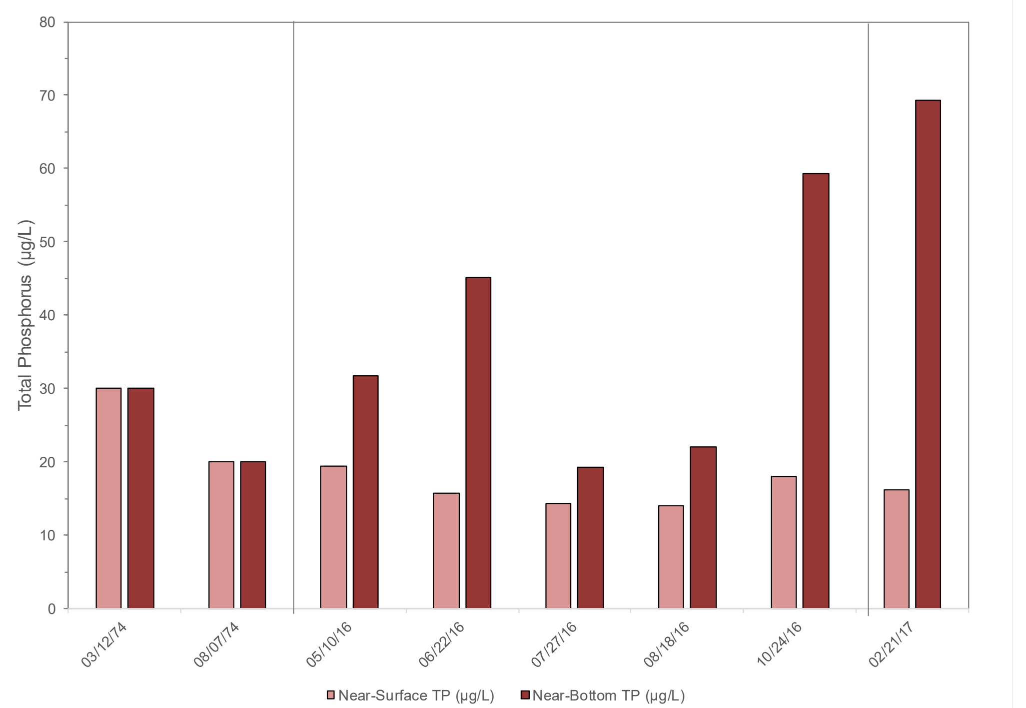


Figure 8.8.1-2. Manitowish Lake surface and bottom total phosphorus values.

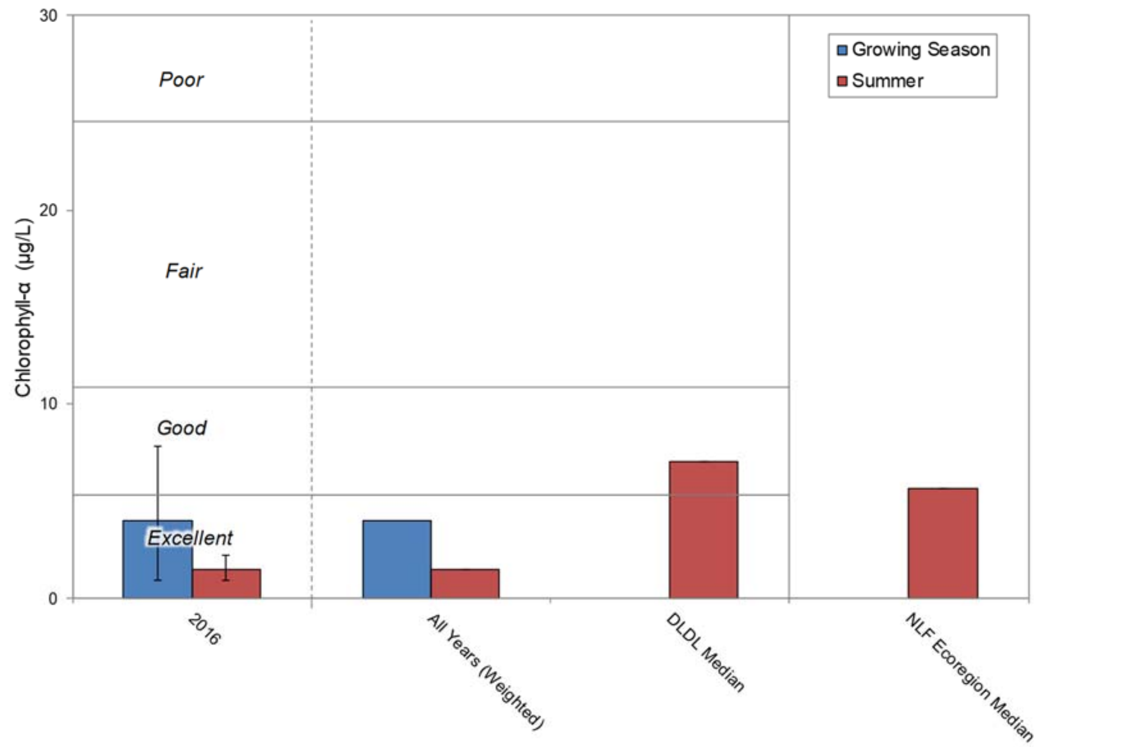


Figure 8.8.1-3. Manitowish Lake, state-wide deep, lowland drainage lakes, and regional chlorophyll-*a* concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

The clarity of Manitowish Lake's water can be described as *Excellent* during the summer months in which data has been collected (Figure 8.8.1-4). A weighted average over this timeframe is greater than the median value for other deep, lowland drainage lakes in the state and is also larger than the regional median. Secchi disk clarity is influenced by many factors, including plankton production and suspended sediments, which themselves vary due to several environmental conditions such as precipitation, sunlight, and nutrient availability. In Manitowish Lake as well as the other lakes in the Manitowish Waters Chain of Lakes, a natural staining of the water plays a role in light penetration, and thus water clarity, as well. The waters of Manitowish Lake contain naturally occurring organic acids that are washed into the lake from nearby wetlands. The acids are not harmful to humans or aquatic species; they are by-products of decomposing terrestrial and wetland plant species. This natural staining may reduce light penetration into the water column, which reduces visibility and also reduces the growing depth of aquatic vegetation within the lake.

True color measures the dissolved organic materials in water. Water samples collected in May and July of 2016 were measured for this parameter, and were found to be 20 Platinum-cobalt units (Pt-co units, or PCU), for both months. Lillie and Mason (1983) categorized lakes with 0-40 PCU as having low color, 40-100 PCU as medium color, and >100 PCU as high color.

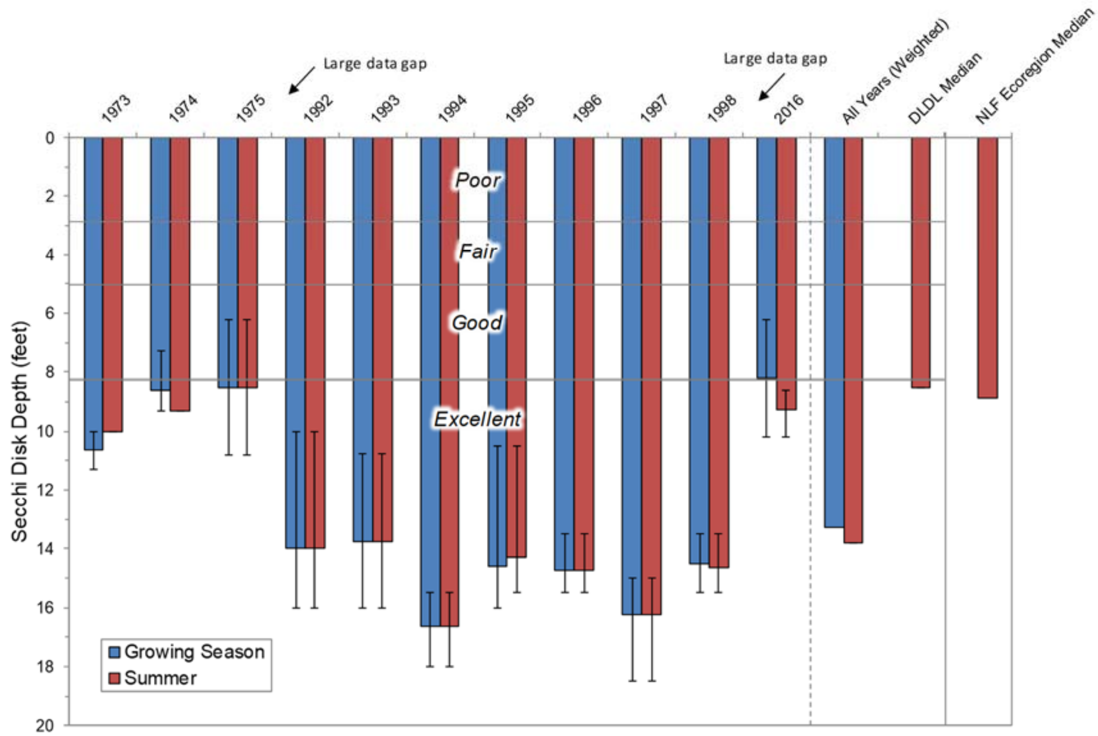


Figure. 8.8.1-4. Manitowish Lake, state-wide deep, lowland drainage lakes, and regional Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Manitowish Lake Trophic State

The TSI values calculated with Secchi disk, chlorophyll-*a*, and total phosphorus values range in values spanning from lower mesotrophic to eutrophic (Figure 8.8.1-5). In general, the best values to use in judging a lake's trophic state are the biological parameters; therefore, relying primarily on total phosphorus and chlorophyll-*a* TSI values, it can be concluded that Manitowish Lake is in an oligo-mesotrophic state.

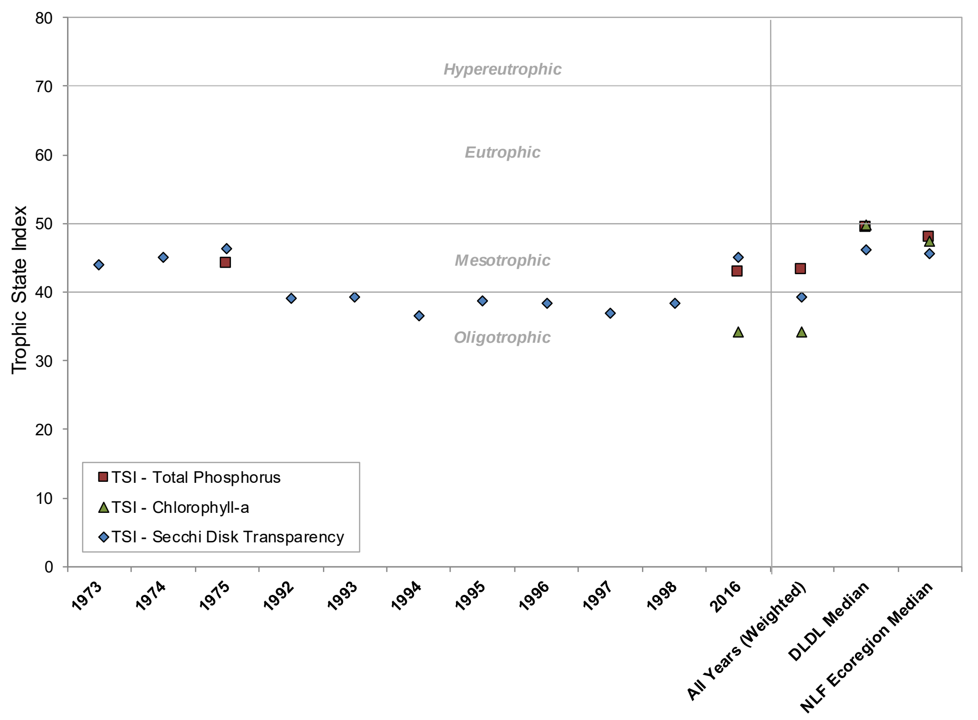


Figure 8.8.1-5. Manitowish Lake, state-wide deep, lowland drainage lakes, and regional Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Dissolved Oxygen and Temperature in Manitowish Lake

Dissolved oxygen and temperature profiles were created during each water quality sampling trip made to Manitowish Lake by Onterra staff. Graphs of those data are displayed in Figure 8.8.1-6 for all sampling events.

Manitowish Lake mixes thoroughly during the spring and fall, when changing air temperatures and gusty winds help to mix the water column. During the summer months, the lake remained thermally stratified, developing an anoxic hypolimnion. This occurrence is not uncommon in Wisconsin lakes, as bacteria break down organic matter that has collected at the bottom of the lake and in doing so utilize any available oxygen. If the lake mixes completely, oxygen will be reintroduced to the lower levels of the water column.

The lake mixes completely again in the fall, re-oxygenating the water in the lower part of the water column. During the winter months, the coldest temperatures are found just under the overlying ice, while oxygen gradually diminishes once again towards the bottom of the lake. In February of 2017, oxygen levels remained sufficient throughout most of the water column to support most aquatic life in northern Wisconsin lakes.

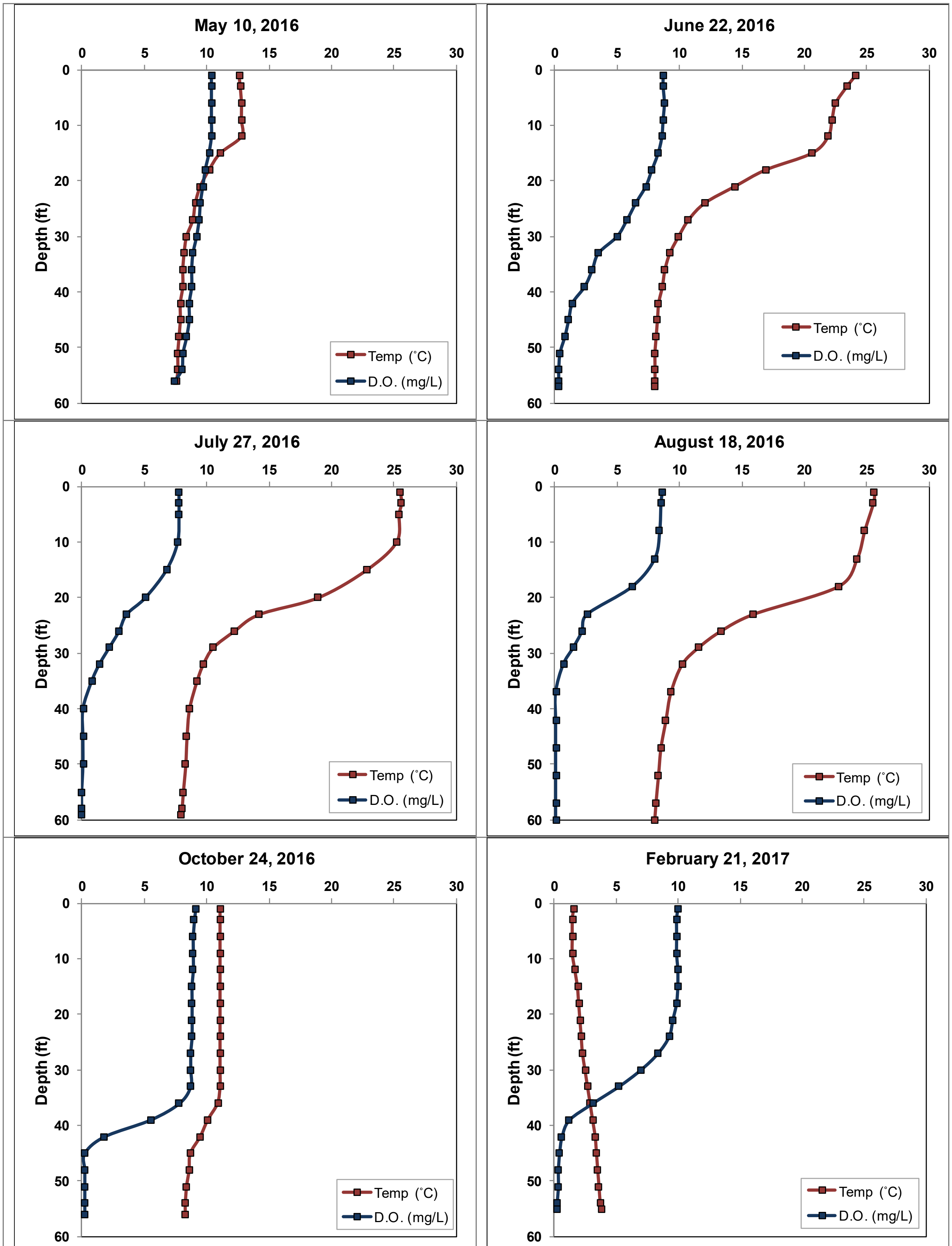


Figure 8.8.1-6. Manitowish Lake dissolved oxygen and temperature profiles.

Additional Water Quality Data Collected at Manitowish Lake

The water quality section is centered on lake eutrophication. However, parameters other than water clarity, nutrients, and chlorophyll-*a* were collected as part of the project. These other parameters were collected to increase the understanding of Manitowish Lake's water quality and are recommended as a part of the WDNR long-term lake trends monitoring protocol. These parameters include; pH, alkalinity, and calcium.

As the Chain-wide Water Quality Section explains, the pH scale ranges from 0 to 14 and indicates the concentration of hydrogen ions (H^+) within the lake's water and is thus an index of the lake's acidity. Manitowish Lake's surface water pH was measured at roughly 7.9 during May and 7.8 in July of 2016. These values are slightly above neutral and falls within the normal range for Wisconsin lakes. Fluctuations in pH with respect to seasonality is common; in-lake processes such as photosynthesis by plants act to reduce acidity by carbon dioxide removal while decomposition of organic matter adds carbon dioxide to water, thereby increasing acidity.

A lake's pH is primarily determined by the amount of alkalinity that is held within the water. Alkalinity is a lake's capacity to resist fluctuations in pH by neutralizing or buffering against inputs such as acid rain. Lakes with low alkalinity have higher amounts of the bicarbonate compound (HCO_3^-) while lakes with a higher alkalinity have more of the carbonate compound of alkalinity ($CO_3^=$). The carbonate form is better at buffering acidity, so lakes with higher alkalinity are less sensitive to acid rain than those with lower alkalinity. The alkalinity in Manitowish Lake was measured at 37.8 and 37.0 mg/L as $CaCO_3$ in May and July of 2016, respectively. This indicates that the lake has a substantial capacity to resist fluctuations in pH and has a low sensitivity to acid rain.

Samples of calcium were also collected from Manitowish Lake during 2016. Calcium is commonly examined because invasive and native mussels use the element for shell building and in reproduction. Invasive mussels typically require higher calcium concentrations than native mussels. The commonly accepted pH range for zebra mussels is 7.0 to 9.0, so Manitowish Lake's pH of 7.85 falls within this range. Lakes with calcium concentrations of less than 12 mg/L are considered to have very low susceptibility to zebra mussel establishment. The calcium concentration of Manitowish Lake was found to be 11.7 mg/L in July of 2016, which is just below the optimal range for zebra mussels. Plankton tows were completed by Onterra staff during the summer of 2016 and these samples were processed by the WDNR for larval zebra mussels. No veligers (larval zebra mussels) were found within these samples.

8.8.2 Manitowish Lake Watershed Assessment

Manitowish Lake's watershed is 51,408 acres in size. Compared to Manitowish Lake's size of 500 acres, this makes for a large watershed to lake area ratio of 102:1. Similar to most lakes that are downstream of other lakes, the large majority of the lake's watershed consists of the lake immediately upstream. For Manitowish Lake this means that 46,088 acres (94%) of the lake's watershed is the Alder Lake subwatershed, 890 acres (2%) from the Little Star subwatershed, and the rest of the Manitowish Lake's watershed is comprised of land cover types including forest (2%), wetlands (1%), and smaller amounts of other landuses (Figure 8.8.2-1). Wisconsin Lakes Modeling Suite (WiLMS) modeling indicates that Manitowish Lake's residence time is approximately 77 days, or the water within the lake is completely replaced 4.7 times per year.

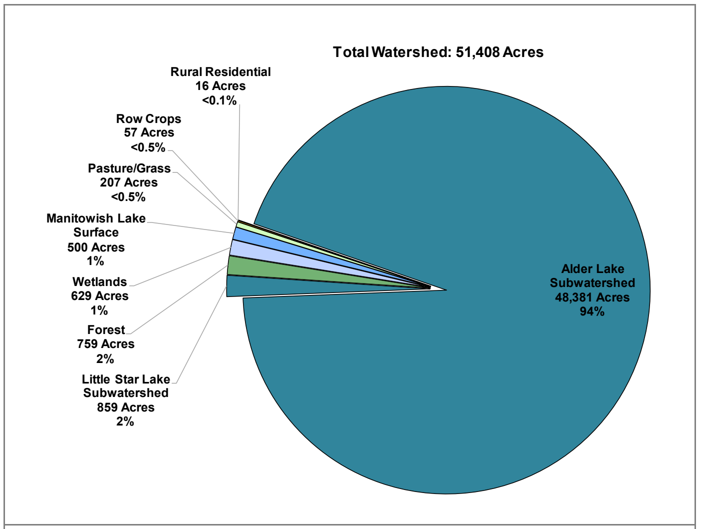


Figure 8.8.2-1. Manitowish Lake watershed proportion of land cover types. Based upon National Land Cover Database (NLCD – Fry et. al 2011).

Of the estimated 3,118 pounds of phosphorus being delivered to Manitowish Lake on an annual basis, approximately 2,735 pounds (88%) originates from the Alder Lake subwatershed, with next largest source being the lake surface itself 134 pounds (4%) and the remainder being from various landuses (Figure 8.8.2-2). Using the estimated annual potential phosphorus load, WiLMS predicted an in-lake growing season average total phosphorus concentration of 16 µg/L, which is essentially the same as the measured growing season average total phosphorus concentration of 15 µg/L. This means the model works reasonably well for Manitowish Lake.

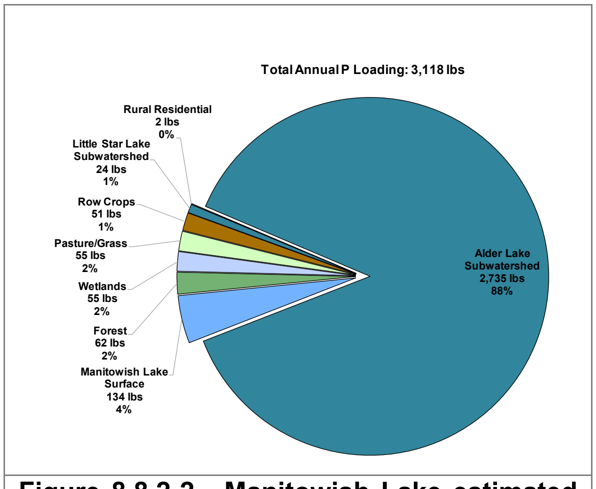


Figure 8.8.2-2. Manitowish Lake estimated potential annual phosphorus loading. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

Because the large majority of the phosphorus that enters Manitowish Lake comes from the upstream Alder Lake, efforts to reduce phosphorus levels in Manitowish Lake should concentrate on reducing phosphorus inputs to the upstream lake.

8.8.3 Manitowish Lake Shoreland Condition

Shoreland Development

As mentioned previously in the Chain-wide Shoreland Condition Section, one of the most sensitive areas of the watershed is the immediate shoreland area. This area of land is the last source of protection for a lake against surface water runoff, and is also a critical area for wildlife habitat. In fall of 2016, Manitowish Lake's immediate shoreline was assessed in terms of its development. Manitowish Lake has stretches of shoreland that fit all of the five shoreland assessment categories. In all, 4.1 miles of natural/undeveloped and developed-natural shoreline were observed during the survey (Figure 8.8.3-1). This constitutes about 59% of Manitowish Lake's shoreline. These shoreland types provide the most benefit to the lake and should be left in their natural state if at all possible. During the survey, 1.5 miles of urbanized and developed–unnatural shoreline (20%) was observed. If restoration of the Manitowish Lake shoreline is to occur, primary focus should be placed on these shoreland areas as they currently provide little benefit to, and actually may harm, the lake ecosystem. Due to water levels in Manitowish Lake, at the time of the fall survey, 1.9 miles of shoreline were inaccessible by boat. This shoreline length was not taken into account in Figure 8.8.3-1. Manitowish Lake Map 1 displays the location of these shoreline lengths around the entire lake.

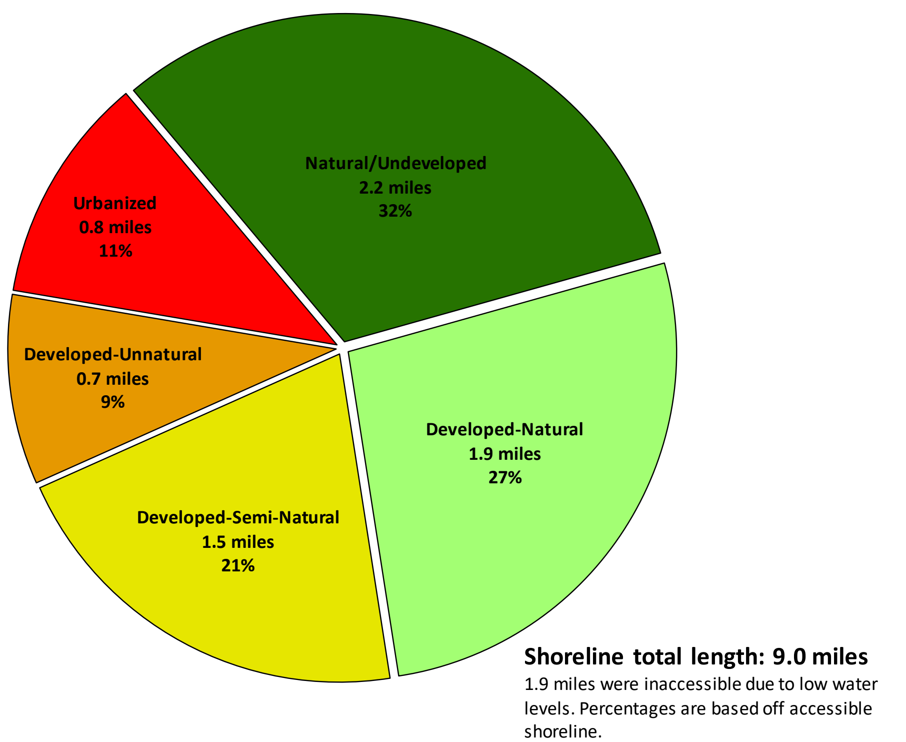


Figure 8.8.3-1. Manitowish Lake shoreland categories and total lengths. Based upon a fall 2016 survey. Locations of these categorized shorelands can be found on Manitowish Lake Map 1.

Coarse Woody Habitat

As part of the shoreland condition assessment, Manitowish Lake was also surveyed to determine the extent of its coarse woody habitat. Coarse woody habitat was identified and classified in three size categories (2-8 inches in diameter, 8+ inches in diameter, or clusters of pieces) as well as four branching categories: no branches, minimal branches, moderate branches, and full canopy. As discussed earlier, research indicates that fish species prefer some branching as opposed to no branching on coarse woody habitat, and increasing complexity is positively correlated with higher fish species richness, diversity and abundance (Newbrey et al. 2005).

During this survey, 175 total pieces of coarse woody habitat were observed along 7.0 miles of shoreline (Manitowish Lake Map 2), which gives Manitowish Lake a coarse woody habitat to shoreline mile ratio of 25:1 (Figure 8.8.3-2). Only instances where emergent coarse woody habitat extended from shore into the water were recorded during the survey. One hundred and forty-seven pieces of 2-8 inches in diameter pieces of coarse woody habitat were found, nineteen pieces of 8+ inches in diameter pieces of coarse woody habitat were found, and nine instances of clusters of coarse woody habitat were found.

To put this into perspective, Wisconsin researchers have found that in completely undeveloped lakes, an average of 345 coarse woody habitat structures may be found per mile (Christensen et al. 1996). Please note the methodologies between the surveys done on Manitowish Lake and those cited in this literature comparison are much different, but still provide a valuable insight into what undisturbed shorelines may have in terms of coarse woody habitat.

Onterra has completed coarse woody habitat surveys on 98 lakes throughout Wisconsin since 2012, with the majority occurring in the NLF ecoregion on lakes with public access. The number of coarse woody habitat pieces per shoreline mile in Manitowish Lake falls just below the median of these 98 lakes (Figure 8.8.3-2).

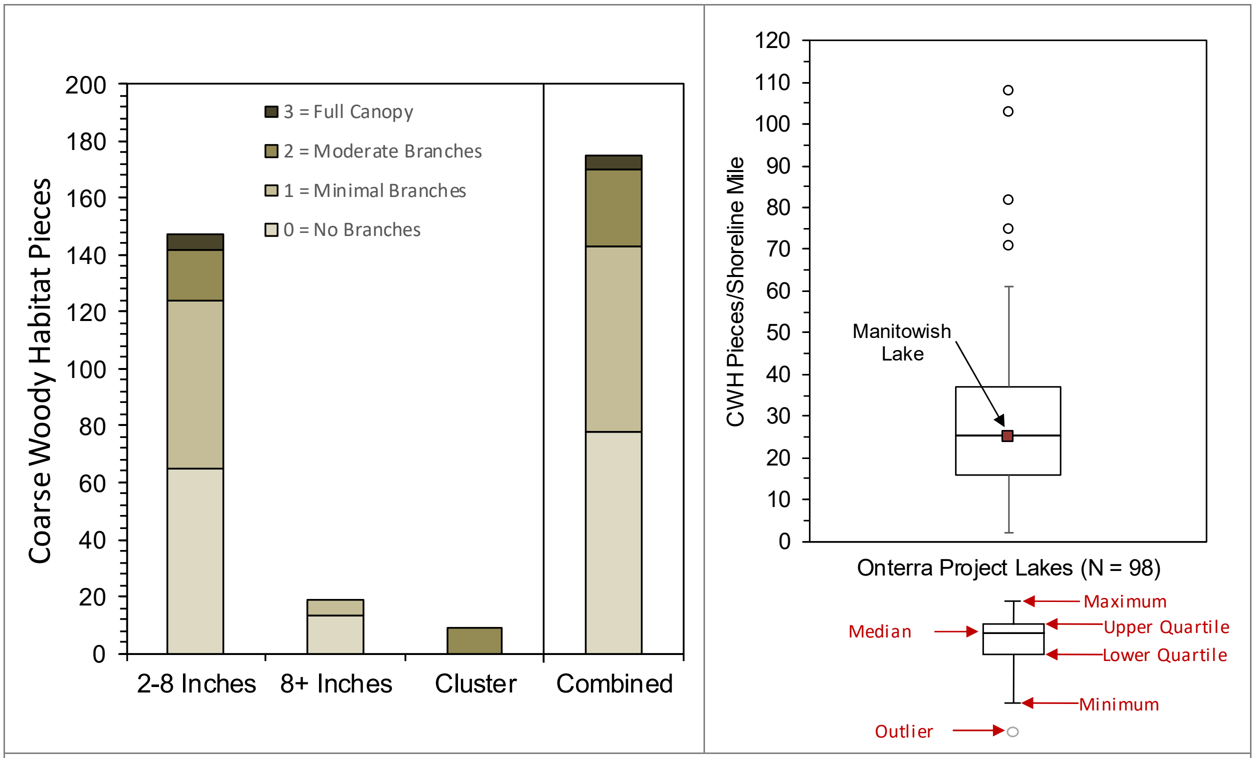


Figure 8.8.3-2. Manitowish coarse woody habitat survey results. Based upon a fall 2016 survey. Locations of the Manitowish Lake coarse woody habitat can be found on Manitowish Lake Map 2.

8.8.4 Manitowish Lake Aquatic Vegetation

An early season aquatic invasive species survey was conducted on Manitowish Lake on June 28 and 29, 2016. While the intent of this survey is to locate any potential non-native species within the lake, the primary focus is to locate occurrences of curly-leaf pondweed which should be at or near its peak growth at this time. During this meander-based survey of the littoral zone, Onterra ecologists did not locate any occurrences of curly-leaf pondweed or any other submersed non-native aquatic plant species in Manitowish Lake.

The aquatic plant point-intercept survey was conducted on Manitowish Lake on July 18 and 19, 2016 by Onterra. The floating-leaf and emergent plant community mapping survey was completed at that same trip to map these community types. During all surveys, 55 species of aquatic plants were located in Manitowish Lake (Table 8.8.4-1). Twenty-nine of these species were sampled directly during the point-intercept survey and are used in the analysis that follows, while 26 species were observed incidentally during visits to Manitowish Lake. Two non-native species, pale-yellow iris (*Iris pseudacorus*) and purple loosestrife (*Lythrum salicaria*) were observed along the Manitowish Lake shoreline.

Aquatic plants were found growing to a depth of 13 feet. As discussed later on within this section, many of the plants found in this survey indicate that the overall community is healthy and diverse. Of the 433 point-intercept locations sampled within the littoral zone, roughly 60% contained aquatic vegetation. Manitowish Lake Map 3 indicates that most of the point-intercept locations that contained aquatic vegetation are located in shallow bays and near shore; areas that have adequate light availability to sustain growth. Approximately 64% of the point-intercept sampling locations where sediment data was collected at were sand, 25% consisted of a fine, organic substrate (muck) and 11% were determined to be rocky (Chain-wide Fisheries Section, Table 3.5-5).

Table 8.8.4-1. Aquatic plant species located in Manitowish Lake during 2016 plant surveys.

Growth Form	Scientific Name	Common Name	Coefficient of Conservatism (C)	2016 (Onterra)
Emergent	*Alisma trivale*	Northern waterplantain	4	I
	Calla palustris	Water arum	9	I
	Carex pellita	Broad-leaved woolly sedge	4	I
	Carex pseudocyperus	Cypress-like sedge	8	I
	Carex utriculata	Common yellow lake sedge	7	I
	Dulichium arundinaceum	Three-way sedge	9	I
	Eleocharis palustris	Creeping spikerush	6	I
	Equisetum fluviatile	Water horsetail	7	I
	Glyceria borealis	Northern manna grass	8	I
	Glyceria canadensis	Rattlesnake grass	7	I
	Iris pseudacorus	Pale yellow iris	Exotic	I
	Juncus effusus	Soft rush	4	I
	Lythrum salicaria	Purple loosestrife	Exotic	I
	Sagittaria latifolia	Common arrowhead	3	I
	Sagittaria rigida	Stiff arrowhead	8	I
	Schoenoplectus acutus	Hardstem bulrush	5	I
	Schoenoplectus pungens	Three-square rush	5	I
	Schoenoplectus tabernaemontani	Softstem bulrush	4	I
	Scirpus cyperinus	Wool grass	4	I
	Typha spp.	Cattail spp.	1	I
FL	*Brasenia schreberi*	Watershield	7	I
	Nuphar variegata	Spatterdock	6	I
	Nymphaea odorata	White water lily	6	X
	Persicaria amphibia	Water smartweed	5	I
	Sparganium fluctuans	Floating-leaf bur-reed	10	X
FL/E	*Sparganium* sp. (sterile)	Bur-reed sp. (sterile)	N/A	I
Submergent	*Bidens beckii*	Water marigold	8	X
	Ceratophyllum demersum	Coontail	3	X
	Chara spp.	Muskgrasses	7	X
	Elatine minima	Waterwort	9	X
	Elodea canadensis	Common waterweed	3	X
	Heteranthera dubia	Water stargrass	6	X
	Isoetes spp.	Quillwort spp.	8	X
	Myriophyllum farwellii	Farwell's watermilfoil	9	I
	Myriophyllum sibiricum	Northern watermilfoil	7	X
	Najas flexilis	Slender naiad	6	X
	Nitella spp.	Stoneworts	7	X
	Potamogeton alpinus	Apline pondweed	9	I
	Potamogeton amplifolius	Large-leaf pondweed	7	X
	Potamogeton epihydrus	Ribbon-leaf pondweed	8	X
	Potamogeton gramineus	Variable-leaf pondweed	7	X
	Potamogeton praelongus	White-stem pondweed	8	X
	Potamogeton pusillus	Small pondweed	7	X
	Potamogeton richardsonii	Clasping-leaf pondweed	5	X
	Potamogeton robbinsii	Fern-leaf pondweed	8	X
	Potamogeton spirillus	Spiral-fruited pondweed	8	X
	Potamogeton strictifolius	Stiff pondweed	8	X
	Potamogeton vaseyi	Vasey's pondweed	10	X
	Potamogeton zosteriformis	Flat-stem pondweed	6	X
	Utricularia intermedia	Flat-leaf bladderwort	9	X
	Utricularia minor	Small bladderwort	10	X
	Utricularia vulgaris	Common bladderwort	7	X
	Vallisneria americana	Wild celery	6	X
S/E	*Eleocharis acicularis*	Needle spikerush	5	X
	Sagittaria cristata	Crested arrowhead	9	X

FL = Floating Leaf; FL/E = Floating Leaf and Emergent; S/E = Submergent and Emergent; FF = Free Floating
X = Located on rake during point-intercept survey; I = Incidental Species

Figure 8.8.4-1 shows that wild celery, fern-leaf pondweed and slender naiad were the most frequently encountered plants within Manitowish Lake. Wild celery is a long, limp, ribbon-leaved turbidity-tolerant species that is a premiere food source for ducks, marsh birds, shore birds and muskrats. Animals may eat the entire plant, including the tubers that reside within the sediment. Fern-leaf pondweed is a low-growing plant that was likely named after its palm-frond or fern-like appearance. This plant is known to provide habitat for smaller aquatic animals that are used as food by larger, predatory fishes. Slender naiad, a common annual species in Wisconsin, is considered to be one of the most important food sources for a number of migratory waterfowl species (Borman et al. 1997). Their numerous seeds, leaves, and stems all provide sources of food. The small, condensed network of leaves provide excellent habitat for aquatic invertebrates.

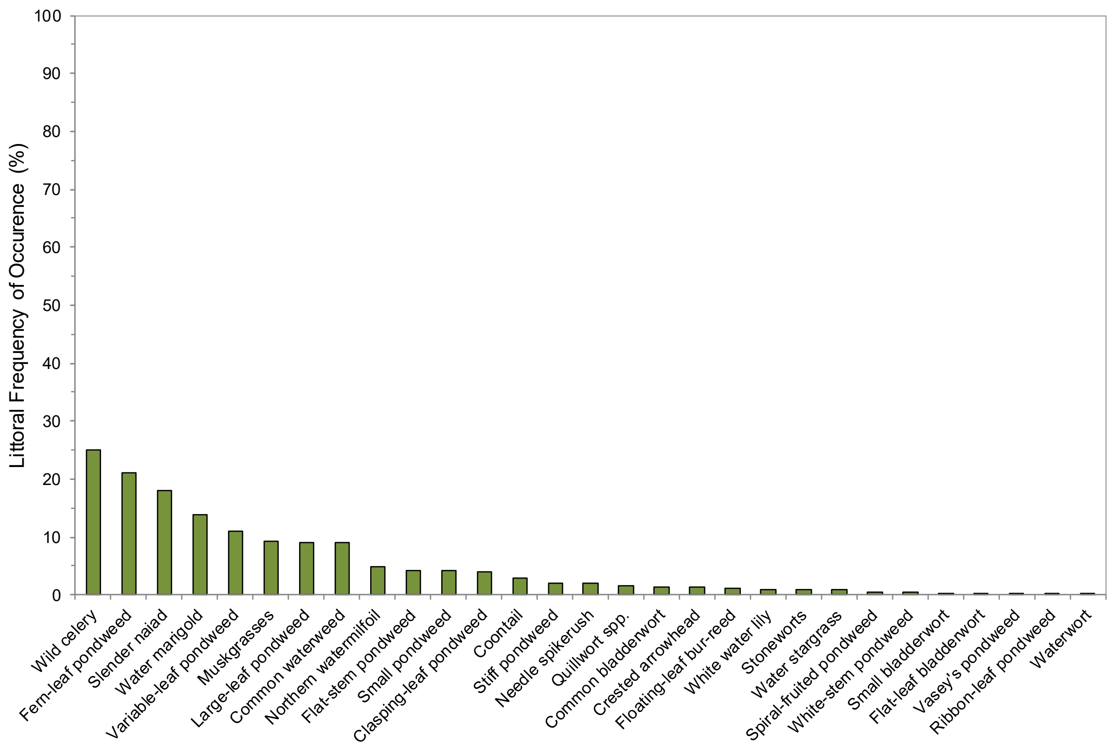


Figure 8.8.4-1. Manitowish Lake aquatic plant littoral frequency of occurrence analysis. Created using data from a 2016 point-intercept survey. .

During aquatic plant inventories, 53 species of native aquatic plants (including incidentals) were found in Manitowish Lake. Because of this, one may assume that the system would also have a high diversity. As discussed earlier, how evenly the species are distributed throughout the system also influence the diversity. The diversity index for Manitowish Lake's plant community (0.91) lies above the Northern Lakes and Forest Lakes ecoregion value (0.86), indicating the lake holds exceptional diversity.

As explained earlier in the Manitowish Waters Chain of Lakes-wide document, the littoral frequency of occurrence analysis allows for an understanding of how often each of the plants is located during the point-intercept survey. Because each sampling location may contain numerous plant species, relative frequency of occurrence is one tool to evaluate how often each plant species is found in relation to all other species found (composition of population). For instance, while wild celery was found at 25% of the sampling locations, its relative frequency of occurrence is

17%. Explained another way, if 100 plants were randomly sampled from Manitowish Lake, 17 of them would be wild celery. This distribution can be observed in Figure 8.8.4-2, where together 14 native species account for 92% of the aquatic plant population within Manitowish Lake, while the other 15 species account for the remaining 8%. Twenty-two additional native species were found incidentally from the lake but not from of the point-intercept survey, and are indicated in Table 8.8.4-1 as incidentals.

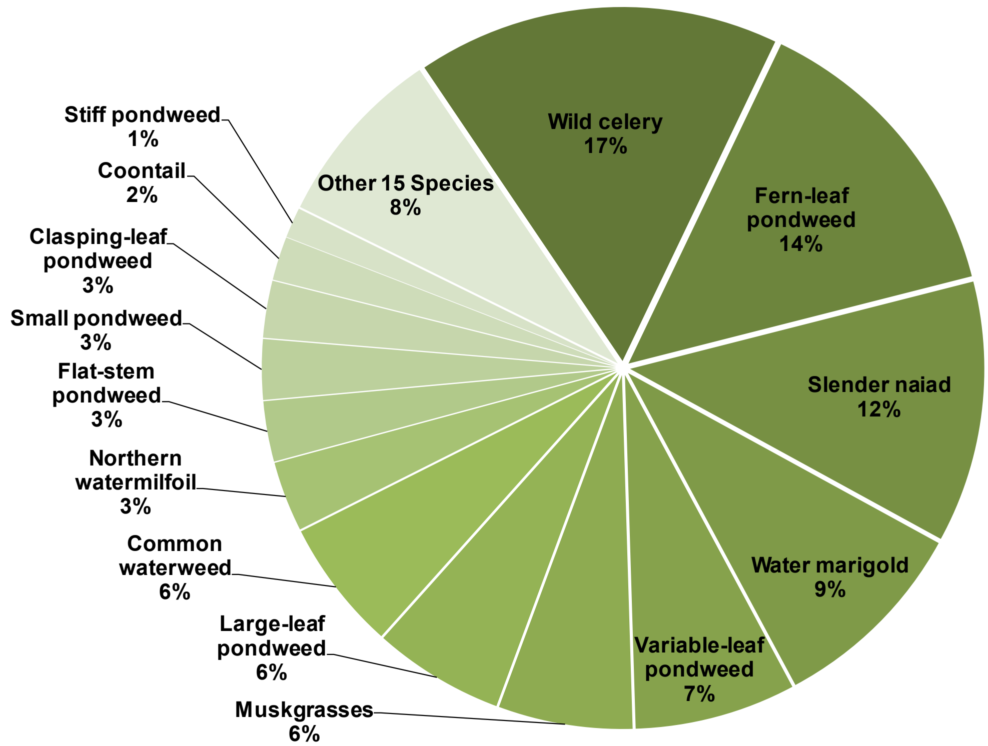


Figure 8.8.4-2. Manitowish Lake aquatic plant relative frequency of occurrence analysis. Created using data from 2016 point-intercept survey.

Manitowish Lake's average conservatism value (6.6) is higher than the state median (6.3) but slightly lower than the Northern Lakes and Forests ecoregion median (6.7). This indicates that the plant community of Manitowish Lake is indicative of an average system within Wisconsin. Combining Manitowish Lake's species richness and average conservatism values to produce its Floristic Quality Index (FQI) results in a value of 47.0 which is above the median values of the ecoregion and state.

The 2016 community map indicates that approximately 18.1 acres of the lake contains these types of plant communities (Manitowish Lake Map 4, Table 8.8.4-2). Twenty-six floating-leaf and emergent species were located on Manitowish Lake (Table 8.8.4-1), all of which provide valuable wildlife habitat. The community map represents a 'snapshot' of the emergent and floating-leaf plant communities, replications of this survey through time will provide a valuable understanding of the dynamics of these communities within Manitowish Lake. This is important, because these communities are often negatively affected by recreational use and shoreland development. Radomski and Goeman (2001) found a 66% reduction in vegetation coverage on developed shorelines when compared to undeveloped shorelines in Minnesota Lakes. Furthermore, they also found a significant reduction in abundance and size of northern pike (*Esox lucius*), bluegill

(*Lepomis macrochirus*), and pumpkinseed (*Lepomis gibbosus*) associated with these developed shorelines.

Table 8.8.4-2. Manitowish Lake acres of emergent and floating-leaf plant communities from the 2016 community mapping survey.

Plant Community	Acres
Emergent	2.3
Floating-leaf	15.2
Mixed Floating-leaf and Emergent	0.6
Total	18.1

Non-Native Aquatic Plants in Manitowish Lake

Pale-yellow Iris

Pale-yellow iris (*Iris pseudacorus*) is a large, showy iris with bright yellow flowers. Native to Europe and Asia, this species was sold commercially in the United States for ornamental use and has since escaped into Wisconsin's wetland areas forming large monotypic colonies and displacing valuable native wetland species. This species was observed flowering along the shoreline areas on the lake during the early-season aquatic invasive species survey. The locations of pale-yellow iris on Manitowish Lake can be viewed on Manitowish Lake Map 4.

Purple Loosestrife

Purple loosestrife (*Lythrum salicaria*) is a perennial herbaceous plant native to Europe and was likely brought over to North America as a garden ornamental. This plant escaped from its garden landscape into wetland environments where it is able to out-compete our native plants for space and resources. First detected in Wisconsin in the 1930's, it has now spread to 70 of the state's 72 counties. Purple loosestrife largely spreads by seed, but also can vegetatively spread from root or stem fragments.

In Manitowish Lake, purple loosestrife was located in mostly on an island on the eastern side of the lake (Manitowish Lake – Map 4). There are a number of effective control strategies for combating this aggressive plant, including herbicide application, biological control by native beetles, and manual hand removal. Due to the low occurrence and distribution of plants, hand removal by volunteers is likely the best option as it would decrease costs significantly. Additional purple loosestrife monitoring would be required to ensure the eradication of the plant from the shorelines and wetland areas around Manitowish Lake.

Curly-leaf Pondweed

Curly-leaf pondweed (*Potamogeton crispus*) is discussed in detail at the end of the Aquatic Plant Section 3.4. Monitoring results, control actions, and a description of the plant's lifecycle are contained in that section.

Curly-leaf pondweed was first discovered in Manitowish Lake during 2013. Through 2019, the infrequent occurrence of this exotic was managed through volunteer and professional hand-harvesting. As a part of the Manitowish Waters Comprehensive Management Plan, Manitowish Lake's curly-leaf pondweed population will be monitored by volunteers and professionals with control actions being implemented as appropriate.

8.8.5 Manitowish Lake Fisheries Data Integration

Fishery management is an important aspect in the comprehensive management of a lake ecosystem; therefore, a brief summary of available data is included here and within each lake's individual report section as a reference. The following section is not intended to be a comprehensive plan for the lake's fishery, as those aspects are currently being conducted by the fisheries biologists overseeing Manitowish Lake. The goal of this section is to provide an overview of some of the data that exists. Although current fish data were not collected as a part of this project, the following information was compiled based upon data available from the Wisconsin Department of Natural Resources (WDNR) the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) and personal communications with DNR Fisheries Biologist Hadley Boehm (WDNR 2018 & GLIFWC 2017).

Fish Stocking

To assist in meeting fisheries management goals, the WDNR may stock fry, fingerling or adult fish in a waterbody that were raised in nearby permitted hatcheries (Photograph 8.8.5-1). Stocking of a lake may be done to assist the population of a species due to a lack of natural reproduction in the system, or to otherwise enhance angling opportunities. Manitowish Lake has been stocked from 1975 to 2000 with muskellunge and walleye (Table 8.8.5-1).

Photograph 8.8.5-1. Fingerling Muskellunge.

Table 8.8.5-1. Stocking data available for Manitowish Lake (1975-2000).

Lake	Year	Species	Age Class	# Fish Stocked	Avg Fish Length (in)
Manitowish Lake	1975	Walleye	Fingerling	15,000	3
Manitowish Lake	1973	Muskellunge	Fingerling	2,596	10
Manitowish Lake	1976	Muskellunge	Fingerling	359	11
Manitowish Lake	1983	Muskellunge	Fingerling	250	11
Manitowish Lake	1984	Muskellunge	Fingerling	500	11
Manitowish Lake	1986	Muskellunge	Fingerling	500	11.5
Manitowish Lake	1987	Muskellunge	Fingerling	1,500	12
Manitowish Lake	1988	Muskellunge	Fingerling	500	10
Manitowish Lake	1990	Muskellunge	Fingerling	433	10
Manitowish Lake	1991	Muskellunge	Fingerling	250	11
Manitowish Lake	1996	Muskellunge	Fingerling	225	10.8
Manitowish Lake	1998	Muskellunge	Large Fingerling	450	12.2
Manitowish Lake	2000	Muskellunge	Large Fingerling	450	9.9

Manitowish Lake Spear Harvest Records

Walleye open water spear harvest records are provided in Figure 8.8.5-1 from 1999 to 2017. As many as 159 walleye have been harvested from the lake in the past (2015), but the average harvest is roughly 84 fish in a given year. Spear harvesters on average have taken 79% of the declared quota. Additionally, on average 14% of walleye harvested have been female.

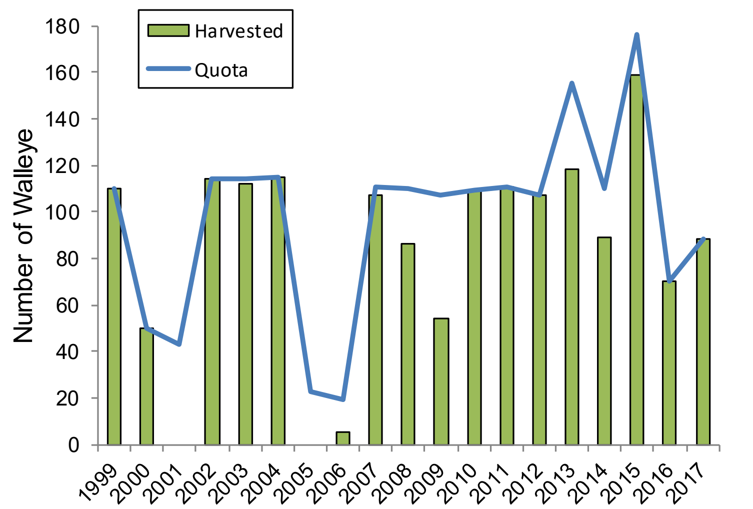


Figure 8.8.5-1. Manitowish Lake walleye spear harvest data. (GLIFWC 1999-2017).

Muskellunge open water spear harvest records are provided in Figure 8.8.5-2 from 1999 to 2017. As many as six muskellunge have been harvested from the lake in the past (2008), however the average harvest is one fish in a given year. Spear harvesters on average have taken 18% of the declared quota.

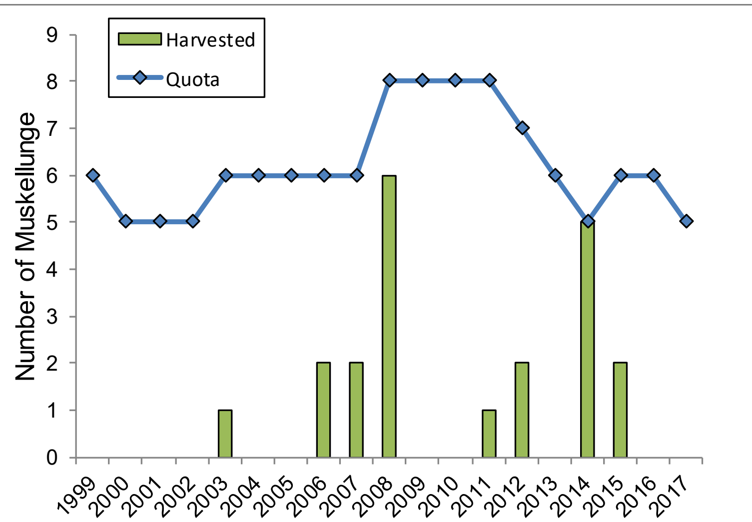
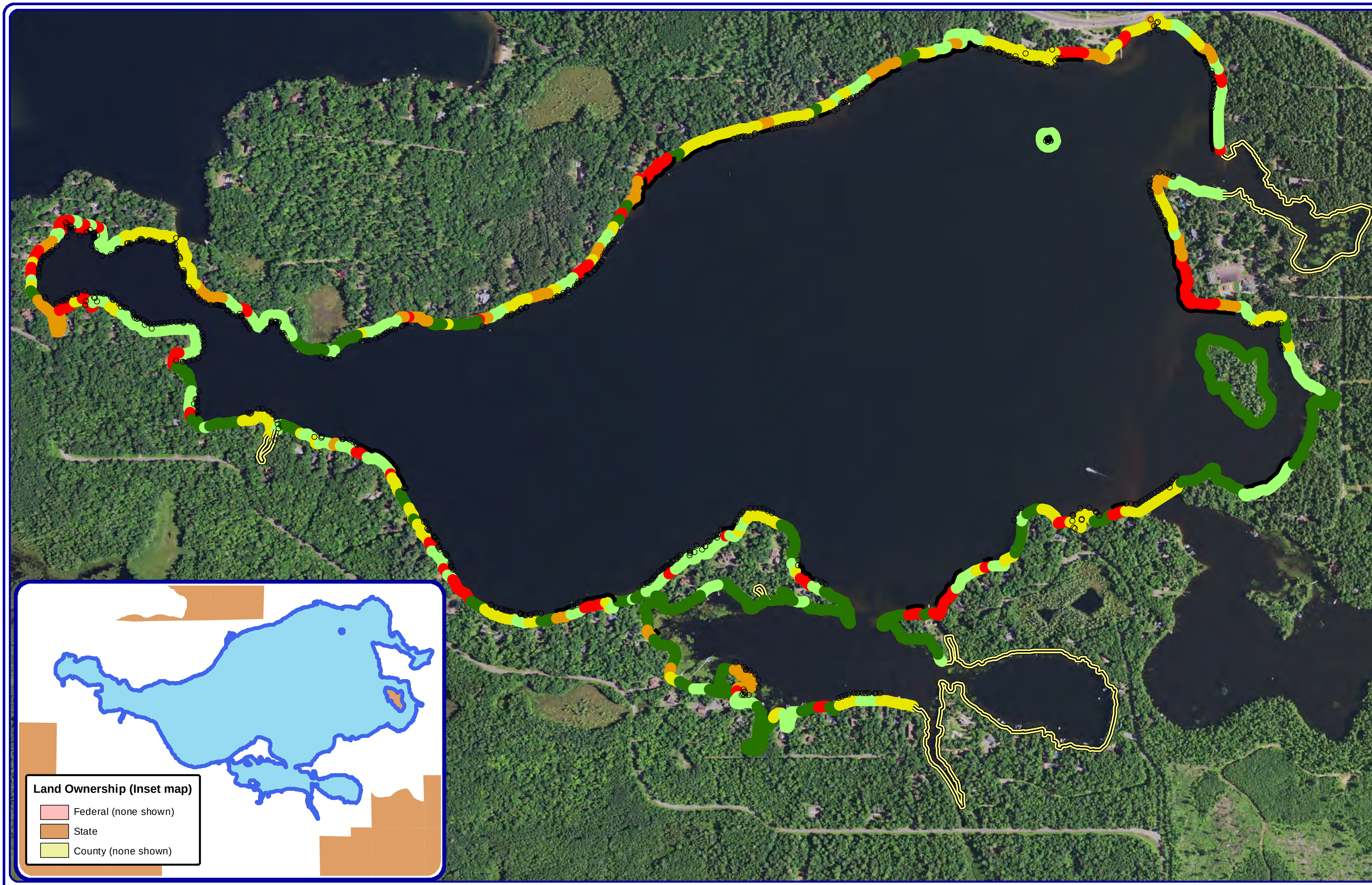


Figure 8.8.5-2. Manitowish Lake muskellunge spear harvest data. (GLIFWC 1999-2017).



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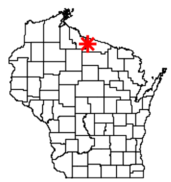
Feet

Onterra, LLC
Lake Management Planning
815 Prosper Road
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Sources:
Hydro: WDNR
Orthophotography: NAIP, 2015
Shoreline Assessment: Onterra, 2016
Map Date: December 8, 2016
Filename: Manitowish_Map1_ShorelandCondition_2016.mxd



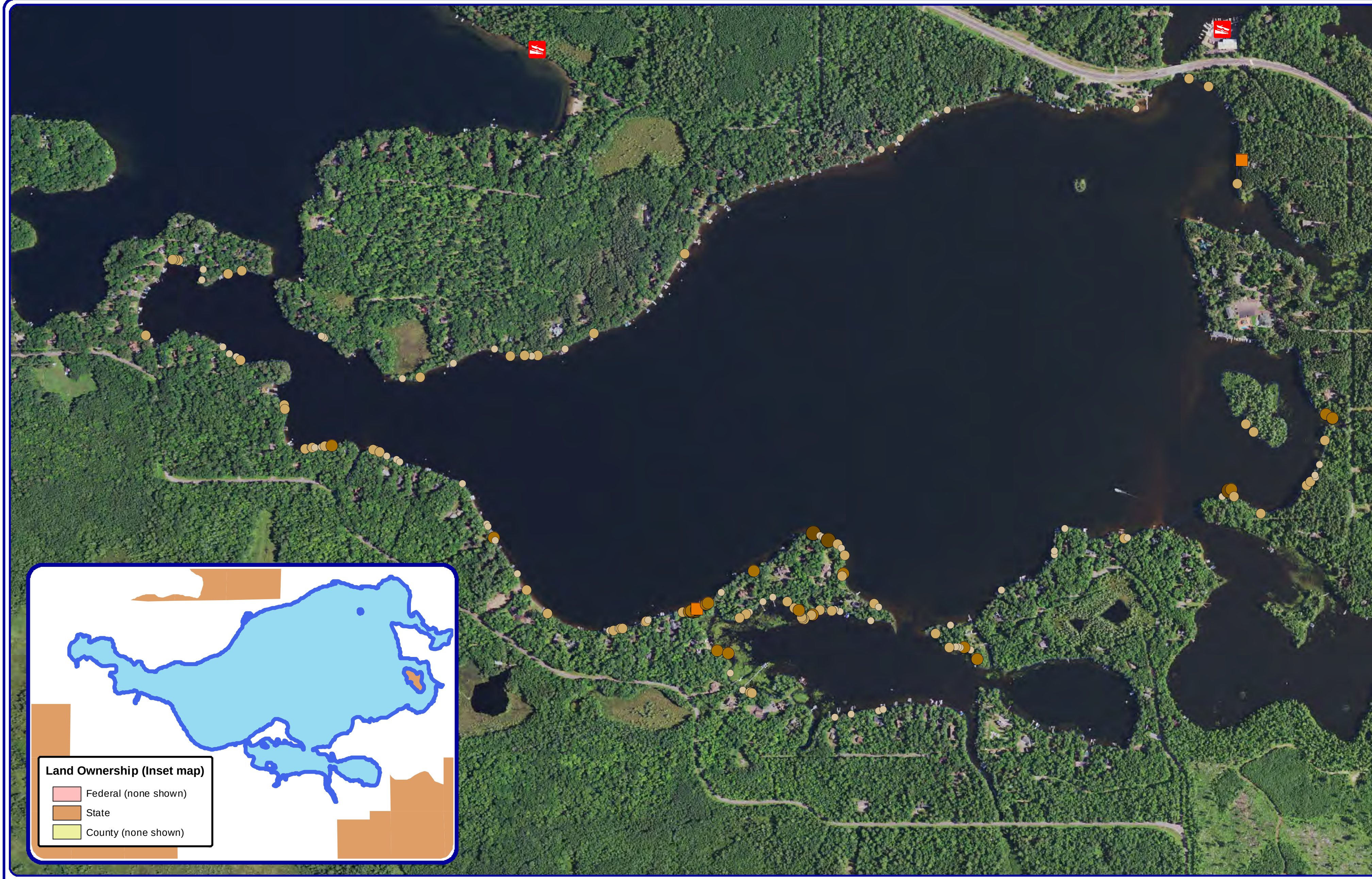
Project Location in Wisconsin

Legend

Natural/Undeveloped
Developed-Natural
Developed-Semi-Natural
Developed-Unnatural
Urbanized
Inaccessible

Seawall
Rip-Rap
Wood/Masonary/Metal

Map 1
Manitowish Lake
Vilas County, Wisconsin
2016 Shoreland Condition



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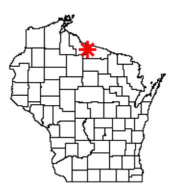
Sources:
Hydro: WDNR
Orthophotography: NAIP, 2015
Shoreline Assessment: Onterra, 2016
Map Date: December 9, 2016
Filename: Manitowish_Map2_CWH_2016.mxd

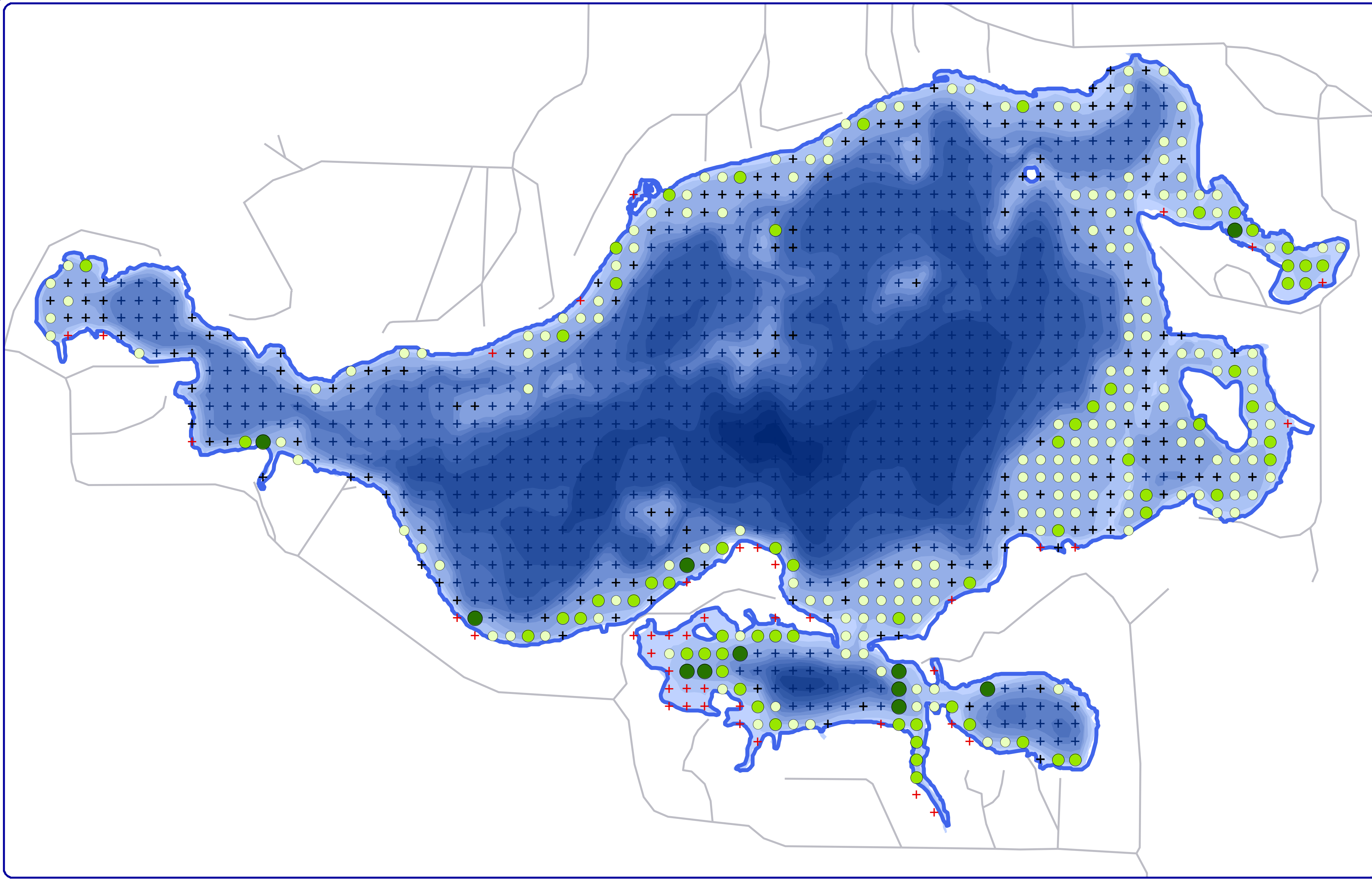


Project Location in Wisconsin

Legend

2-8 Inch Pieces	8+ Inch Pieces	Cluster of Pieces
No Branches	No Branches	No Branches (none)
Minimal Branches	Minimal Branches	Minimal Branches (none)
Moderate Branches	Moderate Branches (none)	Moderate Branches
Full Canopy	Full Canopy (none)	Full Canopy (none)

Map 2
Manitowish Lake
Vilas County, Wisconsin
Coarse Woody Habitat



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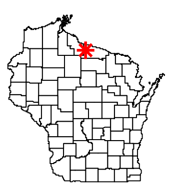
www.onterra-eco.com

Sources:
Roads and Hydro: WDNR
Plant Survey: Onterra, 2016
Map Date: November 30, 2016
Filename: *Manitowish_Map3_TRFPI_2016.mxd*



Project Location in Wisconsin

Legend

- Total Rake Fullness = 1
- Total Rake Fullness = 2
- Total Rake Fullness = 3
- No Vegetation
- Non-Navigable

Map 3
Manitowish Lake
Vilas County, Wisconsin
2016 PI Survey: Aquatic Vegetation Distribution

Legend

Small Plant Communities

- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent

Large Plant Communities

- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent
- Adjacent Wetland Habitat

Exotic Plant Communities

- Purple loosestrife
- Pale yellow iris

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Sources:
Aquatic Plants: Onterra, 2016
Orthophotography: NAIP, 2015
Map date: October 26, 2016
Filename: Manitowish_Map4_Comm_2016.mxd

Manitowish Lake - Map 4

Manitowish Lake
Vilas County, Wisconsin

Emergent & Floating-leaf Aquatic Plant Communities