8.8 Irving Lake

An Introduction to Irving Lake

Irving Lake, Vilas County, is a 427-acre shallow headwater, meso-eutrophic drainage lake with a maximum depth of 13 feet and a mean depth of 4 feet (Irving Lake – Map 1). Its watershed encompasses approximately 1,233 acres within the Manitowish River Watershed and is comprised mainly of intact forests and wetlands. Water leaves Irving Lake to the west through a culvert and flows into Ballard Lake. In 2018, 46 native aquatic plant species were located within the lake, of which slender naiad (*Najas flexilis*) was the most common.

Lake at a Glance - Irving Lake

Morphometry	
Lake Type	Shallow Headwater Drainage Lake
Surface Area (Acres)	427
Max Depth (feet)	13
Mean Depth (feet)	4
Perimeter (Miles)	4.3
Shoreline Complexity	2.2
Watershed Area (Acres)	1,233
Watershed to Lake Area Ratio	2:1

Water Quality	
Trophic State	Meso-Eutrophic
Limiting Nutrient	Phosphorus
Avg Summer P (μg/L)	32
Avg Summer Chl-α (μg/L)	8
Avg Summer Secchi Depth (ft)	6
Summer pH	7.6
Alkalinity (mg/L as $CaCO_3$)	25.3

Vegetation	
Number of Native Species	46
NHI-Listed Species	-
Exotic Species	-
Average Conservatism	7
Floristic Quality	37.2
Simpson's Diversity (1-D)	0.9

8.8.1 Irving Lake Water Quality

Water quality data was collected from Irving Lake on six occasions in 2018-2019. Onterra staff sampled the lake for 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 near-surface samples. In addition to sampling efforts completed in 2018-2019, any historical data were researched and are included within this report as available.

Near-surface total phosphorus data from Irving Lake are available from 1999, 2000, and 2018 (Figure 8.8.1-1). The weighted summer average total phosphorus concentration is 32.1 µg/L and falls into the *good* category for shallow headwater drainage lakes in Wisconsin. Irving Lake's summer average total phosphorus concentrations are just slightly higher than the median value for shallow headwater drainage lakes in the state (29.0 µg/L) and higher than the median value for all lake types in the Northern Lakes and Forests (NLF) ecoregion (21.0 µg/L). Total phosphorus data were also collected in 1926-1929 by Birge and Juday (Splitt 2001). The average summer concentration during this period was 24.5 µg/L, slightly lower than the more recent measured average of 32.1 µg/L. It's important to note that phosphorus concentrations can be variable from year to year and over longer periods of time due to changes in precipitation. Lower concentrations measured in 1926-1929 can be considered a snap-shot of this period, and indicate that phosphorus concentrations likely fluctuate in Irving Lake over longer periods of time.

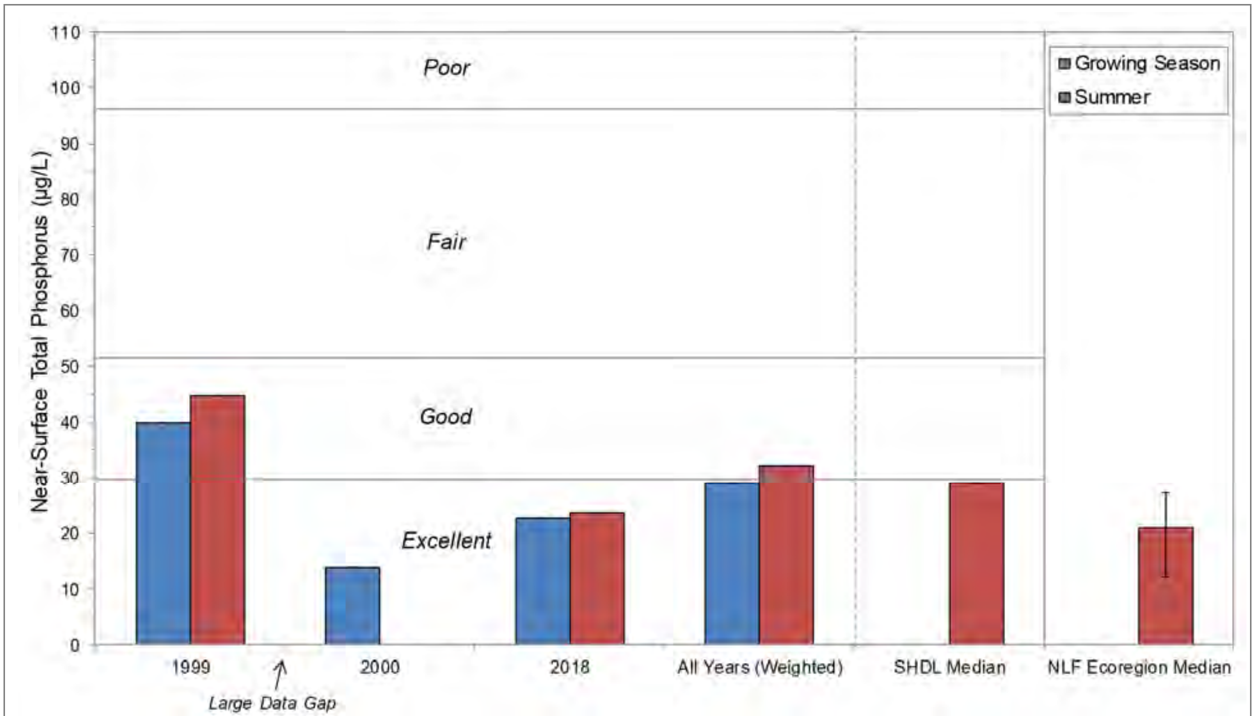


Figure 8.8.1-1. Irving Lake, statewide shallow headwater drainage lakes, and regional total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Chlorophyll-*a* data are available from Irving Lake from 1999 and 2018 (Figure 8.8.1-2). Irving Lake's weighted summer average chlorophyll-*a* concentration is 7.8 µg/L and falls into the *excellent* category for shallow headwater drainage lakes in Wisconsin. Irving Lake's weighted summer average chlorophyll-*a* concentration is very close to the median value for shallow headwater drainage lakes in the state (7.5 µg/L) and slightly higher than the median value of 5.6 µg/L for all lake types in the NLF ecoregion.

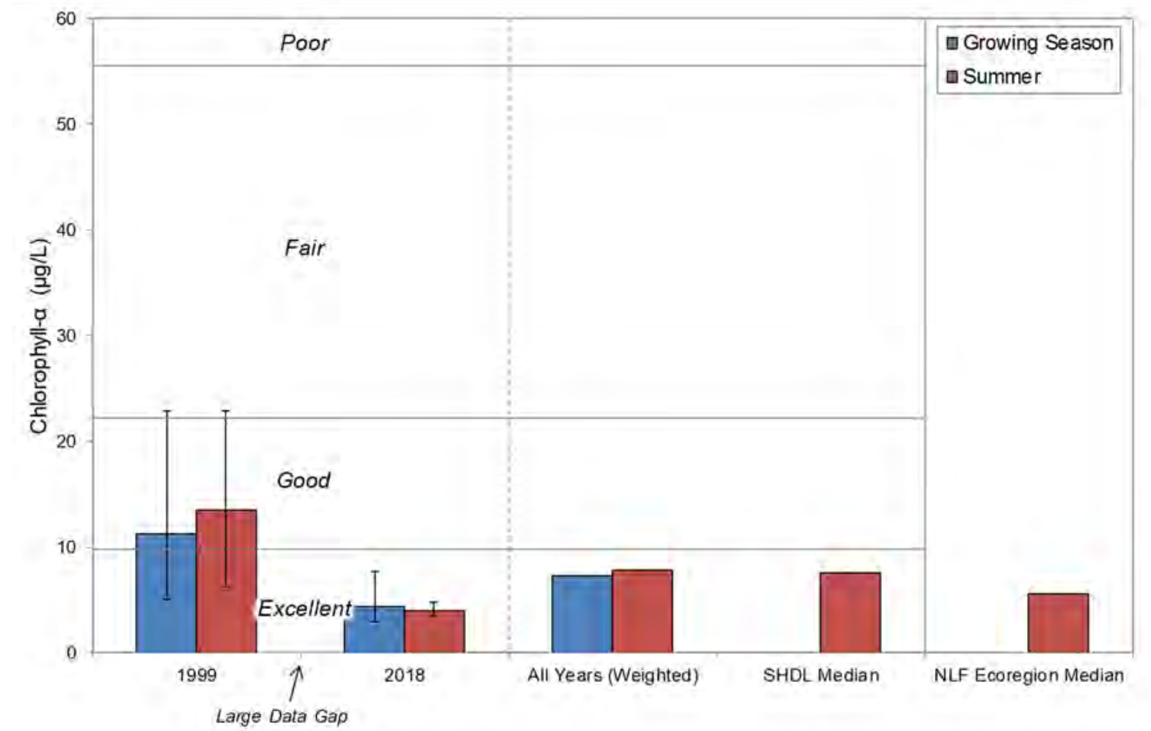


Figure 8.8.1-2. Irving Lake, statewide shallow headwater drainage lakes, and regional chlorophyll-*a* concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Secchi disk transparency data are available from Irving Lake from 1998-2000 and 2017-2019 (Figure 8.8.1-3). The weighted summer average Secchi disk depth is 6.0 feet and falls into the *excellent* category for shallow headwater drainage lakes in Wisconsin. Irving Lake's weighted summer average Secchi disk depth is similar to the median value of 5.6 feet for shallow headwater drainage lakes in the state and is approximately 2.9 feet shallower than the median value for all lakes types in the NLF ecoregion.

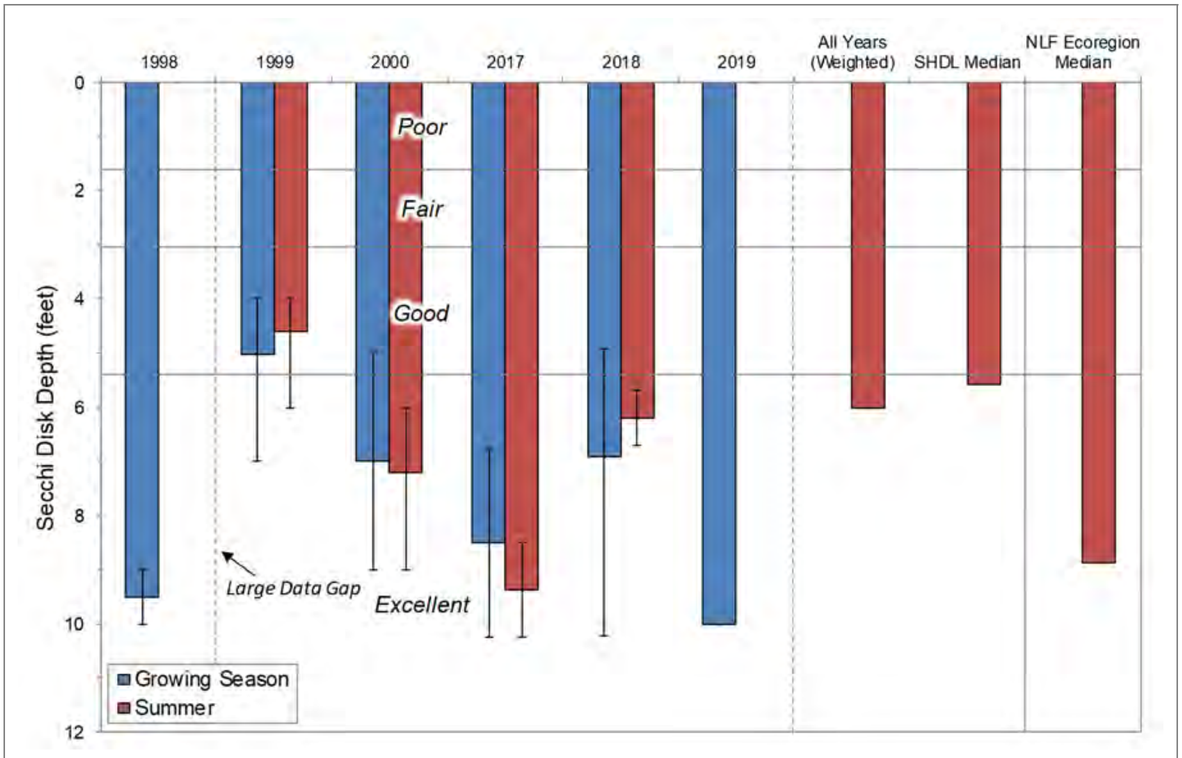


Figure 8.8.1-3. Irving Lake, statewide shallow headwater drainage lakes, and regional Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Limiting Plant Nutrient of Irving Lake

Using midsummer nitrogen and phosphorus concentrations from Irving Lake, a nitrogen:phosphorus ratio of 23:1 was calculated. This finding indicates that Irving Lake is indeed phosphorus limited as are the vast majority of Wisconsin lakes. In general, this means that cutting phosphorus inputs may limit plant growth within the lake.

Irving Lake Trophic State

Figure 8.8.1-4 contains the Trophic State Index (TSI) values for Irving Lake. These TSI values are calculated using summer near-surface total phosphorus, chlorophyll-*a*, and Secchi disk transparency data collected as part of this project along with available historical data. In general, the best values to use in assessing a lake's trophic state are chlorophyll-*a* and total phosphorus, as water clarity can be influenced by other factors other than phytoplankton such as dissolved organic compounds. The closer the calculated TSI values are for these three parameters are to one another indicates a higher degree of correlation.

The weighted TSI values for total phosphorus and chlorophyll-*a* (and Secchi disk transparency) in Irving Lake indicate the lake is at present in a eutrophic state. Irving Lake's productivity is just slightly higher when compared to other shallow headwater drainage lakes in Wisconsin and all lake types within the NLF ecoregion.

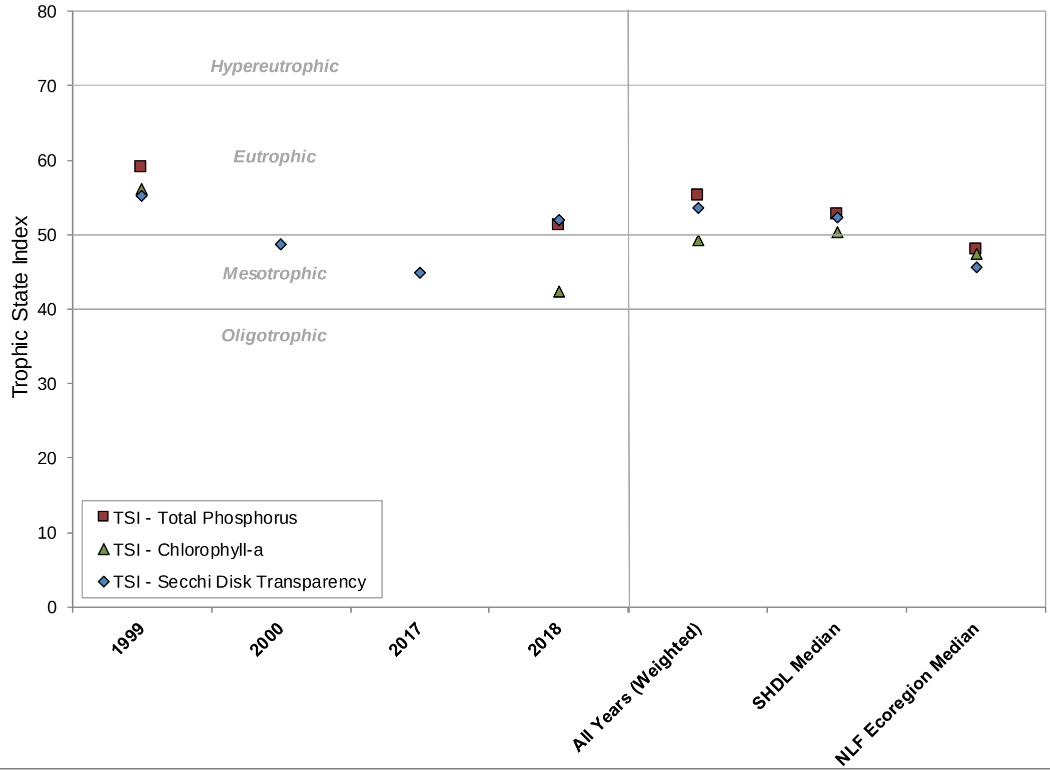


Figure 8.8.1-4. Irving Lake, statewide shallow lowland drainage lakes, and regional Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Dissolved Oxygen and Temperature in Irving Lake

Dissolved oxygen and temperature were measured during water quality sampling visits to Irving Lake by Onterra staff. Profiles depicting these data are displayed in Figure 8.8.1-5.

Irving Lake is *polymictic* [lakes that are too shallow to thermally stratify and can mix throughout the growing season] and the temperature at the bottom was over 20°C in July 2018, indicating that the lake frequently mixes (Figure 8.8.1-5).

The profile on February 20, 2019 indicated that oxygen levels throughout the lake were below 2.0 mg/L which suggests that the lake is subject to a winter fishkill. This is the result of the lake's shallow depth and abundance of macrophytes which as they decay remove oxygen from the water column. Fortunately fish are able to sense when oxygen levels are getting low, and in the case of Irving Lake, likely move downstream to Ballard Lake.

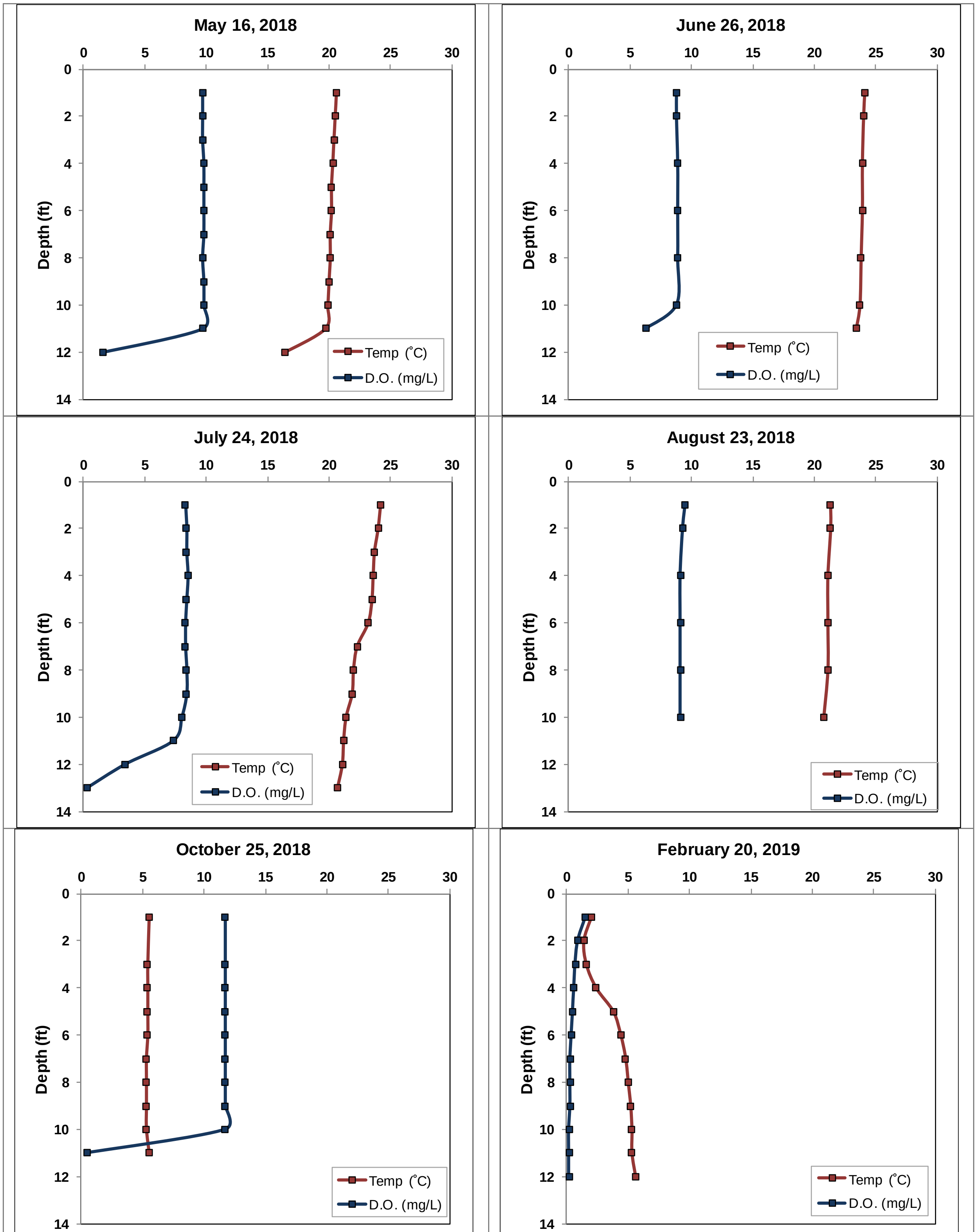


Figure 8.8.1-5. Irving Lake 2018-2019 dissolved oxygen and temperature profiles.

8.8.2 Irving Lake Watershed Assessment

Irving Lake's watershed encompasses an area of approximately 1,233 acres, yielding a very small watershed to lake area ratio of 2:1 (Figure 8.7.2-1, Irving Lake– Map 2). According to WiLMS modeling, the lake's water residence time is 1.7 years, meaning the lake water is replaced approximately 0.6 times per year (flushing rate).

Approximately 35% of Irving Lake's watershed is composed of the lake's surface, 32% of wetlands, 30% of forest, 3% of pasture/grass, and <1% of shoreland development (Figure 8.8.2-1).

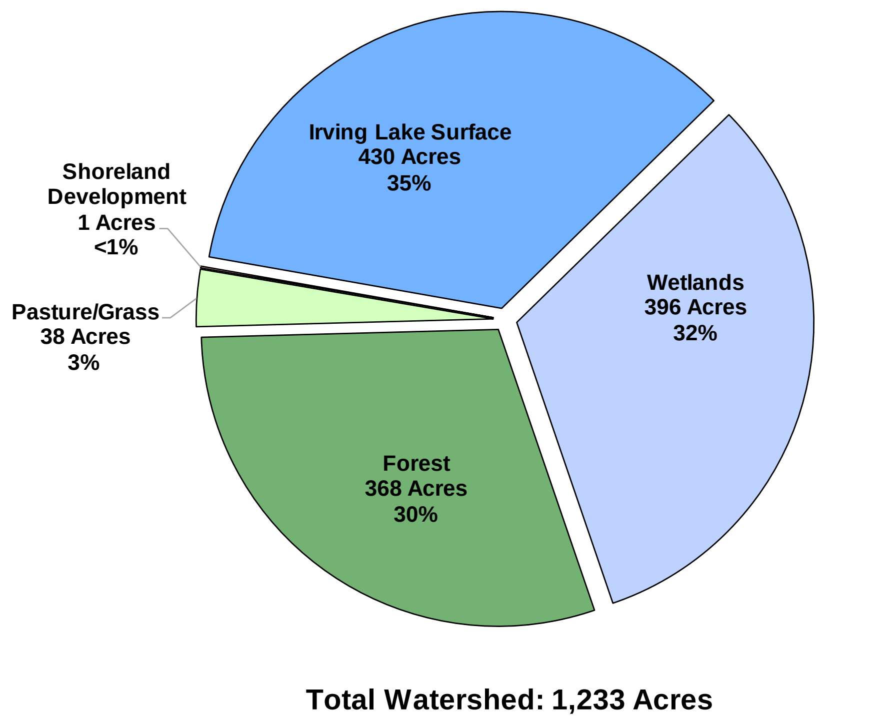


Figure 8.8.2-1. Irving Lake watershed land cover types in acres. Based upon National Land Cover Database (NLCD – Fry et. al 2011).

Using the land cover data described above, WiLMS was utilized to estimate the annual potential phosphorus load from Irving Lake's watershed. It was estimated that approximately 183 pounds of phosphorus is delivered to Irving Lake from its watershed on an annual basis (Figure 8.8.2-2).

Of the estimated 183 pounds of phosphorus being delivered annually to Irving Lake, 115 pounds (63%) is estimated to originate from direct atmospheric deposition into the lake, 35 pounds (19%) from wetlands, 22 pounds (12%) from forest, and 11 pounds (6%) from pasture/grass (Figure 8.8.2-2).

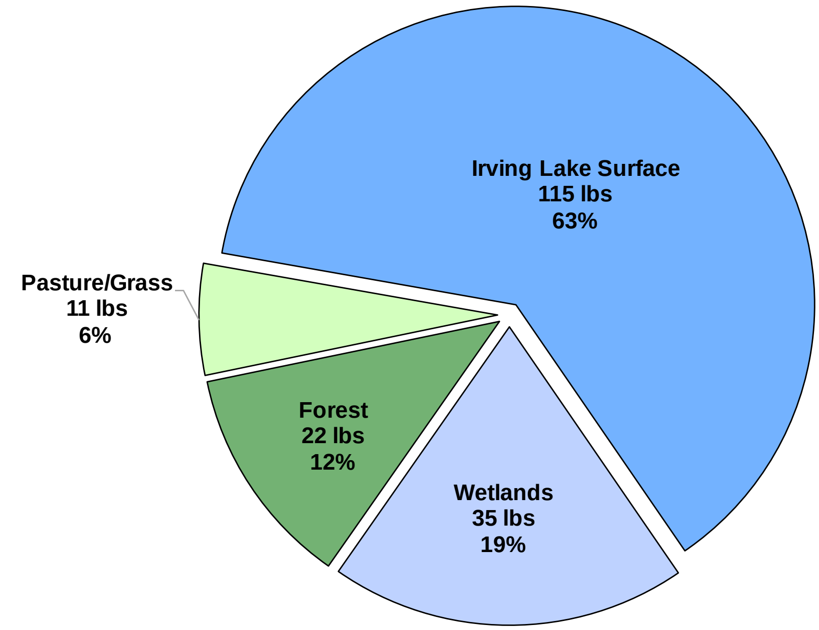


Figure 8.8.2-2. Irving Lake watershed phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

Using predictive equations, WiLMS estimated that based on the 183 pounds of phosphorus which are loaded to Irving Lake annually, the lake should have an in-lake growing season mean (GSM) total phosphorus concentration of approximately 27 µg/L. This predicted GSM total phosphorus concentration is higher than the measured GSM concentration of 23 µg/L. The discrepancy between predicted and measured total phosphorus concentrations likely means that either less phosphorus is entering the lake than estimated or that some of the phosphorus is being incorporated into the macrophytes, e.g. wild rice. The latter is most likely the reason since Irving Lake has a substantial wild rice population most years. There is a significant benthic algal community associated with the rice which would remove phosphorus from the water column.

8.8.3 Irving Lake Shoreland Condition

Shoreland Development

As mentioned previously in the Town-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 the fall of 2018, Irving Lake's immediate shoreline was assessed in terms of its development. Irving Lake has stretches of shoreland that fit all of the five shoreland assessment categories. In all, 4.2 miles of natural/undeveloped and developed-natural shoreline were observed during the survey (Figure 8.8.3-1). This constitutes about 99% of Irving 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, <0.01 miles of urbanized and developed–unnatural shoreline (<1%) was observed. If restoration of the Irving 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. Irving Lake - Map 3 displays the location of these shoreline lengths around the entire lake.

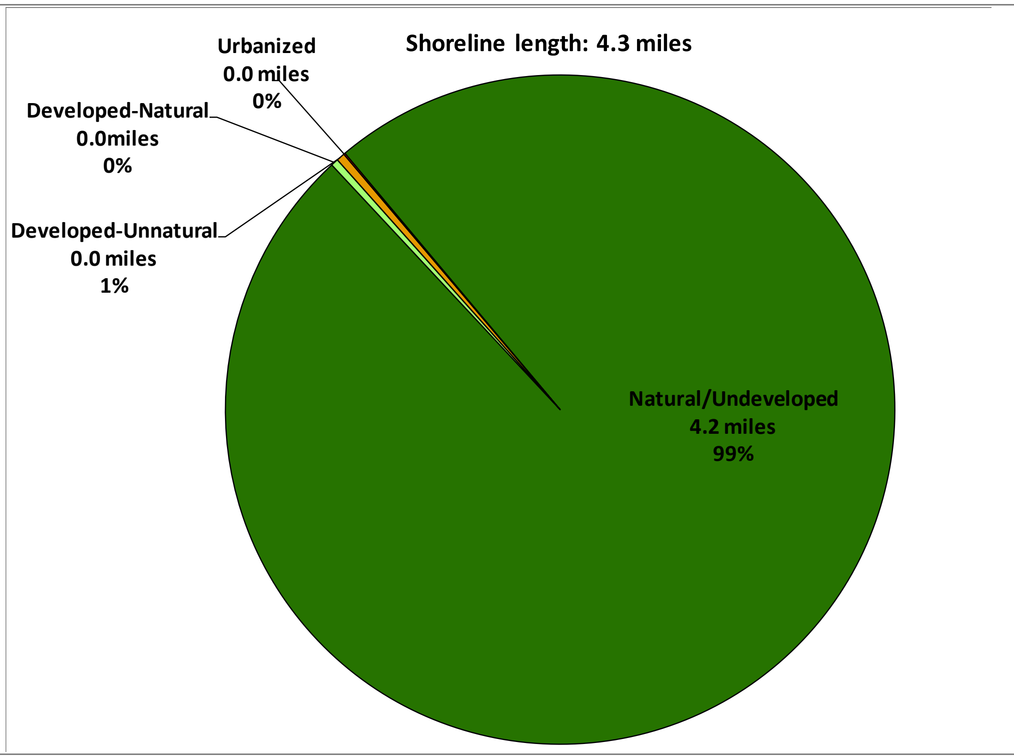


Figure 8.8.3-1. Irving Lake shoreland categories and total lengths. Based upon a fall 2018 survey. Locations of these categorized shorelands can be found on Irving Lake - Map 3.

Coarse Woody Habitat

A survey for coarse woody habitat was conducted in conjunction with the shoreland assessment (development) survey. Coarse woody habitat was identified, and classified in three size categories (2-8 inches in diameter, >8 inches in diameter, and cluster 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, 142 total pieces of coarse woody habitat were observed along 4.2 miles of shoreline (Irving Lake - Map 4), which gives Irving Lake a coarse woody habitat to shoreline mile ratio of 33:1 (Figure 8.8.3-2). Only instances where emergent coarse woody habitat extended from shore into the water were recorded during the survey. Of the 142 total pieces of coarse woody habitat observed during the survey, 83 pieces were 2-8 inches in diameters, 59 were 8 inches in diameter or greater, and no clusters of pieces 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 Irving 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 Irving Lake fell just below the 75th percentile of these 98 lakes (Figure 8.8.3-2).

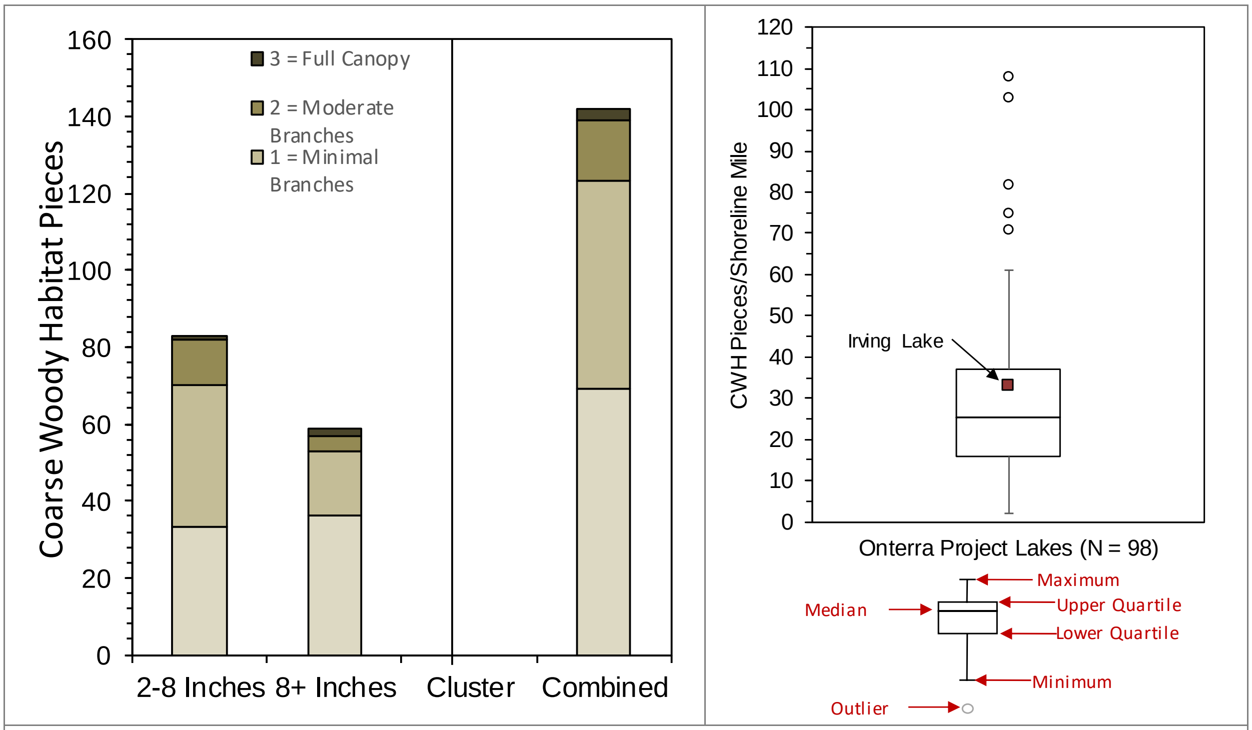


Figure 8.8.3-2. Irving Lake coarse woody habitat survey results. Based upon a fall 2018 survey. Locations of Irving Lake coarse woody habitat can be found on Irving Lake - Map 4.

8.8.4 Irving Lake Aquatic Vegetation

An Early-Season Aquatic Invasive Species (ESAIS) Survey was conducted by Onterra ecologists on Irving Lake on June 27, 2018. While the intent of this survey is to locate any potential non-native species within the lake, the primary focus is to locate potential occurrences of the non-native curly-leaf pondweed, which should be at or near its peak growth at this time. No aquatic invasive species were located during this survey.

Photograph 8.5.4-1. Irving Lake

The whole-lake aquatic plant point-intercept survey was conducted on Irving Lake by Onterra ecologists on July 23, 2018. The emergent and floating-leaf aquatic plant community mapping survey was completed by Onterra on July 25-26, 2018. During these surveys, a total of 46 native aquatic plant species were located (Table 8.8.4-1). No exotic plants were found during the survey.

As discussed in the primer section, sediment data were collected at each sampling location within the littoral zone during the point-intercept survey. Approximately 98% of the point-intercept locations within littoral areas contained fine, organic sediments (muck) and 2% contained sand (Figure 8.8.4-1). The only areas containing sand were in shallow areas along the northern shoreline of the lake (Irving Lake - Map 5). Much of the southern and eastern shoreline areas were non-navigable due to the abundance of emergent and floating-leaf plants. Like terrestrial plants, different aquatic plant species are adapted to grow in certain substrate types; some species are only found growing in mucky substrates, others only in sandy areas, and some can be found growing in either. Lakes that have varying substrate types generally support a higher number of plant species because the different habitat types that are available.

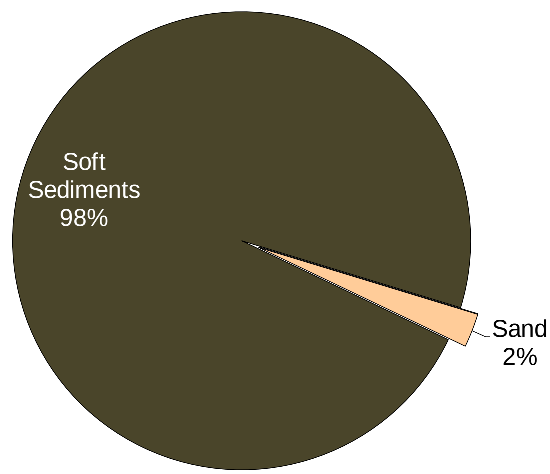


Figure 8.8.4-1. Irving Lake 2018 proportion of substrate types. Created from data collected during the 2018 whole-lake point-intercept survey (N = 294).

Table 8.8.4-1. List of aquatic plant species located in Irving Lake during Onterra 2018 aquatic plant surveys.

Irving Lake

Growth Form	Scientific Name	Common Name	Coefficient of Conservatism (C)	2018 (Onterra)
Emergent	*Calla palustris*	Water arum	9	I
	Carex aquatilis	Long-bracted tussock sedge	7	I
	Carex comosa	Bristly sedge	5	I
	Carex pseudocyperus	Cypress-like sedge	8	I
	Carex utriculata	Common yellow lake sedge	7	I
	Dulichium arundinaceum	Three-way sedge	9	I
	Iris sp.	Iris sp.	N/A	I
	Juncus effusus	Soft rush	4	I
	Pontederia cordata	Pickerelweed	9	X
	Sagittaria latifolia	Common arrowhead	3	I
	Scirpus cyperinus	Wool grass	4	I
	Sparganium androcladum	Shining bur-reed	8	I
	Typha spp.	Cattail spp.	1	I
	Zizania spp.	Wild rice sp.	8	I
	Zizania palustris	Northern wild rice	8	X
FL	*Brasenia schreberi*	Watershield	7	X
	Nuphar variegata	Spatterdock	6	I
	Nymphaea odorata	White water lily	6	X
	Persicaria amphibia	Water smartweed	5	I
	Sparganium angustifolium	Narrow-leaf bur-reed	9	I
Submergent	*Bidens beckii*	Water marigold	8	X
	Ceratophyllum demersum	Coontail	3	X
	Chara spp.	Muskgrasses	7	X
	Elodea canadensis	Common waterweed	3	X
	Myriophyllum sibiricum	Northern watermilfoil	7	X
	Nitella spp.	Stoneworts	7	X
	Najas flexilis	Slender naiad	6	X
	Potamogeton epihydrus	Ribbon-leaf pondweed	8	X
	Potamogeton natans	Floating-leaf pondweed	5	X
	Potamogeton strictifolius	Stiff pondweed	8	X
	Potamogeton obtusifolius	Blunt-leaved pondweed	9	X
	Potamogeton gramineus	Variable-leaf pondweed	7	X
	Potamogeton pusillus	Small pondweed	7	X
	Potamogeton praelongus	White-stem pondweed	8	X
	Potamogeton amplifolius	Large-leaf pondweed	7	X
	Potamogeton robbinsii	Fern-leaf pondweed	8	X
	Potamogeton zosteriformis	Flat-stem pondweed	6	X
	Utricularia intermedia	Flat-leaf bladderwort	9	X
	Utricularia vulgaris	Common bladderwort	7	X
	Utricularia gibba	Creeping bladderwort	9	X
	Vallisneria americana	Wild celery	6	X
S/E	*Comarum palustre*	Marsh cinquefoil	N/A	I
	Eleocharis acicularis	Needle spikerush	5	X
	Juncus pelocarpus	Brown-fruited rush	8	X
	Sagittaria graminea	Grass-leaved arrowhead	9	I
	Schoenoplectus subterminalis	Water bulrush	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

Of the 292 point-intercept sampling locations that fell at or below the maximum depth of plant growth in 2018, approximately 47% contained aquatic vegetation. Irving Lake – Map 6 displays the point-intercept locations that contained aquatic vegetation in 2018, and the total rake fullness ratings at those locations. Thirty-nine percent of the point-intercept locations had a total rake fullness (TRF) rating of 1, 5% had a total rake fullness rating of 2, and 3% had the highest total rake fullness rating of 3 (Figure 8.8.4-2). Fifty-three percent of the littoral zone had no vegetation. The large percentage of sampling points that had either no vegetation or the lowest TRF rating of 1 means that where plants are found on Irving Lake, they are very sparse.

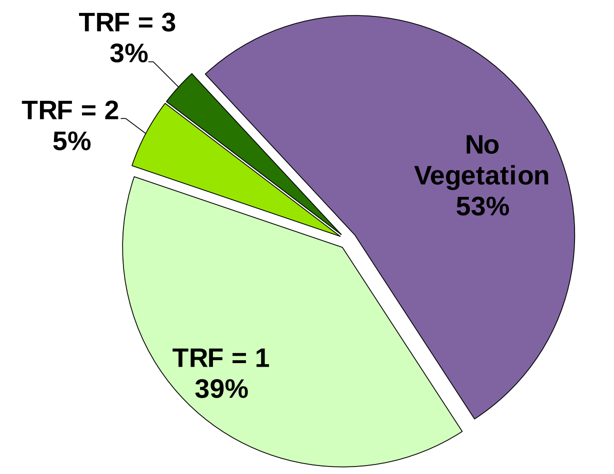


Figure 8.8.4-2. Irving Lake 2018 aquatic vegetation total rake fullness ratings (TRF). Created from data collected during the 2018 whole-lake point-intercept survey (N = 292).

Of the 46 native aquatic plant species located in Irving Lake in 2018, 28 were encountered directly on the rake (Figure 8.8.4-3). The remaining 18 plants were located incidentally, meaning they were observed by Onterra ecologists while on the lake but they were not directly sampled on the rake at any of the point-intercept sampling locations. Incidental species typically include emergent and floating-leaf species that are often found growing on the fringes of the lake and submersed species that are relatively rare within the plant community. Of the 28 species directly sampled with the rake during the point-intercept survey, slender naiad, wild celery, flat-stem pondweed, and common waterweed were the four most frequently encountered plants, respectively (Figure 8.8.4-3).

Slender naiad, the most abundant aquatic plant in Irving Lake in 2018 with a littoral occurrence of 17% (Figure 8.8.4-3), is one of three native naiads that can be found in Wisconsin. Being an annual, it produces numerous seeds on an annual basis and is considered to be one of the most important food sources for a number of migratory waterfowl species (Borman et al. 1997). In addition, slender naiad's small, condensed network of leaves provide excellent habitat for aquatic invertebrates.

Wild celery, the second most abundant aquatic plant in Irving Lake in 2018 with a littoral occurrence of 8% (Figure 8.8.4-3), has bundles of long submersed leaves that are flat and ribbon-like which emerge from a basal rosette and provide excellent structural habitat for aquatic organisms. Spreading rapidly via rhizomes, wild celery is often found growing in large colonies where their extensive root systems stabilize bottom sediments. In mid- to late-summer, the coiled flower stalks of wild celery can be observed at or near the surface, and following pollination, large banana-shaped seed pods can also be seen. These seed pods have been shown to be an important food source for waterfowl (Borman et al. 1997).

Flat-stem pondweed was the third most abundant aquatic plant in Irving Lake in 2018 with a littoral occurrence of just under 6% (Figure 8.8.4-3). Flat-stem pondweed is often more abundant in productive lakes with soft sediments. Flat-stem pondweed, as its name implies, can be distinguished from other pondweeds by its conspicuously flattened stem.

Common waterweed was the fourth most abundant aquatic plant encountered in Irving Lake in 2018, with a littoral occurrence of approximately 5% (Figure 8.8.4-3). Common waterweed is found throughout lakes in Wisconsin and North America and are often dominant in areas with soft sediments. Its dense foliage provides valuable aquatic habitat while its ability to derive nutrients directly from the water aid in improving water quality.

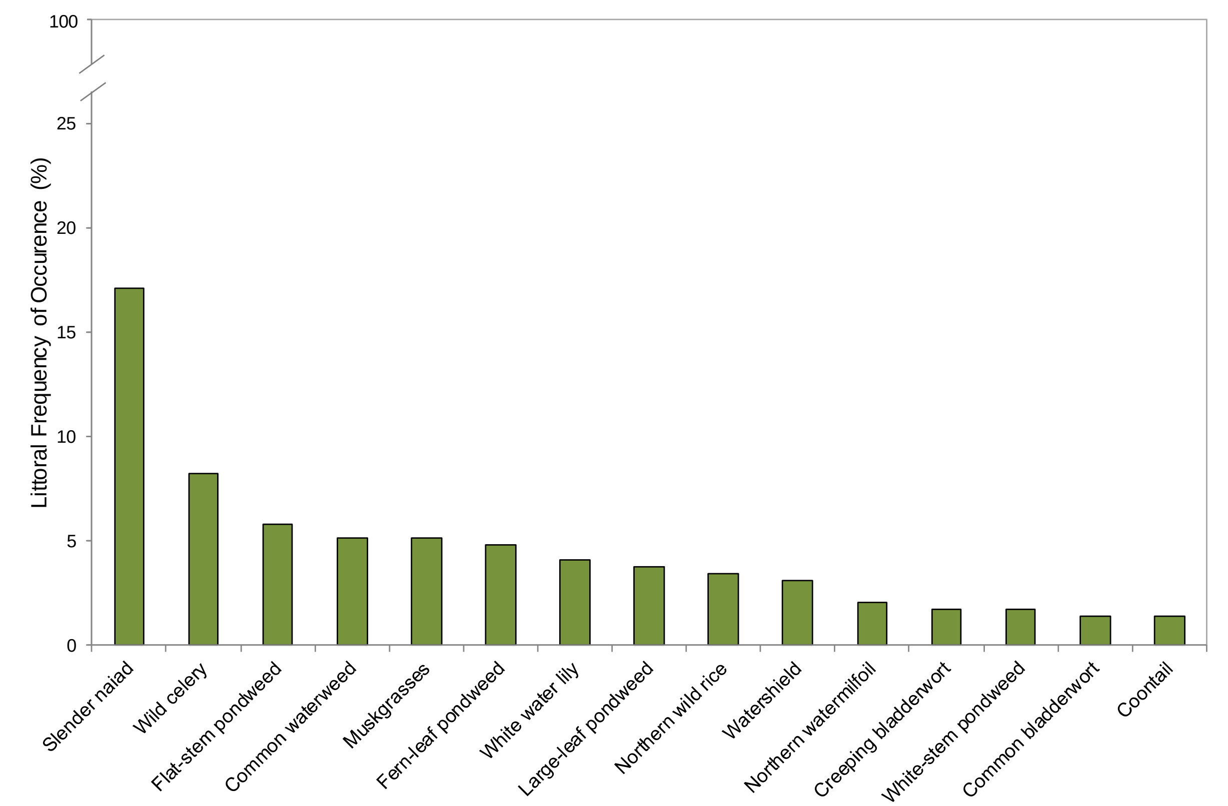


Figure 8.8.4-3. Irving Lake 2018 littoral frequency of occurrence of aquatic plant species. Created using data from 2018 whole-lake point-intercept survey. Only species with an LFOO of at least 1% are shown.

As discussed in the Town-wide section, the calculations used to create the Floristic Quality Index (FQI) for a lake's aquatic plant community are based on the aquatic plant species that were encountered on the rake during the point-intercept survey and do not include incidental species. The native species encountered on the rake during the 2018 point-intercept survey and their conservatism values were used to calculate the FQI of Irving Lake's aquatic plant community (equation shown below).

$$\text{FQI} = \text{Average Coefficient of Conservatism} * \sqrt{\text{Number of Native Species}}$$

Figure 8.5.4-4 compares 2018 FQI components of Irving Lake to median values of lakes within the Northern Lakes and Forests (NLF) ecoregion and lakes throughout Wisconsin. The number of native aquatic plant species encountered on the rake, or native species richness, was 28 for the 2018 survey. Irving Lake's species richness is above the median value for lakes within the ecoregion and the state.

Irving Lake's average conservatism in 2018 was 7.0 (Figure 8.8.4-4). Irving Lake's average conservatism is slightly higher than the median values for lakes in the ecoregion and throughout Wisconsin, which indicates Irving Lake's aquatic plant community contains a higher than average number of aquatic plants that are considered to be sensitive to environmental degradation and require high-quality habitats. Given Irving Lake's higher native species richness and conservatism values from 2018, Irving Lake has a higher Floristic Quality Index value of 37.2. This FQI value is above the median values for lakes in the ecoregion and the state, and indicates that Irving Lake's aquatic plant community is of higher quality than the majority of lakes throughout Wisconsin.

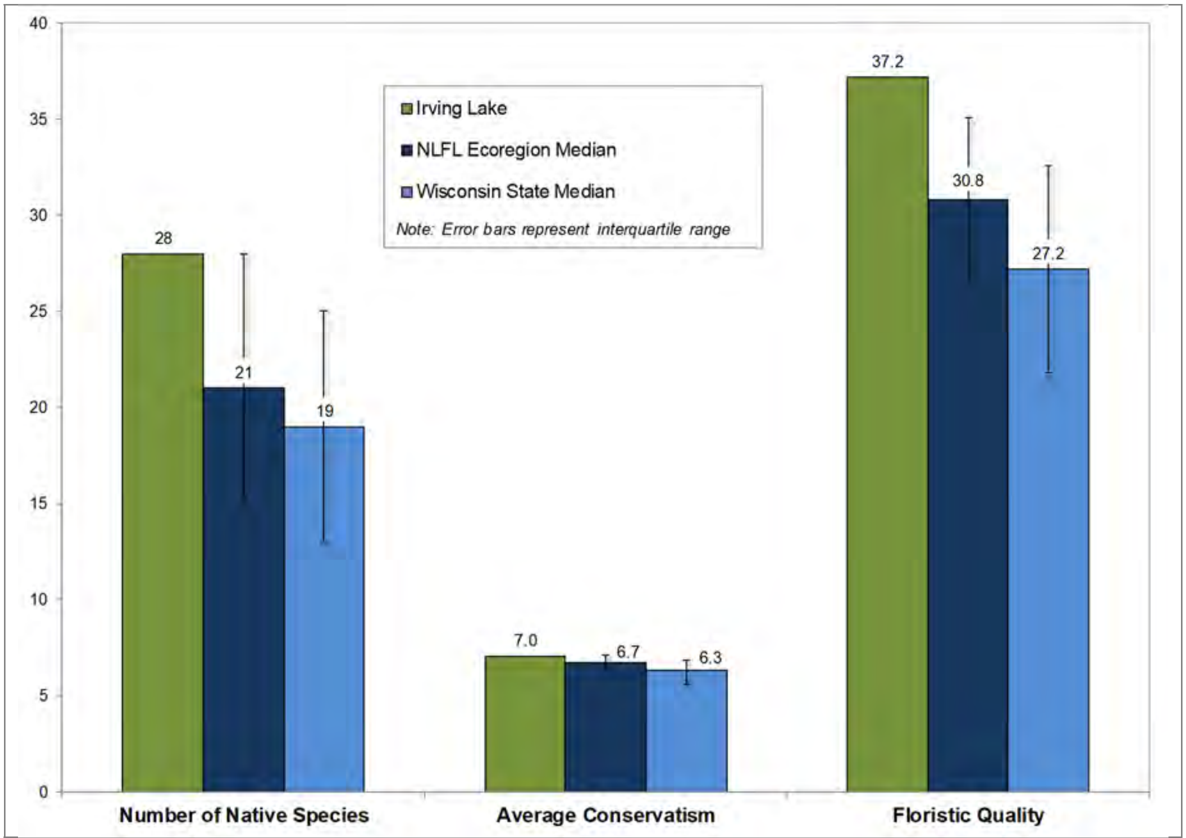


Figure 8.8.4-4. Irving Lake Floristic Quality Assessment. Created using data from Onterra 2018 whole-lake point-intercept survey. Analysis follows Nichols (1999).

As explained in the Town-wide section, lakes with diverse aquatic plant communities have higher resilience to environmental disturbances and greater resistance to invasion by non-native plants. In addition, a plant community with a mosaic of species with differing morphological attributes provides zooplankton, macroinvertebrates, fish, and other wildlife with diverse structural habitat and various sources of food. Because Irving Lake contains a higher number of native aquatic plant species, one may assume the aquatic plant community has high species diversity. However, species diversity is also influenced by how evenly the plant species are distributed within the community.

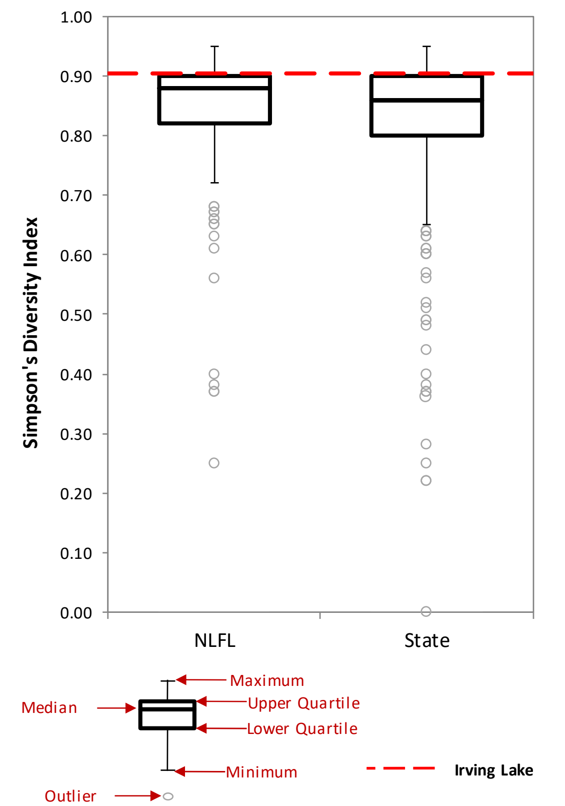


Figure 8.8.4-5. Irving Lake species diversity index. Created using data from the Onterra 2018 point-intercept survey.

While a method for characterizing diversity values of fair, poor, etc. does not exist, lakes within the same ecoregion may be compared to provide an idea of how Irving Lake's diversity value ranks. Using data collected by Onterra and WDNR Science Services, quartiles were calculated for 212 lakes within the NLF ecoregion (Figure 8.8.4-5). Using the data collected from the 2018 point-intercept survey, Irving Lake's aquatic plant community is shown to have a slightly higher than average species diversity with a Simpson's Diversity Index value of 0.90. In other words, if two individual aquatic plants were randomly sampled from Irving Lake in 2018, there would be a 90% probability that they would be different species. This diversity value falls just above the median for the ecoregion and above the median for lakes throughout the state.

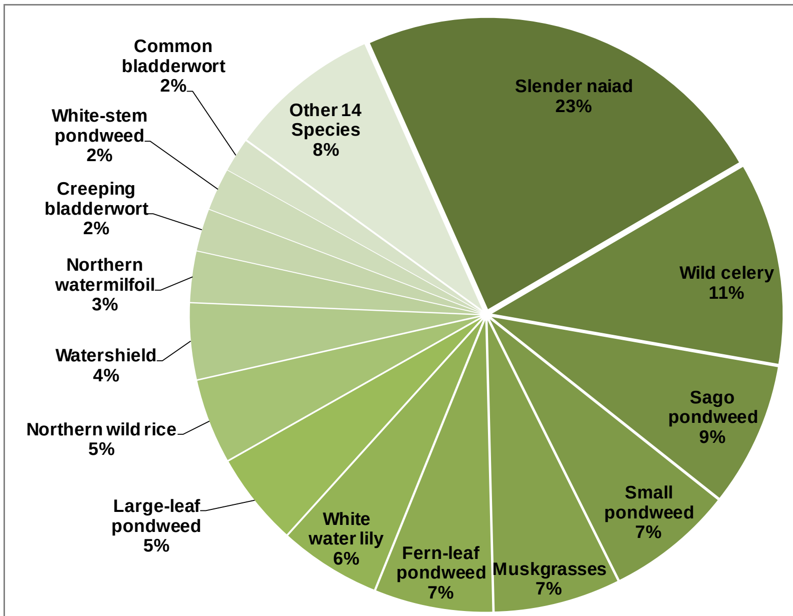


Figure 8.8.4-6. Irving Lake 2018 relative frequency of occurrence of aquatic plant species. Created using data from 2018 point-intercept survey.

One way to visualize Irving Lake's species diversity is to look at the relative occurrence of aquatic plant species. Figure 8.8.4-6 displays the relative frequency of occurrence of aquatic plant species created from the 2018 whole-lake point-intercept survey and illustrates the relatively even distribution of aquatic plant species within the community. A plant community that is dominated by just a few species yields lower species diversity. 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 slender naiad was found at 17% of the littoral sampling locations in Irving Lake in 2018, its relative frequency of occurrence is 23%. Explained another way, if 100 plants were randomly sampled from Irving Lake in 2018, 23 of them would be slender naiad.

In 2018, Onterra ecologists also conducted a survey aimed at mapping emergent and floating-leaf aquatic plant communities in Irving Lake. This survey revealed Irving Lake contains approximately 151 acres of these communities comprised of 18 different aquatic plant species (Irving Lake – Map 7 and Table 8.8.4-2). This accounts for about 35% of the lake surface area. These native emergent and floating-leaf plant communities provide valuable fish and wildlife habitat that is important to the ecosystem of the lake. These areas are particularly important during times of fluctuating water levels, since structural habitat of fallen trees and other forms of course-woody habitat can be quite sparse along the shores of receding water lines.

The community map represents a ‘snapshot’ of the important emergent and floating-leaf plant communities, and a replication of this survey in the future will provide a valuable understanding of the dynamics of these communities within Irving Lake. This is important, because these communities are often negatively affected by recreational use and shoreland development.

Table 8.8.4-2. Irving Lake 2018 acres of emergent and floating-leaf aquatic plant communities. Created using data from 2018 aquatic plant community mapping survey.

Plant Community	Acres
Emergent	0.2
Floating-leaf	0.4
Mixed Emergent & Floating-leaf	150.6
Total	**151.3**

8.8.5 Aquatic Invasive Species in Irving Lake

As is discussed in section 2.0 Stakeholder Participation, the lake stakeholders were asked about aquatic invasive species (AIS) and their presence in Irving Lake within the anonymous stakeholder survey. The WDNR lists one invasive species as *observed* within Irving Lake (Table 8.8.5-1). The *observed* status means that the species has either not been verified by a taxonomic expert, or the species does not have an established population.

Table 8.8.5-1. AIS present within Irving Lake

Type	Common name	Scientific name	Location within the report
Invertebrates	Banded Mystery Snail	*Viviparus georgianus*	Section 8.8.5 - Below

More information on these invasive species or any other AIS can be found at the following links:

- http://dnr.wi.gov/topic/invasives/
- https://nas.er.usgs.gov/default.aspx
- https://www.epa.gov/greatlakes/invasive-species

Aquatic Animals

Mystery snails

There are two types of mystery snails found within Wisconsin waters, the Chinese mystery snail (*Cipangopaludina chinensis*) and the banded mystery snail (*Viviparus georgianus*). Both snails can be identified by their large size, thick hard shell and hard operculum (a trap door that covers the snail's soft body). These traits also make them less edible to native predators. These species thrive in eutrophic waters with very little flow. They are bottom-dwellers eating diatoms, algae and organic and inorganic bottom materials. One study conducted in northern Wisconsin lakes found that the Chinese mystery snail did not have strong negative effects on native snail populations (Solomon et al. 2010). However, researchers did detect negative impacts to native snail communities when both Chinese mystery snails and the rusty crayfish were present (Johnson et al. 2009). Banded mystery snails were given the *observed* status in Irving Lake in 2017.

8.8.6 Irving 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 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 Irving 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 Steve Gilbert (WDNR 2019 & GLIFWC 2018).

Irving Lake Fishery

Energy Flow of a Fishery

When examining the fishery of a lake, it is important to remember what drives that fishery, or what is responsible for determining its mass and composition. The gamefish in Irving Lake are supported by an underlying food chain. At the bottom of this food chain are the elements that fuel algae and plant growth – nutrients such as phosphorus and nitrogen, and sunlight. The next tier in the food chain belongs to zooplankton, which are tiny crustaceans that feed upon algae and plants, and insects. Smaller fish called planktivores feed upon zooplankton and insects, and in turn become food for larger fish species. The species at the top of the food chain are called piscivores and are the larger gamefish that are often sought after by anglers, such as bass and walleye.

A concept called energy flow describes how the biomass of piscivores is determined within a lake. Because algae and plant matter are generally small in energy content, it takes an incredible amount of this food type to support a sufficient biomass of zooplankton and insects. In turn, it takes a large biomass of zooplankton and insects to support planktivorous fish species. And finally, there must be a large planktivorous fish community to support a modest piscivorous fish community. Studies have shown that in natural ecosystems, it is largely the amount of primary productivity (algae and plant matter) that drives the rest of the producers and consumers in the aquatic food chain. This relationship is illustrated in Figure 8.8.6-1.

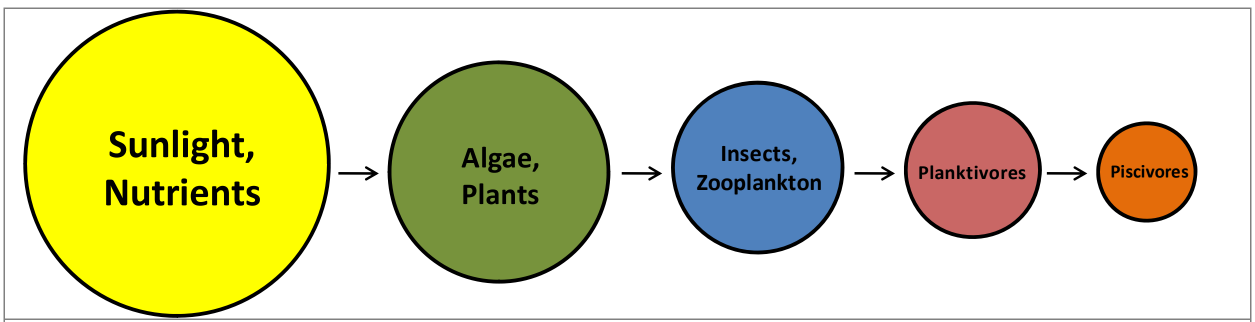


Figure 8.8.6-1. Aquatic food chain. Adapted from Carpenter et. al 1985.

As discussed in the Water Quality section, Irving Lake is a eutrophic system, meaning it has high nutrient content and thus relatively high primary productivity. Simply put, this means Irving Lake should be able to support sizable populations of predatory fish (piscivores) because the supporting food chain is relatively robust. Table 8.8.6-1 shows the popular game fish present in the system.

Table 8.8.6-1. Gamefish present in Irving Lake with corresponding biological information (Becker, 1983).

Common Name (*Scientific Name*)	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Black Crappie (*Pomoxis nigromaculatus*)	7	May - June	Near *Chara* or other vegetation, over sand or fine gravel	Fish, cladocera, insect larvae, other invertebrates
Bluegill (*Lepomis macrochirus*)	11	Late May - Early August	Shallow water with sand or gravel bottom	Fish, crayfish, aquatic insects and other invertebrates
Largemouth Bass (*Micropterus salmoides*)	13	Late April - Early July	Shallow, quiet bays with emergent vegetation	Fish, amphipods, algae, crayfish and other invertebrates
Muskellunge (*Esox masquinongy*)	30	Mid April - Mid May	Shallow bays over muck bottom with dead vegetation, 6 - 30 in.	Fish including other muskies, small mammals, shore birds, frogs
Northern Pike (*Esox lucius*)	25	Late March - Early April	Shallow, flooded marshes with emergent vegetation with fine leaves	Fish including other pike, crayfish, small mammals, water fowl, frogs
Pumpkinseed (*Lepomis gibbosus*)	12	Early May - August	Shallow warm bays 0.3 - 0.8 m, with sand or gravel bottom	Crustaceans, rotifers, mollusks, flatworms, insect larvae (terrestrial and aquatic)
Rock Bass (*Ambloplites rupestris*)	13	Late May - Early June	Bottom of course sand or gravel, 1 cm - 1 m deep	Crustaceans, insect larvae, and other invertebrates
Smallmouth Bass (*Micropterus dolomieu*)	13	Mid May - June	Nests more common on north and west shorelines over gravel	Small fish including other bass, crayfish, insects (aquatic and terrestrial)
Walleye (*Sander vitreus*)	18	Mid April - Early May	Rocky, wavewashed shallows, inlet streams on gravel bottoms	Fish, fly and other insect larvae, crayfish
Yellow Perch (*Perca flavescens*)	13	April - Early May	Sheltered areas, emergent and submergent veg	Small fish, aquatic invertebrates

Photograph 8.8.6-1. Fyke net positioned in the littoral zone of a Wisconsin Lake (left) and an electroshocking boat (right).

Fish Stocking

To assist in meeting fisheries management goals, the WDNR may permit the stocking of fry, fingerling or adult fish in a waterbody that were raised in permitted hatcheries (Photograph 8.8.6-2). 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. Irving Lake has been stocked from 1974 to 2013 with walleye and muskellunge (Table 8.8.6-2).

Photograph 8.8.6-2. Fingerling Muskellunge.

Table 8.8.6-2. Stocking data available for Irving Lake (1974-2013).

Year	Species	Strain (Stock)	Age Class	# Fish Stocked	Avg Fish Length (in)
1990	Muskellunge	Unspecified	Fingerling	350	11
1988	Muskellunge	Unspecified	Fingerling	300	10.5
1985	Muskellunge	Unspecified	Fingerling	800	12
1984	Muskellunge	Unspecified	Fingerling	490	11
1982	Muskellunge	Unspecified	Fingerling	800	13
1977	Muskellunge	Unspecified	Fingerling	400	9
1976	Muskellunge	Unspecified	Fingerling	375	11
1973	Muskellunge	Unspecified	Fingerling	2,000	3
1997	Muskellunge	Unspecified	Fry	64,800	0.5
1996	Muskellunge	Unspecified	Fry	100,000	0.5
1973	Muskellunge	Unspecified	Fry	60,000	
2000	Muskellunge	Unspecified	Large Fingerling	800	9.9
1999	Muskellunge	Unspecified	Large Fingerling	400	11.7
1998	Muskellunge	Unspecified	Large Fingerling	800	10.8
1997	Muskellunge	Unspecified	Large Fingerling	800	10.8
2018	Muskellunge	Upper Wisconsin River	Large Fingerling	100	11.6
2017	Muskellunge	Upper Wisconsin River	Large Fingerling	64	10.8
2016	Muskellunge	Upper Wisconsin River	Large Fingerling	100	11.42
2015	Muskellunge	Upper Wisconsin River	Large Fingerling	48	11.7
2014	Muskellunge	Upper Wisconsin River	Large Fingerling	100	11.3
2013	Muskellunge	Upper Wisconsin River	Large Fingerling	100	9.7
1974	Walleye	Unspecified	Fingerling	10,000	3
1978	Walleye	Unspecified	Fingerling	20,000	2
1981	Walleye	Unspecified	Fingerling	21,500	3
1983	Walleye	Unspecified	Fingerling	17,790	2.5
1985	Walleye	Unspecified	Fingerling	20,440	2
1987	Walleye	Unspecified	Fingerling	60,000	2
1989	Walleye	Unspecified	Fingerling	20,100	2
1991	Walleye	Unspecified	Fingerling	8,127	3
2009	Walleye	Mississippi Headwaters	Small Fingerling	10,980	1.6
2011	Walleye	Mississippi Headwaters	Small Fingerling	14,094	1.8
2013	Walleye	Mississippi Headwaters	Small Fingerling	12,705	2

Fishing Activity

Based on data collected from the stakeholder survey (Appendix B), fishing (open water) was the first most important reason for owning property on or near Ballard, Irving and White Birch Lakes (Question #18). Figure 8.6.6-2 displays the fish that Ballard, Irving and White Birch Lakes stakeholders enjoy catching the most, with muskellunge and walleye being the most popular. Approximately 78% of these same respondents believed that the quality of fishing on the lake was either good or fair (Figure 8.6.6-3). Approximately 69% of respondents who fish Ballard Lake believe the quality of fishing has remained the same or is somewhat worse since they first started fishing the lake (Figure 8.6.6-4).

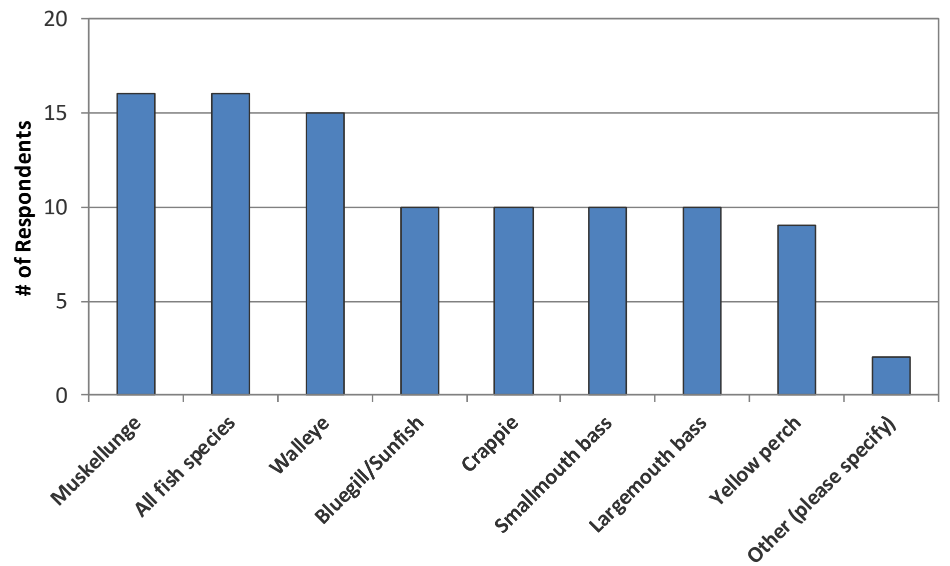


Figure 8.6.6-2. Stakeholder survey response Question #12. *What species of fish do you like to catch on your lake?*

Figure 8.6.6-3. Stakeholder survey response Question #13. *How would you describe the current quality of fishing on your lake?*

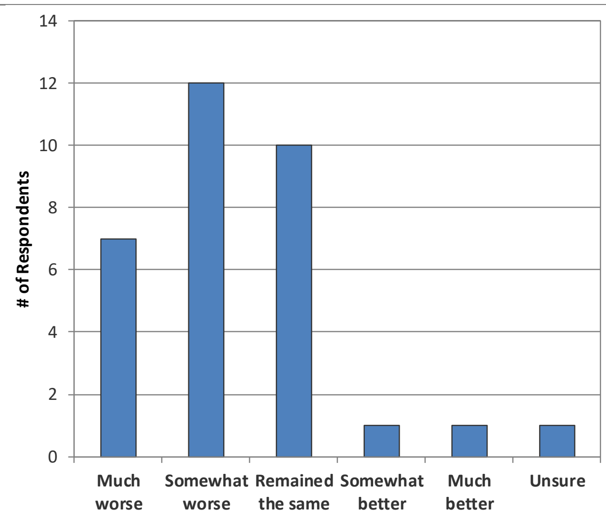


Figure 8.6.6-4. Stakeholder survey response Question #14. *How has the quality of fishing changed on your lake since you started fishing the lake?*

Irving Lake Spear Harvest Records

Approximately 22,400 square miles of northern Wisconsin was ceded to the United States by the Lake Superior Chippewa tribes in 1837 and 1842 (Figure 8.8.6-5). Irving Lake falls within the ceded territory based on the Treaty of 1842. This allows for a regulated open water spear fishery by Native Americans on lakes located within the Ceded Territory.

While within the ceded territory, Irving Lake has only experienced a spearfishing harvest in 2013 which resulted in four muskellunge and one walleye.

Figure 8.8.6-5. Location of Irving Lake within the Native American Ceded Territory (GLIFWC 2017). This map was digitized by Onterra; therefore, it is a representation and not legally binding.

Irving Lake Fish Habitat

Substrate Composition

Just as forest wildlife require proper trees and understory growth to flourish, fish require certain substrates and habitat types to nest, spawn, escape predators, and search for prey. Lakes with primarily a silty/soft substrate, many aquatic plants, and coarse woody debris may produce a completely different fishery than lakes that are largely sandy/rocky, and contain few aquatic plant species or coarse woody habitat.

Substrate and habitat are critical to fish species that do not provide parental care to their eggs. Northern pike is one species that does not provide parental care to its eggs (Becker 1983). Northern pike broadcast their eggs over woody debris and detritus, which can be found above sand or muck. This organic material suspends the eggs above the substrate, so the eggs are not buried in sediment and suffocate as a result. Walleye are another species that does not provide parental care to its eggs. Walleye preferentially spawn in areas with gravel or rock in places with moving water or wave action, which oxygenates the eggs and prevents them from getting buried in sediment. Fish that provide parental care are less selective of spawning substrates. Species such as bluegill tend to prefer a harder substrate such as rock, gravel or sandy areas if available, but have been found to spawn and care for their eggs in muck as well.

According to the point-intercept survey conducted by Onterra in 2017, 98% of the substrate sampled in the littoral zone of Irving Lake were soft sediments and 2% composed of sand sediments.

Woody Habitat

As discussed in the Shoreland Condition Section, the presence of coarse woody habitat is important for many stages of a fish's life cycle, including nesting or spawning, escaping predation as a juvenile, and hunting insects or smaller fish as an adult. Unfortunately, as development has increased on Wisconsin lake shorelines in the past century, this beneficial habitat has often been the first to be removed from the natural shoreland zone. Leaving these shoreland zones barren of coarse woody habitat can lead to decreased abundances and slower growth rates in fish (Sass 2009). A fall 2018 survey documented 142 pieces of coarse woody along the shores of Irving Lake, resulting in a ratio of approximately 33 pieces per mile of shoreline.

Fish Habitat Structures

Some fisheries managers may look to incorporate fish habitat structures on the lakebed or littoral areas extending to shore for the purpose of improving fish habitats. These projects are typically conducted on lakes lacking significant coarse woody habitat in the shoreland zone. The "Fish sticks" program, outlined in the WDNR best practices manual, adds trees to the shoreland zone restoring fish habitat to critical near shore areas. Typically, every site has 3 – 5 trees which are partially or fully submerged in the water and anchored to shore (Photograph 8.8.6-3). The WDNR recommends placement of the fish sticks during the winter on ice when possible to prevent adverse impacts on fish spawning or egg incubation periods. The program requires a WDNR permit and can be funded through many different sources including the WDNR, County Land & Water Conservation Departments or partner contributions.

Photograph 8.8.6-3. Examples of fish sticks (left) and half-log habitat structures. (Photos by WDNR)

Fish cribs are a fish habitat structure that is placed on the lakebed. Installing fish cribs may be cheaper than fish sticks; however some concern exists that fish cribs can concentrate fish, which in turn leads to increased predation and angler pressure.

Half-logs are another form of fish spawning habitat placed on the bottom of the lakebed (Photograph 8.8.6-3). Smallmouth bass specifically have shown an affinity for overhead cover when creating spawning nests, which half-logs provide (Wills 2004). If the waterbody is exempt from a permit or a permit has been received, information related to the construction, placement and maintenance of half-log structures are available online.

An additional form of fish habitat structure is spawning reefs. Spawning reefs typically consist of small rubble in a shallow area near the shoreline for mainly walleye habitat. Rock reefs are sometimes utilized by fisheries managers when attempting to enhance spawning habitats for some fish species. However, a 2004 WDNR study of rock habitat projects on 20 northern Wisconsin lakes offers little hope the addition of rock substrate will improve walleye reproduction (WDNR 2004).

Placement of a fish habitat structure in a lake does not require a permit if the project meets certain conditions outlined by the WDNR's checklists available online:

(https://dnr.wi.gov/topic/waterways/Permits/Exemptions.html)

If a project does not meet all of the conditions listed on the checklist, a permit application may be sent in to the WDNR and an exemption requested. The TPL may work with the local WDNR fisheries biologist to determine if the installation of fish habitat structures should be considered in aiding fisheries management goals for Irving Lake.

Regulations

Regulations for Irving Lake gamefish species as of June 2019 are displayed in Table 8.8.6-3. For specific fishing regulations on all fish species, anglers should visit the WDNR website (*www.http://dnr.wi.gov/topic/fishing/regulations/hookline.html)* or visit their local bait and tackle shop to receive a free fishing pamphlet that contains this information.

Table 8.8.6-3. WDNR fishing regulations for Irving Lake (As of June 2019).

Species	Daily bag limit	Length Restrictions	Season
Panfish (bluegill, pumpkinseed, sunfish, crappie and yellow perch)	25	None	Open All Year
Smallmouth bass (Early Season)	Catch and release only	None	May 4, 2019 to June 14, 2019
Largemouth and Smallmouth bass	5	14"	June 15, 2019 to March 1, 2020
Largemouth bass	5	14"	May 4, 2019 to June 14, 2019
Muskellunge and hybrids	1	40"	May 25, 2019 to November 30, 2019
Northern pike	5	None	May 4, 2019 to March 1, 2020
Walleye, sauger, and hybrids	3	The minimum length is 15", but walleye, sauger, and hybrids from 20" to 24" may not be kept, and only 1 fish over 24" is allowed.	May 4, 2019 to March 1, 2020
Bullheads	Unlimited	None	Open All Year

General Waterbody Restrictions: Motor Trolling is allowed with 1 hook, bait, or lure per angler, and 2 hooks, baits, or lures

Mercury Contamination and Fish Consumption Advisories

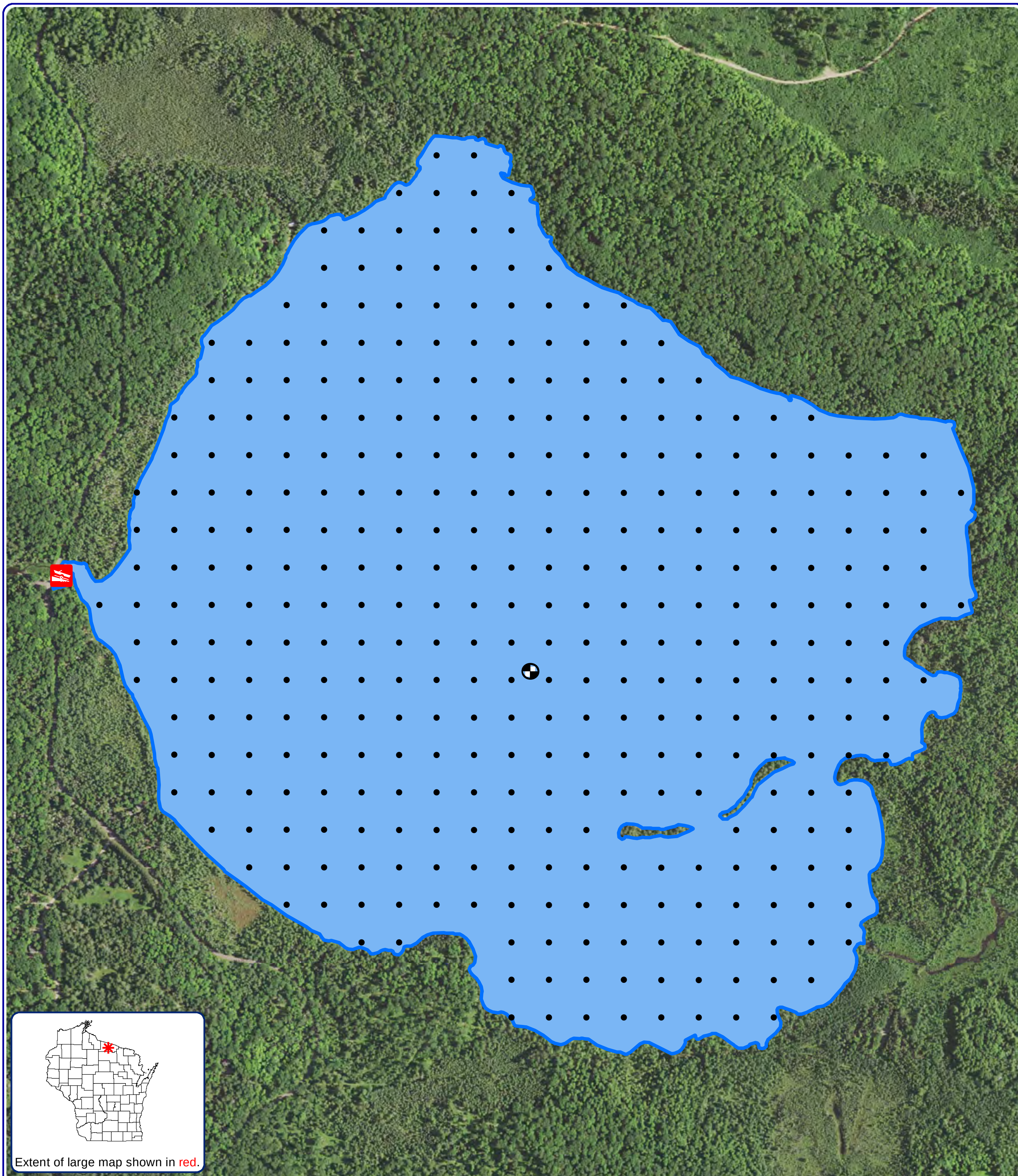
Freshwater fish are amongst the healthiest of choices you can make for a home-cooked meal. Unfortunately, fish in some regions of Wisconsin are known to hold levels of contaminants that are harmful to human health when consumed in great abundance. The two most common contaminants are polychlorinated biphenyls (PCBs) and mercury. These contaminants may be found in very small amounts within a single fish, but their concentration may build up in your body over time if you consume many fish. Health concerns linked to these contaminants range from poor balance and problems with memory to more serious conditions such as diabetes or cancer. These contaminants, particularly mercury, may be found naturally to some degree. However, the majority of fish contamination has come from industrial practices such as coal-burning facilities, waste incinerators, paper industry effluent and others. Though environmental regulations have reduced emissions over the past few decades, these contaminants are greatly resistant to breakdown and may persist in the environment for a long time. Fortunately, the human body is able to eliminate contaminants that are consumed however this can take a long time depending upon the type of contaminant, rate of consumption, and overall diet. Therefore, guidelines are set upon the consumption of fish as a means of regulating how much contaminant could be consumed over time.

General fish consumption guidelines for Wisconsin inland waterways are presented in Figure 8.8.6-6. There is an elevated risk for children as they are in a stage of life where cognitive development is rapidly occurring. As mercury and PCB both locate to and impact the brain, there are greater restrictions on women who may have children or are nursing children, and also for children under 15.

Fish Consumption Guidelines for Most Wisconsin Inland Waterways		
	Women of childbearing age, nursing mothers and all children under 15	**Women beyond their childbearing years and men**
Unrestricted*	-	Bluegill, crappies, yellow perch, sunfish, bullhead and inland trout
1 meal per week	Bluegill, crappies, yellow perch, sunfish, bullhead and inland trout	Walleye, pike, bass, catfish and all other species
1 meal per month	Walleye, pike, bass, catfish and all other species	Muskellunge
Do not eat	Muskellunge	-

**Doctors suggest that eating 1-2 servings per week of low-contaminant fish or shellfish can benefit your health. Little additional benefit is obtained by consuming more than that amount, and you should rarely eat more than 4 servings of fish within a week.*

Figure 8.8.6-6. Wisconsin statewide safe fish consumption guidelines. Graphic displays consumption guidance for most Wisconsin waterways. Figure adapted from WDNR website graphic (http://dnr.wi.gov/topic/fishing/consumption/)



800
Feet

Onterra LLC
Lake Management Planning

815 Prosper Rd
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

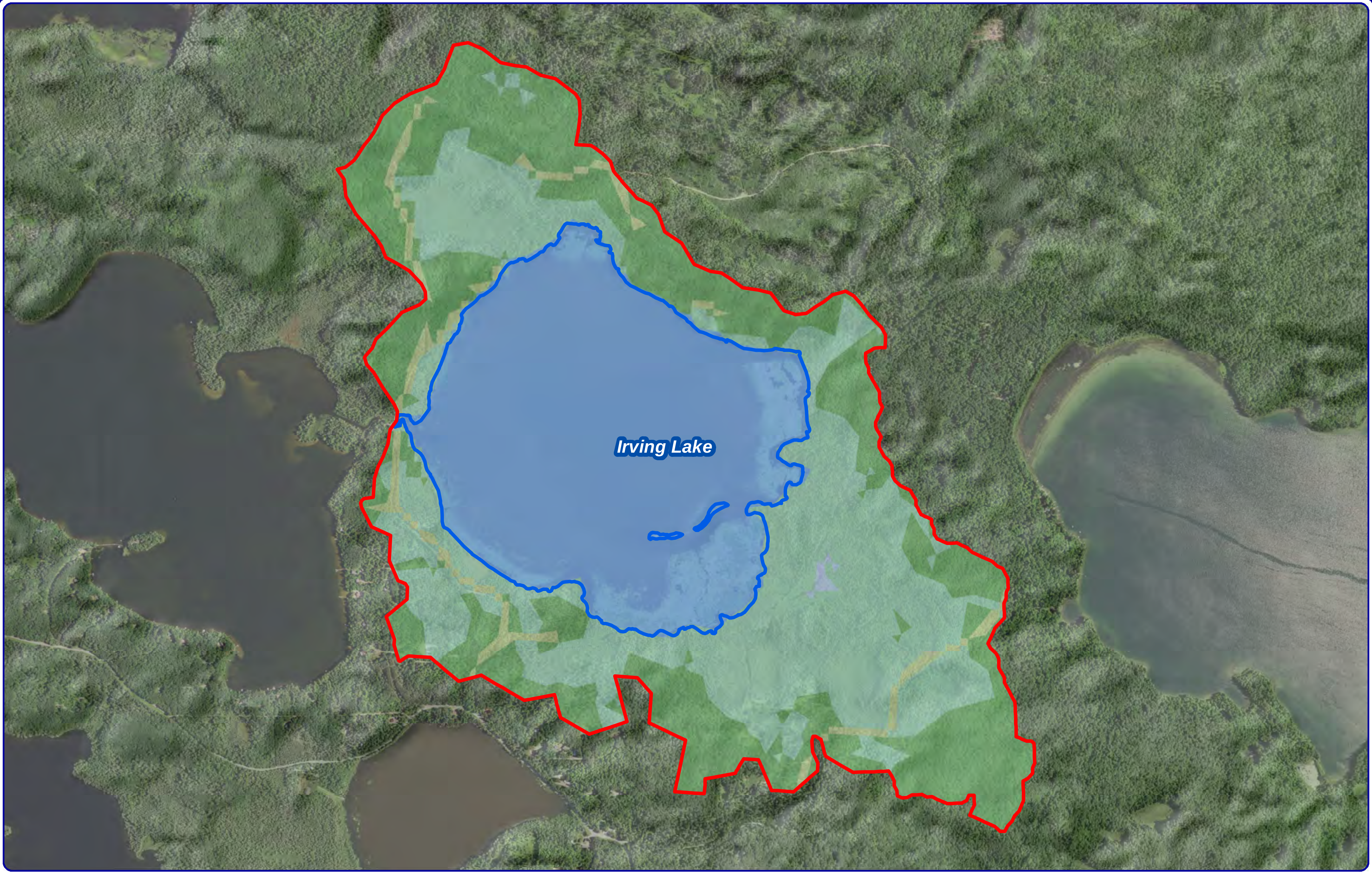
Sources
Hydro: WDNR
Survey: Onterra, 2018
Orthophotography: NAIP, 2017
Map date: July 17, 2019 HAL
Filename: Irving_Location.mxd

Legend

- Irving Lake ~427 acres
- Public Access
- Water Quality Sampling Location
- Point-intercept Sample Location *68 meter points*

Irving Lake - Map 1
Town of Plum Lake
Vilas County, Wisconsin

Project Location & Lake Boundaries



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1,700

Feet

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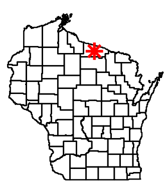
Sources:
Hydro: WDNR
Bathymetry: WDNR, digitized by Onterra
Orthophotography: NAIP 2015
Land Cover: NLCD 2011
Watershed Boundaries: Onterra 2019
Map Date: July 19, 2019 AMS
Filename: *Irving_WS_2019.mxd*



Project Location in Wisconsin

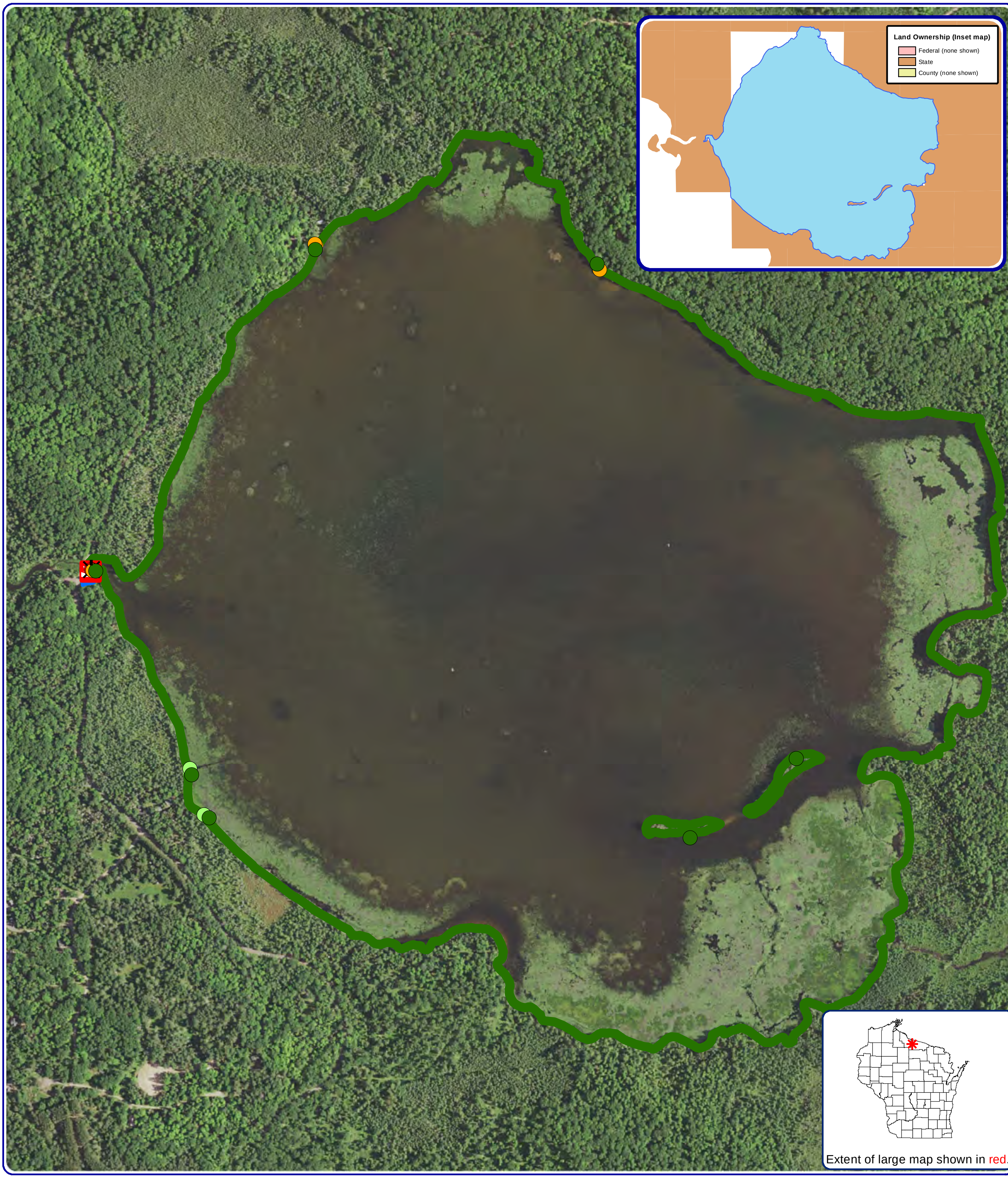
Legend

Land Cover Types

- Forest
- Forested Wetlands
- Wetlands
- Open Water
- Rural Open Space
- Pasture/Grass
- Rural Residential
- Irving Lake Watershed Boundary

Irving Lake - Map 2
Town of Plum Lake
Vilas County, Wisconsin

Watershed Boundaries & Land Cover Types



1,150

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Legend

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

Seawall Modifier

Masonary/Wood Seawall
Rip-Rap

Irving Lake - Map 3

Town of Plum Lake

Vilas County, Wisconsin

Shoreland Condition Assessment

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Sources
Hydro: WDNR
Shoreland Assessment: Onterra, 2018
Orthophotography: NAIP, 2017
Map date: April 3, 2019 AMS
Filename: Irving_SA_Oct18.mxd

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Legend

2-8 Inch Pieces	8+ Inch Pieces	Cluster of Pieces
No Branches	No Branches	No Branches
Minimal Branches	Minimal Branches	Minimal Branches
Moderate Branches	Moderate Branches	Moderate Branches
Full Canopy	Full Canopy	Full Canopy

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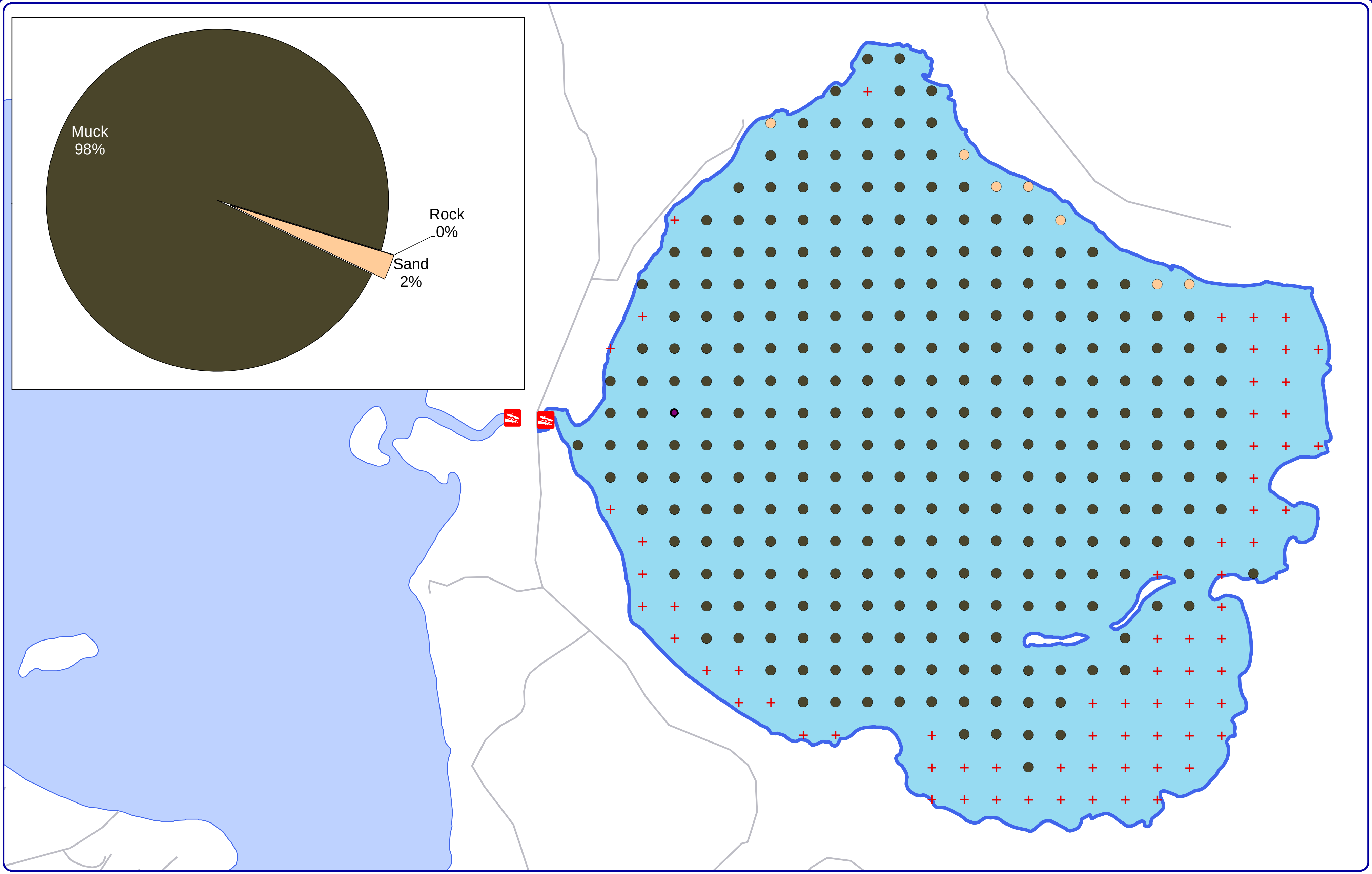
Sources
Hydro: WDNR
CWH Survey: Onterra, 2018
Orthophotography: NAIP, 2017
Map date: April 3, 2019 AMS
Filename: Irving_CWH_Oct18.mxd

Irving Lake - Map 4
Town of Plum Lake
Vilas County, Wisconsin
Coarse Woody Habitat



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890
Feet

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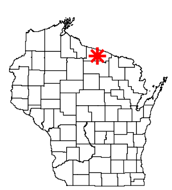
Sources:
Hydro and Roads: WDNR
Bathymetry: WDNR, digitized by Onterra
Aquatic Plant Survey: Onterra, 2018
Map Date: July 19, 2019 AMS
Filename: Irving_SubstratePI_2018.mxd



Project Location in Wisconsin

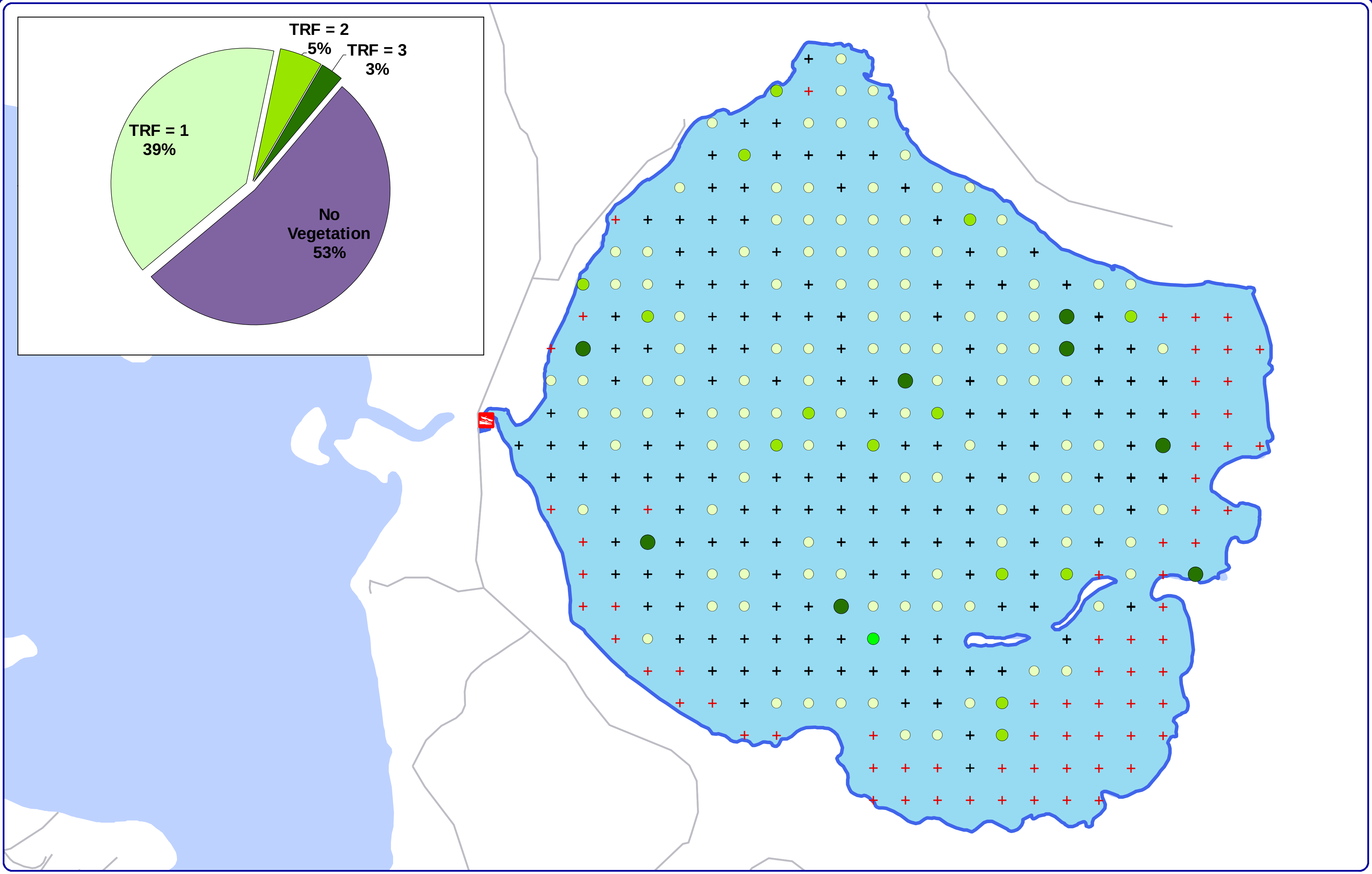
Legend

- Soft/Organic Sediments
- Rock
- Sand
- Too Deep
- Non-navigable

Irving Lake- Map 5

Town of Plum Lake
Vilas County, Wisconsin

2018 PI Survey: Substrate Types



890
Feet

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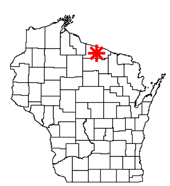
920.338.8860
www.onterra-eco.com

Sources:
Roads and Hydro: WDNR
Bathymetry: WDNR, digitized by Onterra
Plant Survey: Onterra, 2018
Map Date: July 8, 2018
Filename: *Irving_TRFPI_2018.mxd*



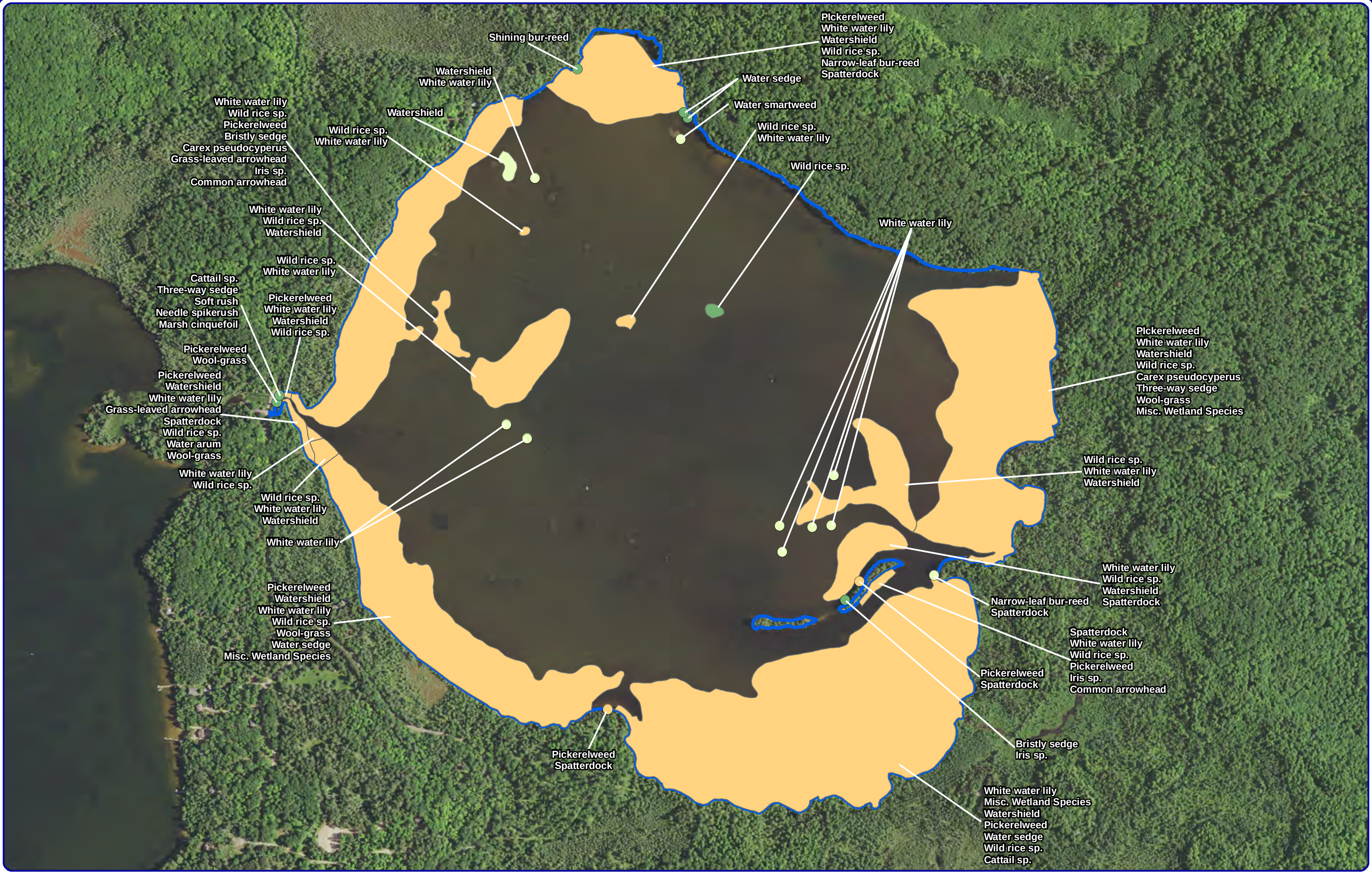
Project Location in Wisconsin

Legend

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

Irving Lake - Map 6
Town of Plum Lake
Vilas County, Wisconsin

2018 PI Survey: Aquatic Vegetation Distribution



N
W E
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350
Feet

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De Pere, WI 54115
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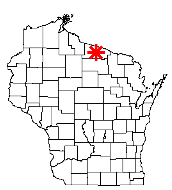
Sources
Hydro: WDNR
Aquatic Plants: Onterra, YEAR
Orthophotography: NAIP, YEAR
Map date: Month, Day, Year Initals
Filename: Insert Filename.mxd



Project Location in Wisconsin

Legend

Small Plant Communities
- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent

Large Plant Communities
- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent

Irving Lake - Map 7
Town of Plum Lake
Vilas County, Wisconsin

Emergent & Floating-leaf Aquatic Plant Communities