MIRROR LAKE MANAGEMENT DISTRICT

June 4, 2025

The Mirror Lake Management District
Request for public comments regarding Aquatic Plant Management Plan Update
June 2025

The Mirror Lake Management District (MLMD) contracted with Onterra, LLC in June 2024 to assist the MLMD with updating the *Aquatic Plant Management Plan* which is a sub-set of the *Mirror Lake Comprehensive Management Plan,* that was drafted and approved in 2014. Onterra is the company that originally assisted the MLMD with creating both plans.

As required by the WI DNR, the Aquatic Plant Management Plan must be updated every five years to coincide with the application for a *Mechanical/Manual Aquatic Plant Control Permit* for the MLMD to operate their harvesting program in Mirror Lake. Since 2012 Onterra has performed three plant surveys of the lake to fulfill that requirement – in 2012, 2019 and the current one in 2024.

As a requirement for the permit, the plan must be available to the public for review and to allow for people to make comments. Only written comments will be accepted and taken up by the MLMD. The link will be available starting June 2 and will remain up for 21 days. All written comments on the plan must be sent to glcsandrac@charter.net. Any non-written comments or comments sent to another address will not be considered.

The Mirror Lake Aquatic Plant Management Plan Official First Draft Update can be found on the Town of Delton website at: https://townofdeltonwi.gov/links/. Click on the “Mirror Lake Management District (MLMD)” tab.

P.O. Box 216 Lake Delton, WI 53940

DRAFT

Mirror Lake
Aquatic Plant Management Plan

Sauk County, Wisconsin
May 2025
Official First Draft for Agency Review

Created by: Sam Dodge, Ryan Flynn and Tim Hoyman
Onterra, LLC
De Pere, WI

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Acknowledgements

This management planning effort was truly a team-based project and could not have been completed without the input of the following individuals:

Mirror Lake Information & Planning Meeting Attendees

Mark Blakeslee
Jerry Collins
Cathy Sperl
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Pat Cieskewicz, Superintendent, Mirror Lake State Park
Niel Pfaff, Vierbicher & Associates

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1.0 INTRODUCTION

Mirror Lake (Photo 1.0-1, Map 1) is an approximate 137-acre eutrophic impoundment of Dell Creek in Sauk County. Its watershed encompasses approximately 67 square miles across portions of Sauk and Juneau counties. Water flows from Mirror Lake over the Delton Dam through Dell Creek, into Lake Delton, and ultimately the Wisconsin River.

Photograph 1.0-1. Mirror Lake, Sauk County, Wisconsin.

In 2014, the *Mirror Lake Comprehensive Management Plan* (Onterra, LLC, 2014) was finalized and included the development of management goals and actions designed to maintain and enhance the ecological health of Mirror Lake and the quality of life for its stakeholders. These management goals were developed through the collaborative efforts of Mirror Lake Management District (MLMD) members, Wisconsin Department of Natural Resources (WDNR) staff, and Onterra ecologists.

The western and south-central portions of Mirror Lake support abundant submersed aquatic plant growth, some of which grow to levels which impede navigation and recreation in these areas. In addition, in areas where submersed vegetation grows to the surface, large mats of floating duckweed (genera: *Lemna*, *Spirodela*, and *Wolffia*) develop. Studies completed in 2012 as part of the Mirror Lake Management Plan development found that the nuisance levels of aquatic plant growth were primarily caused by the native species coontail (*Ceratophyllum demersum*) and common waterweed (*Elodea canadensis*), and in early summer prior to senescence, the non-native curly-leaf pondweed (*Potamogeton crispus*).

In an effort to maintain reasonable navigation in Mirror Lake, the MLMD operates a district-owned mechanical harvester to reduce the density of aquatic vegetation in areas where navigation is impeded. Management Goal 4 within the 2012 *Mirror Lake Comprehensive Management Plan* details the WDNR-approved mechanical harvesting plan which allows for the harvesting of vegetation for navigation on an as-needed basis within approximately 34 acres of Mirror Lake. Map 2 illustrates four types of harvesting areas; the primary harvest areas which encompass approximately 30 acres in Upper and Lower Mirror Lake, 50- and 30-foot-wide navigational lanes which extend into Dell Creek, and a 30-foot duckweed harvesting lane in the narrows between Upper and Lower Mirror Lake.

Mechanical harvesting has worked well to control nuisance aquatic plant growth in Mirror Lake. This is especially important considering the large amount of passive recreation on the waterbody originating from Mirror Lake State Park and residential lots. Table 1.0-1 includes the annual harvest loads from 2019-24 on Mirror Lake.

Every five years, the MLMD updates their Aquatic Plant Management (APM) plan in order to renew their mechanical harvesting permit. One component of updating the APM plan is completion of a whole-lake aquatic plant point-intercept survey. The MLMD contracted with Onterra, LLC to complete a whole-lake point-intercept survey on Mirror Lake in 2024, after completing the previous survey in 2019. This report serves to present the results of the 2024 aquatic plant point-intercept survey and compare with data collected during the same surveys completed in 2012 and 2019.

Year	Loads Harvested
2019	8
2020	4.5
2021	12
2022	11
2023	10.5
2024	6

Table 1.0-1. Annual loads harvested from Mirror Lake from 2019-2024.

In summary, the 2024 survey showed that the overall occurrence of aquatic plants in Mirror Lake was 71%, meaning that the overall occurrence had increased back to similar levels as 2012 (69%), after declining substantially in 2019 (53%). In total, eight native plant species saw increases in their occurrence between 2019 and 2024, but the non-native Eurasian watermilfoil (*Myriophyllum spicatum*) was not statistically different between the 2019 and 2024 surveys. The occurrence of the non-native curly-leaf pondweed (*Potamogeton crispus*) saw a decline in occurrence of 43% from 2019 to 2024. These changes in Mirror Lake's aquatic plant community and other aquatic plant community assessment metrics are discussed in this report. Based on the 2024 aquatic plant survey, it is not believed that any changes to Mirror Lake's mechanical harvesting strategy are needed.

Mirror Lake Management District Board of Commissioners Meeting

On April 30, 2025, Tim Hoyman presented the findings of the 2024 aquatic plant surveys, and updated water quality and watershed summaries to the district board and invited guests. Tim answered several questions pertaining to aquatic plant growth and water quality. The last third of the meeting was spent discussing past management actions and potential changes to the lake's aquatic plant management plan.

2.0 AQUATIC PLANTS

2.1 Primer on Aquatic Plant Data Analysis & Interpretation

Although the occasional lake user may consider aquatic plants (macrophytes) to be weeds and are often considered as a nuisance to the recreational use of the lake, these plants are an essential element in a healthy and functioning lake ecosystem (Photo 2.1-1). It is important that lake stakeholders understand the importance of lake plants and the many functions they serve in maintaining and protecting a lake ecosystem. With increased understanding and awareness, most lake users will recognize the importance of the aquatic plant community and their potential negative effects on it.

Photograph 2.1-1. Southern wild rice (Zizania aquatica) marsh in Upper Mirror Lake. Photo credit Onterra (2019).

Diverse aquatic vegetation provides habitat and food for many kinds of aquatic life, including fish, insects, amphibians, waterfowl, and even terrestrial wildlife. For instance, wild celery (*Vallisneria americana)* and seeds of floating-leaf pondweed (*Potamogeton natans*) both serve as excellent food sources for migratory waterfowl. Emergent stands of vegetation provide necessary spawning habitat for fish such as northern pike (*Esox lucius*) and yellow perch (*Perca flavescens*). In addition, many of the insects that are eaten by young fish rely heavily on aquatic plants and the periphyton attached to them as their primary food source.

Aquatic plants also provide cover for feeder fish and zooplankton, stabilizing the predator-prey relationships within the system. Furthermore, rooted aquatic plants prevent shoreland erosion and the resuspension of bottom sediments and nutrients by absorbing wave energy and locking sediments within their root masses. In areas where plants do not exist, waves can resuspend bottom sediments decreasing water clarity and increasing nutrient levels that may lead to phytoplankton blooms. Lake plants also produce oxygen through photosynthesis and use nutrients that may otherwise be used by phytoplankton, helping to minimize nuisance phytoplankton blooms.

Because most aquatic plants are rooted in place and are unable to relocate in the wake of environmental change, they are often the first aquatic community to indicate that changes may be occurring within the system. For this reason, aquatic plants are used as indicators of environmental health. Aquatic plant communities can respond in variety of ways; there may be increases or reductions in the occurrence of sensitive species, or a complete loss. Or, certain growth forms, such as emergent and floating-leaf communities may disappear from certain areas of the waterbody. With periodic monitoring and proper analysis, these changes are relatively easy to detect and provide relevant information for making management decisions.

Under certain conditions, a few species may grow to levels which can interfere with the use of the lake. Excessive plant growth can limit recreational use by deterring navigation, swimming, and fishing activities. It can also lead to changes in fish population structure by providing too much cover for feeder fish resulting in reduced predation by predator fish, which could result in a stunted pan-fish population. Exotic plant species, such as Eurasian watermilfoil (EWM) and curly-leaf pondweed (CLP) can also upset the delicate balance of a lake ecosystem by out competing native plants and reducing species diversity. These invasive plant species can form dense stands that are a nuisance to humans and provide low-value habitat for fish and other wildlife.

When plant abundance negatively affects the lake ecosystem and limits the use of the resource, plant management and control may be necessary. The management goals should always include the control of invasive species and restoration of native communities through environmentally sensitive and economically feasible methods. No aquatic plant management plan should only contain methods to control plants, they should also contain methods on how to protect and possibly enhance the important plant communities within the lake. Unfortunately, the latter is often neglected and the ecosystem suffers as a result.

Aquatic Plant Survey Methods

On June 24, 2024, Onterra ecologists completed a whole-lake aquatic plant point-intercept survey on Mirror Lake using the same sampling locations and methodology as the surveys that were completed by Onterra on June 25, 2012 and on June 25, 2019. The aquatic plant point-intercept survey method as developed by the WDNR Bureau of Science Services (Hauxwell et al. 2010) was used in Mirror Lake in 2024. Based upon guidance from the WDNR, sampling locations were spaced 37 meters apart resulting in a total of 400 sampling locations.

At each point-intercept location within the *littoral zone*, information regarding the depth, substrate type (soft sediments, sand, or rock/gravel), and the plant species sampled along with their relative abundance on the sampling rake was recorded (Figure 2.1-1). A pole-mounted rake was used to collect the plant samples, depth, and sediment information at point locations of 15 feet or less. A rake head tied to a rope (rope rake) was used at sites greater than 15 feet. Depth information was collected using graduated marks on the pole of the rake or using an onboard sonar unit at depths greater than 15 feet. Also, when a rope rake was used, information regarding substrate type was not collected due to the inability of the sampler to accurately feel the bottom with this sampling device. The point-intercept survey produces a great deal of information about a lake's aquatic vegetation and overall health. These data are analyzed and presented in numerous ways; each is discussed in more detail the following section.

The **Littoral Zone** is the area of the lake where sunlight is able to penetrate to the sediment providing aquatic plants with sufficient light to carry out photosynthesis.

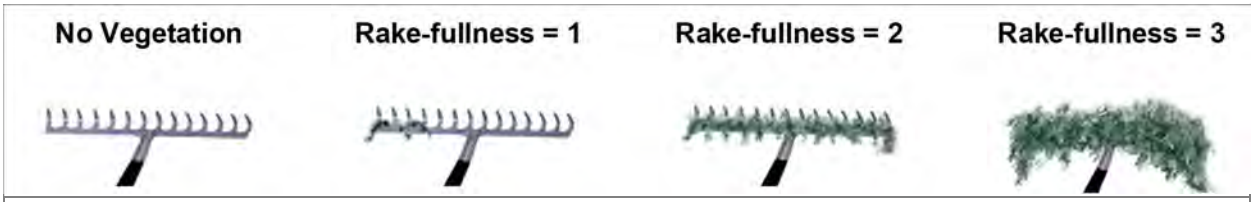

Figure 2.1-1. Aquatic plant rake fullness ratings. Adapted from Hauxwell et al (2010).

2.2 Data Interpretation

Species List

The species list is simply a list of all of the aquatic plant species, both native and non-native, that were located during the surveys completed on Mirror Lake in 2012, 2019 and 2024. The list also contains the growth-form of each plant found (e.g. submergent, emergent, etc.), its scientific name, common name, and its coefficient of conservatism. The latter is discussed in more detail below. Changes in this list over time, whether it is differences in total species present, gains and losses of individual species, or changes in growth forms that are present, can be an early indicator of changes in the ecosystem.

Frequency of Occurrence

Frequency of occurrence describes how often a certain aquatic plant species is found within a lake as determined from the whole-lake point-intercept survey. Obviously, all of the plants cannot be counted in a lake, so samples are collected from pre-determined areas. In the case of the whole-lake point-intercept survey completed on Mirror Lake, plant samples were collected from plots laid out on a grid that covered the lake. Using the data collected from these plots, an estimate of occurrence of each plant species can be determined. The occurrence of aquatic plant species is displayed as the *littoral frequency of occurrence*. Littoral frequency of occurrence is used to describe how often each species occurred in the plots that are within the maximum depth of plant growth (littoral zone), and is displayed as a percentage.

Floristic Quality Assessment

The floristic quality of a lake's aquatic plant community is calculated using its native *species richness* and their *average conservatism*. Species richness is the number of native aquatic plant species that were physically encountered on the rake during the point-intercept survey. Average conservatism is calculated by taking the sum of the coefficients of conservatism (C-values) of the native species located and dividing it by species richness. Every plant in Wisconsin has been assigned a coefficient of conservatism, ranging from 1-10, which describes the likelihood of that species being found in an undisturbed environment. Species which are more specialized and require undisturbed habitat are given higher coefficients, while species which are more tolerant of environmental disturbance have lower coefficients.

For example, algal-leaf pondweed (*Potamogeton confervoides*) is only found in nutrient-poor, acid lakes in northern Wisconsin and is prone to decline if degradation of these lakes occurs. Because of algal-leaf pondweed's special requirements and sensitivity to disturbance, it has a C-value of 10. In contrast, sago pondweed (*Stuckenia pectinata*) with a C-value of 3, is tolerant of disturbance and is often found in greater abundance in degraded lakes that have higher nutrient concentrations and low water clarity. Higher average conservatism values generally indicate a healthier lake as it is able to support a greater number of environmentally-sensitive aquatic plant species. Low average conservatism values indicate a degraded environment, one that is only able to support disturbance-tolerant species.

On their own, the species richness and average conservatism values for a lake are useful in assessing a lake's plant community; however, the best assessment of the lake's plant community health is determined when the two values are used to calculate the lake's floristic quality. The

floristic quality is calculated using the species richness and average conservatism value of the aquatic plant species that were solely encountered on the rake during the point-intercept surveys (equation shown below). This assessment allows the aquatic plant community of Mirror Lake to be compared through time as well as to other lakes within the region and state.

FQI = Average Coefficient of Conservatism * √ Number of Native Species

Species Diversity

Species diversity is often confused with species richness. As defined previously, species richness is simply the number of species found within a given community. While species diversity utilizes species richness, it also takes into account evenness or the variation in abundance of the individual species within the community. For example, a lake with 10 aquatic plant species that had relatively similar abundances within the community would be more diverse than another lake with 10 aquatic plant species where 50% of the community was comprised of just one or two species.

An aquatic system with high species diversity is more stable than a system with a low diversity. This is analogous to a diverse financial portfolio in that a diverse aquatic plant community can withstand environmental fluctuations much like a diverse portfolio can handle economic fluctuations. A lake with a diverse plant community is also better suited to compete against exotic infestations than a lake with a lower diversity. The diversity of a lake's aquatic plant community is determined using the Simpson's Diversity Index (1-D):

$$D = \sum (n/N)^2$$

where: n = the total number of instances of a particular species
N = the total number of instances of all species and
D is a value between 0 and 1

If a lake has a diversity index value of 0.90, it means that if two plants were randomly sampled from the lake there is a 90% probability that the two individuals would be of a different species. The Simpson's Diversity Index values from Mirror Lake are compared to data collected by Onterra and the WDNR Science Services on 392 lakes throughout Wisconsin.

2.3 Mirror Lake Aquatic Plant Survey Results

The data that continues to be collected from Wisconsin lakes is revealing that aquatic plant communities are highly dynamic, and populations of individual species have the capacity to fluctuate, sometimes greatly, in their occurrence from year to year and over longer periods of time. These fluctuations can be driven by a combination of natural factors including variations in temperature, ice and snow cover (winter light availability), nutrient availability, water levels and flow, water clarity, length of the growing season, herbivory, disease, and competition (Lacoul & Freedman, 2006). Adding to the complexity of factors which affect aquatic plant community dynamics, human-related disturbances such as the application of herbicides for non-native plant management, mechanical harvesting, watercraft use, and pollution runoff also affect aquatic plant community composition (Asplund & Cook, 1997); (Lacoul & Freedman, 2006).

Whole-lake point-intercept surveys have been completed on Mirror Lake in 2012, 2019 and 2024. This report highlights the 2024 point-intercept survey results and integrates comparisons to the previous surveys throughout the section. Table 2.3-1 illustrates some basic survey statistics from each of the three point-intercept surveys

Table 2.3-1. Mirror Lake 2012, 2019 and 2024 aquatic plant survey summary statistics.

Mirror Lake Summary Statistics	2012	2019	2024
Total number of sites visited	314	262	310
Total number of sites with plants	216	132	219
Maximum depth of plants (feet)	14	12	15
Total number of sites shallower than the maximum depth of plants	313	248	310
Frequency of plants at sites shallower than the maximum depth of plants	69%	53%	71%
Simpson's Diversity Index (1-D)	0.88	0.89	0.88
Average number of all plant species per site (sites with plants only)	3.3	2.5	3.1
Average number of native plant species per site (sites with plants only)	2.9	1.1	3.0

The biomass of aquatic vegetation rebounded between the 2019 and 2024 surveys as indicated by the total rake fullness (TRF) ratings (Figure 2.3-1). In 2024, 23% of the sampling locations had aquatic vegetation with a TRF rating of 2 or 3, indicating higher aquatic plant biomass. In 2019, the number of sampling locations with a TRF rating of 2 was down to 15%, while no sampling locations were found to have a TRF rating of 3 during that suvery. Both of these are still lower than in 2012, when 41% of sampling locations had aquatic vegetation with a TRF rating of 2 or 3, indicating higher aquatic plant biomass than the two later sampling years. The maximum depth of recorded aquatic plant growth was 12 feet in 2019 compared to 14 feet in 2012 and 15 feet in 2024.

In 2024, a total of 34 aquatic plant species were located in Mirror Lake, 21 of which were physically encountered on the rake during the point-intercept survey (Figure 2.3-2; Table 2.3-2). The remaining 13 native species 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 rare within the plant community. Of the 22 aquatic plant species that were physically encountered during the 2024 point-intercept survey, coontail (*Ceratophyllum demersum*) was the most frequently encountered (45.2%), with common waterweed (*Elodea canadensis; 34.5%*) and turion duckweed (*Lemna turionafera; 32.6%*) were the next most common species.

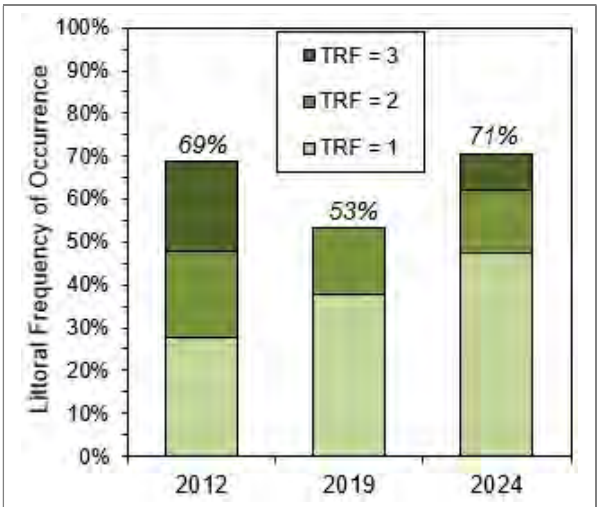

Figure 2.3-1. Mirror Lake 2012, 2019 and 2024 littoral frequency of occurrence of vegetation and total rake fullness (TRF) ratings. Decline in vegetation is statistically valid (Chi-Square α = 0.05).

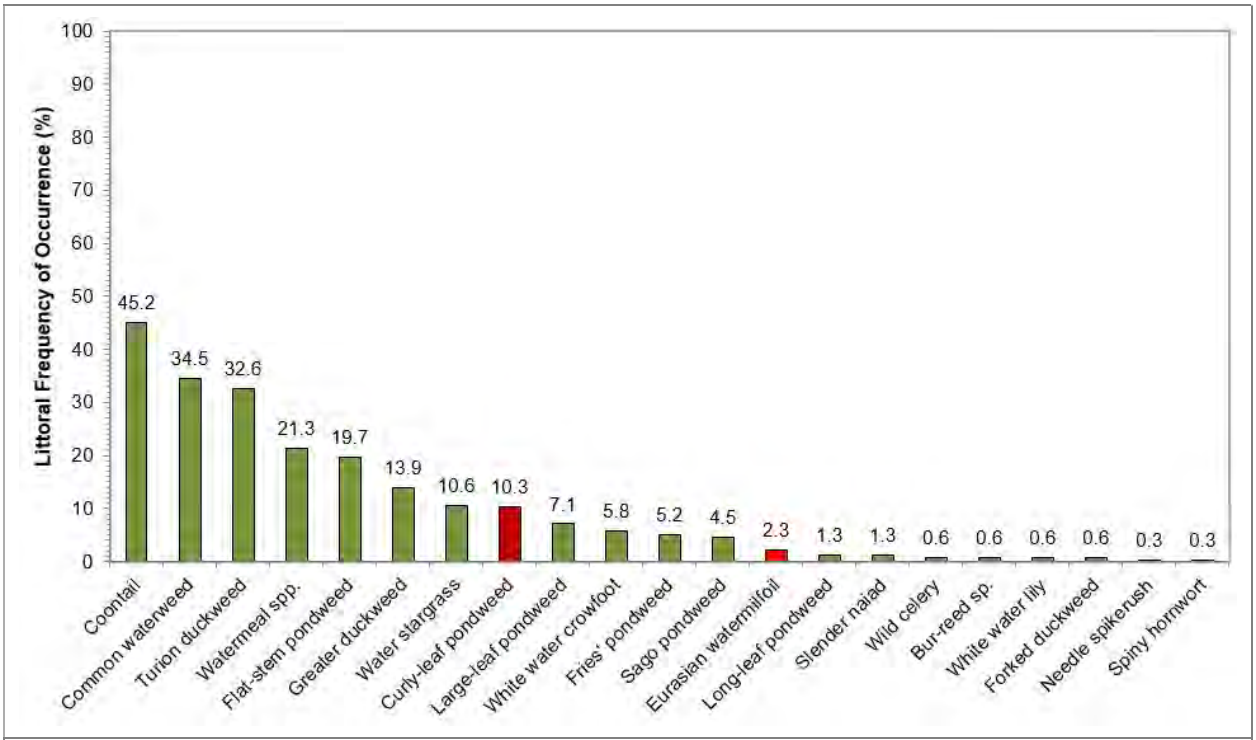

Figure 2.3-2. Littoral frequency of occurrence of aquatic plant species in Mirror Lake in 2024. Data from 2024 point-intercept survey

In addition to the point intercept surveys, an emergent and floating-leaf plant community mapping survey was completed as a part of the Aquatic Plant Management project in 2024. Table 2.3-2 displays the species that have been documented during all surveys on Mirror Lake. Table 2.3-2 is organized by growth form which separates out species based on whether they are emergent species, floating-leaf species, submergent species, or free-floating species. Species with an "X" on the table indicates the species was physically encountered on the rake during the point-intercept survey. Examples of other species that were observed, but were not sampled on the survey rake are referred to as incidentals and are listed with an "I". Often times, many of the incidentally encountered species were those that were identified during the emergent and floating-leaf community mapping survey which are typically found growing on the shoreline or in shallow areas of the lake.

As discussed in the primer section, the calculations used for 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 does not include incidental species. Mirror Lake's native aquatic plant species richness in 2024 was found to be above the median value for lakes within the Driftless Area (DA) ecoregion and even with the median for lakes throughout Wisconsin (Figure 3.2-3). The 2024 aquatic plant studies in Mirror Lake show a resurgence in occurrence for the majority of plant species since 2019 to 2024. Despite the apparent decrease and increase in vegetation between 2012, 2019, and 2024, the aquatic plant population is still considered to be well above average when compared to other lakes in the same ecoregion, but still equal or less than the average when compared to lakes statewide.

Table 2.3-2. Aquatic plant species located in Mirror Lake during Onterra 2012, 2019 and 2024 aquatic plant surveys.

Growth Form	Scientific Name	Common Name	Status in Wisconsin	Coefficient of Conservatism	2012	2019	2024
Emergent	*Acorus calamus*	Sweetflag	Non-Native - Naturalized	N/A	I	I	
	Calla palustris	Water arum	Native	9	X	I	I
	Carex comosa	Bristly sedge	Native	5	I	I	
	Carex lurida	Shallow sedge	Native	8	I	I	
	Carex sp. 1	Sedge sp. 1	Native	N/A			I
	Eleocharis obtusa	Blunt spikerush	Native	3	I		
	Eleocharis palustris	Creeping spikerush	Native	6			I
	Fallopia japonica	Japanese knotweed	Non-Native - Invasive	N/A	I	I	
	Iris pseudacorus	Pale-yellow iris	Non-Native - Invasive	N/A	I		
	Iris spp. (sterile)	Iris spp. (sterile)	Unknown (Sterile)	N/A			I
	Iris versicolor	Northern blue flag	Native	5			I
	Juncus effusus	Soft rush	Native	4	I		
	Sagittaria latifolia	Common arrowhead	Native	3	X	I	I
	Sagittaria rigida	Stiff arrowhead	Native	8	I	I	
	Schoenoplectus pungens	Three-square rush	Native	5			I
	Schoenoplectus tabernaemontani	Softstem bulrush	Native	4	I	I	I
	Scirpus atrovirens	Black bulrush	Native	3	I	I	
	Scirpus cyperinus	Wool grass	Native	4	I	I	I
	Typha spp.	Cattail spp.	Unknown (Sterile)	N/A			I
	Zizania aquatica	Southern wild rice	Native	8	X	X	
	Zizania spp.	Wild rice sp.	Native	8			I
FL	*Nymphaea odorata*	White water lily	Native	6	I	X	X
	Persicaria amphibia	Water smartweed	Native	5			I
FL/E	*Sparganium sp.*	Bur-reed sp.	Native	N/A	I	I	X
Submergent	*Callitriche palustris*	Common water starwort	Native	8	I		
	Ceratophyllum demersum	Coontail	Native	3	X	X	X
	Ceratophyllum echinatum	Spiny hornwort	Native	10			X
	Chara spp.	Muskgrasses	Native	7	X		
	Elodea canadensis	Common waterweed	Native	3	X	X	X
	Elodea nuttallii	Slender waterweed	Native	7	X	I	
	Heteranthera dubia	Water stargrass	Native	6	X	X	X
	Myriophyllum spicatum	Eurasian watermilfoil	Non-Native - Invasive	N/A	X	X	X
	Najas flexilis	Slender naiad	Native	6	X		X
	Potamogeton amplifolius	Large-leaf pondweed	Native	7	X	X	X
	Potamogeton crispus	Curly-leaf pondweed	Non-Native - Invasive	N/A	X	X	X
	Potamogeton epihydrus	Ribbon-leaf pondweed	Native	8	X	X	
	Potamogeton friesii	Fries' pondweed	Native	8	X	X	X
	Potamogeton nodosus	Long-leaf pondweed	Native	5	X	X	X
	Potamogeton strictifolius	Stiff pondweed	Native	8	X	X	
	Potamogeton zosteriformis	Flat-stem pondweed	Native	6	X	X	X
	Ranunculus aquatilis	White water crowfoot	Native	8	X	X	X
	Sagittaria sp. (rosette)	Arrowhead sp. (rosette)	Native	N/A			I
	Stuckenia pectinata	Sago pondweed	Native	3	X	X	X
	Vallisneria americana	Wild celery	Native	6			X
S/E	*Eleocharis acicularis*	Needle spikerush	Native	5			X
FF	*Lemna trisulca*	Forked duckweed	Native	6			X
	Lemna turionifera	Turion duckweed	Native	2	X	X	X
	Spirodela polyrhiza	Greater duckweed	Native	5	X	X	X
	Wolffia spp.	Watermeal spp.	Native	N/A	X	X	X

X = Located on rake during point-intercept survey; I = Incidentally located; not located on rake during point-intercept survey
FL = Floating-leaf; FL/E = Floating-leaf & Emergent; S/E = Submergent and/or Emergent; FF = Free-floating

The average conservatism of the 19 native aquatic plants recorded on the rake in 2024 was 5.6, falling above the median value (4.6) for lakes within the DA ecoregion and below the median value (6.3) for lakes throughout Wisconsin (Figure 2.3-3). This indicates that Mirror Lake has an average number of native aquatic plant species with high conservatism values when compared to the majority of lakes within the DA ecoregion.

Using Mirror Lake's 2024 native aquatic plant species richness and average conservatism to calculate the Floristic Quality Index value yields a value of 24.4, the which is well above the median values for lakes within the DA ecoregion but below the median values for lakes within the state. This indicates that Mirror Lake's aquatic plant community is of above average quality in terms of species richness and community composition compared to lakes within the ecoregion.
Whole-lake point-intercept surveys are used to quantify the abundance of individual species within the lake. Table 2.3-3 shows the littoral frequency of occurrence (LFOO) of aquatic plants from the 2012, 2019 and 2024 point-intercept surveys. Due to their morphologic similarity and often difficulty differentiating between the two, the occurrences of common waterweed (*E. canadensis*) and slender waterweed (*E. nuttallii*) were combined for this analysis. The Chi-square analysis is also displayed which indicates statistically valid changes in occurrence between each survey. the overall occurrence of vegetation in Mirror Lake was found to have increased between the 2019 and 2024 surveys, and the occurrences of dominant plant species also exhibited increases in their occurrence. Eleven aquatic plant species exhibited statistically valid changes in their occurrences in Mirror Lake between 2012 and 2019. Three species, large-leaf pondweed, stiff pondweed and curly-leaf pondweed (CLP), exhibited declines in their occurrence, while eight native aquatic plant species exhibited an increase in their occurrences (Table 2.3-3). The occurrences of the remaining

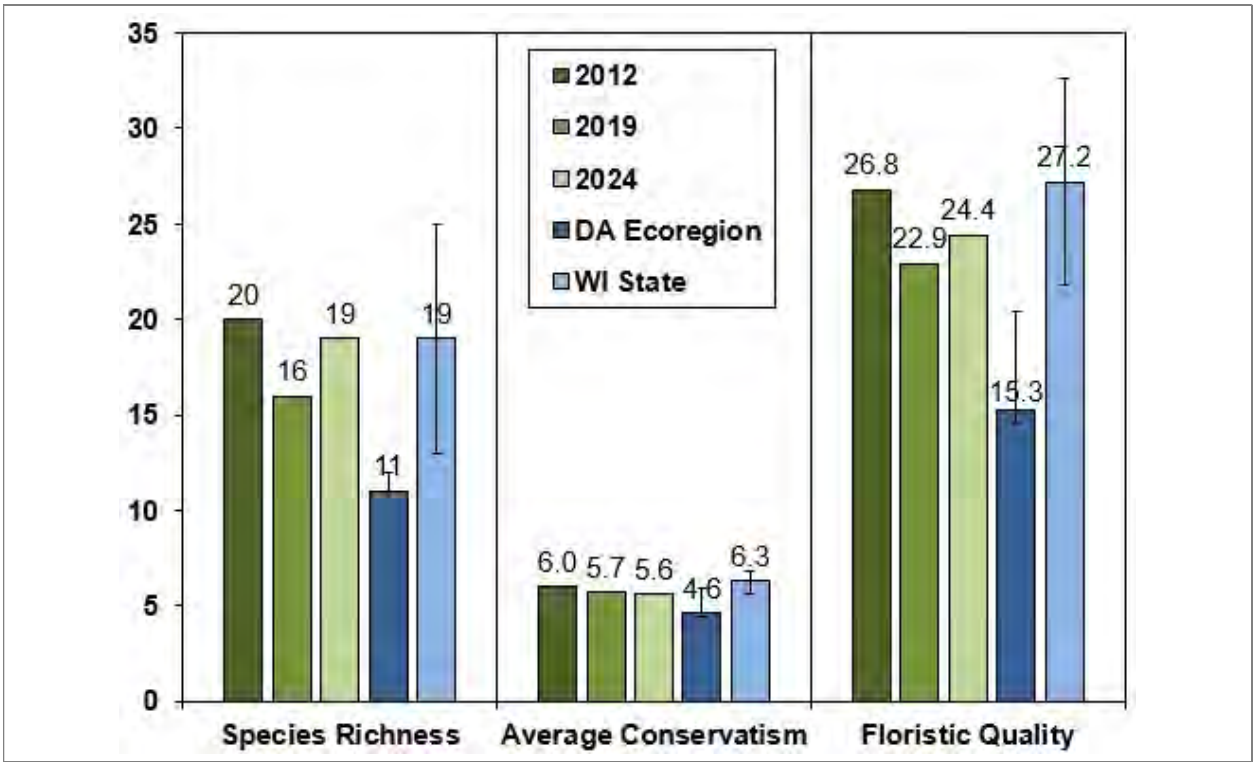

Figure 2.3-3. Mirror Lake Floristic Quality Analysis. Created using data from Onterra 2012, 2019 and 2024 whole-lake point-intercept surveys. Analysis follows Nichols (1999).

14 species, including Eurasian watermilfoil (EWM), were not statistically different between 2019 and 2024.

Table 2.3-3. Littoral frequency of Occurrence and Chi-square Analysis of Aquatic Plants in Mirror Lake from 2012, 2019 and 2024 Point-Intercept Surveys.

Scientific Name	Common Name	LFOO (%)			2012-2019		2019-2024	
		2012	2019	2024	% Change	Direction	% Change	Direction
Ceratophyllum demersum	Coontail	44.7	23.8	45.2	-46.8	▼	89.8	▲
Elodea canadensis & E. nuttallii	Common & Slender waterweeds	52.4	17.7	34.5	-66.1	▼	94.5	▲
Elodea canadensis	Common waterweed	51.8	17.7	34.5	-65.7	▼	94.5	▲
Lemna turionifera	Turion duckweed	30.0	12.1	32.6	-59.7	▼	169.3	▲
Wolffia spp.	Watermeal spp.	22.7	4.4	21.3	-80.4	▼	380.0	▲
Potamogeton zosteriformis	Flat-stem pondweed	8.6	12.9	19.7	49.6	△	52.5	▲
Potamogeton crispus	Curly-leaf pondweed	12.8	18.1	10.3	42.0	△	-43.1	▼
Heteranthera dubia	Water stargrass	18.2	9.7	10.6	-46.9	▼	10.0	△
Potamogeton amplifolius	Large-leaf pondweed	12.8	19.0	7.1	48.3	▲	-62.6	▼
Spirodela polyrhiza	Greater duckweed	0.3	1.2	13.9	278.6	△	1046.7	▲
Myriophyllum spicatum	Eurasian watermilfoil	13.1	2.8	2.3	-78.5	▼	-20.0	▽
Potamogeton friesii	Fries' pondweed	4.5	2.0	5.2	-54.9	▽	156.0	△
Ranunculus aquatilis	White water crowfoot	2.6	2.0	5.8	-21.1	▽	188.0	▲
Stuckenia pectinata	Sago pondweed	2.2	2.8	4.5	26.2	△	60.0	△
Potamogeton nodosus	Long-leaf pondweed	1.6	0.4	1.3	-74.8	▽	220.0	△
Potamogeton strictifolius	Stiff pondweed	1.3	3.2	0.0	152.4	△	-100.0	▼
Elodea nuttallii	Slender waterweed	3.5	0.0	0.0	-100.0	▼		-
Najas flexilis	Slender naiad	0.3	0.0	1.3	-100.0	▽		△
Zizania aquatica	Southern wild rice	1.0	1.2	0.0	26.2	△	-100.0	▽
Nymphaea odorata	White water lily	0.0	0.4	0.6		△	60.0	△
Vallisneria americana	Wild celery	0.0	0.0	0.6		-		△
Sparganium sp.	Bur-reed sp.	0.0	0.0	0.6		-		△
Potamogeton epihydrus	Ribbon-leaf pondweed	0.3	1.2	0.0	278.6	△	-100.0	▽
Lemna trisulca	Forked duckweed	0.0	0.0	0.6		-		△
Fissidens spp. & Fontinalis spp.	Aquatic Moss	1.3	0.0	0.0	-100.0	▽		-
Eleocharis acicularis	Needle spikerush	0.0	0.0	0.3		-		△
Ceratophyllum echinatum	Spiny hornwort	0.0	0.0	0.3		-		△
Sagittaria latifolia	Common arrowhead	0.3	0.0	0.0	-100.0	▽		-
Chara spp.	Muskgrasses	0.3	0.0	0.0	-100.0	▽		-
Calla palustris	Water arum	0.3	0.0	0.0	-100.0	▽		-

▲ or ▼ = Change Statistically valid (Chi-square α = 0.05)
△ or ▽ = Change Not Statistically valid (Chi-square α = 0.05)

The WDNR developed a web-based viewer that has the capability of showing the point-intercept survey results on an individual species level. At current, only the 2012 and 2019 data are uploaded to the database, with the expectation that the 2024 data will be added in the future. The web viewer aids in understanding the shifts in the lake for where certain aquatic plants are present. The application can be found here: https://dnr-wisconsin.shinyapps.io/AquaticPlantExplorer/. For many of the native aquatic plants shown below, there was a valid decline in occurrence from 2012-2019, followed by a valid increase in occurrence from 2019-2024.

During the 2012 surveys on Mirror Lake, large blanket-like mats of duckweed and watermeal were observed within the lake's western basin (Photo 2.3-1), and as is discussed within the 2019 *Mirror Lake Comprehensive Management Plan*, the abundance of these free-floating species is an indicator of excessive nutrient levels, specifically ammonia nitrogen. In 2019, these blanket-like mats of duckweed and watermeal were observed in Mirror Lake's western basin but covered a smaller area when compared to 2012 (Photo 2.3-2). In 2024, these mats were still observed in many parts of Mirror Lake, but at a higher occurrence than in 2019 (Photo 2.3-3). The point-intercept survey data indicated turion duckweed and watermeal spp. both saw statistically valid increases of occurrence from 2019 to 2024. The frequency of occurrence of these two species were mapped at almost the same levels that they first were back in 2012 (Figure 2.3-6).

Photographs 2.3-1-3. Duckweed and watermeal coverage in 2012 vs 2019 vs 2024. Photos taken on June 25, 2012, June 25, 2019 and June 24, 2024. Photo credit Onterra.

The diversity of Mirror Lake's plant community, calculated using the Simpson's Diversity Index, has remained almost the exact same from 2012-2024, remaining between 0.88 and 0.89 (Figure 2.3-4). Compared to 392 lakes statewide, Mirror Lake's Simpson's Diversity Index value has always been above the 75th percentile, and the lake is considered to have high aquatic plant species diversity.

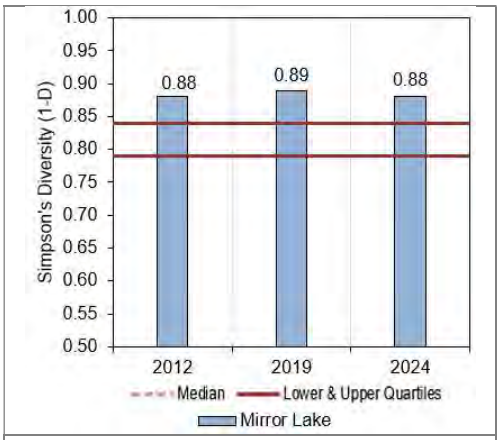

Figure 2.3-4. Mirror Lake 2012, 2019 and 2024 Simpson's Diversity Index. Created using data from 2012, 2019 and 2024 point-intercept surveys.

3.0 WATER QUALITY SUMMARY

Reporting of water quality assessment results can often be a difficult and ambiguous task. Foremost is that the assessment inherently calls for a baseline knowledge of lake chemistry and ecology. Many of the parameters assessed are part of a complicated cycle and each element may occur in many different forms within a lake. Furthermore, because judging water quality is often subjective, water quality values that may be considered poor for one lake may be considered good for another. However, focusing on specific aspects or parameters that are important to lake ecology, comparing those values to similar lakes within the same region and historical data from the study lake provides an excellent method to evaluate the quality of a lake's water.

Many types of analyses are available for assessing the condition of a particular lake's water quality. In this document, the water quality analysis focuses upon attributes that are directly related to the productivity of the lake. In other words, the water quality that impacts and controls the fishery, plant production, and even the aesthetics of the lake are related here. Specific forms of water quality analysis are used to indicate not only the health of the lake, but also to provide a general understanding of the lake's ecology and assist in management decisions. Each type of analysis used in this report is elaborated on below.

As mentioned above, chemistry is a large part of water quality analysis. In most cases, listing the values of specific parameters really does not lead to an understanding of a lake's water quality, especially in the minds of non-professionals. A better way of relating the information is to compare it to lakes with similar physical characteristics and lakes within the same regional area. In this document, a portion of the water quality information collected on Mirror Lake is compared to other lakes in the state with similar characteristics. In addition, the assessment can also be clarified by limiting the primary analysis to parameters that are important in the lake's ecology and trophic state (see below). Three water quality parameters, called the *trophic parameters*, are focused upon in the Mirror Lake's water quality analysis:

Phosphorus is the nutrient that controls the growth of plants in the vast majority of Wisconsin lakes. It is important to remember that in lakes, the term plants includes both algae and macrophytes. Monitoring and evaluating concentrations of phosphorus within the lake helps to create a better understanding of the current and potential growth rates of the plants within the lake.

Chlorophyll-*a* is the green pigment in plants used during photosynthesis. Chlorophyll-*a* concentrations are directly related to the abundance of free-floating algae in the lake. Chlorophyll-*a* values increase during algal blooms.

Secchi disk transparency is a measurement of water clarity. Of all limnological parameters, it is the most used and the easiest for non-professionals to understand. Furthermore, measuring Secchi disk transparency over long periods of time is one of the best methods of monitoring the health of a lake. The measurement is conducted by lowering a weighted, 20-cm diameter disk with alternating black and white quadrates (a Secchi disk) into the water and the average of the depths at which it disappears and then reappears is recorded.

The parameters described above are interrelated. Phosphorus controls free-floating algal abundance, which is measured by chlorophyll-*a* levels. Water clarity, as measured by Secchi disk transparency, is directly affected by the particulates that are suspended in the water. In the majority

of natural Wisconsin lakes, the primary particulate matter is algae; therefore, algal abundance directly affects water clarity. In addition, studies have shown that water clarity is used by most lake users to judge water quality – clear water equals clean water (Canter et al. 1994, Dinius 2007, and Smith et al. 1991).

Trophic State

Total phosphorus, chlorophyll-*a*, and water clarity values are directly related to the trophic state of the lake. As nutrients, primarily phosphorus, accumulate within a lake, its productivity increases and the lake progresses through three trophic states: oligotrophic, mesotrophic, and finally eutrophic. Every lake will naturally progress through these states and under natural conditions (i.e. not influenced by the activities of humans) this progress can take tens of thousands of years. Unfortunately, human influence has accelerated this natural aging process in many Wisconsin lakes. Monitoring the trophic state of a lake gives stakeholders a method by which to gauge the productivity of their lake over time. Yet, classifying a lake into one of three trophic states often does not give clear indication of where a lake really exists in its trophic progression because each trophic state represents a range of productivity. Therefore, two lakes classified in the same trophic state can actually have very different levels of production.

Trophic states describe the lake's ability to produce plant matter (production) and include three continuous classifications: Oligotrophic lakes are the least productive lakes and are characterized by being deep, having cold water, and few plants. Eutrophic lakes are the most productive and normally have shallow depths, warm water, and high plant biomass. Mesotrophic lakes fall between these two categories.

However, through the use of a trophic state index (TSI), an index number can be calculated using phosphorus, chlorophyll-*a*, and clarity values that represent the lake's position within the eutrophication process. This allows for a clearer understanding of the lake's trophic state while facilitating clearer long-term tracking. Carlson (1977) presented a trophic state index that gained great acceptance among lake managers.

Comparisons with Other Datasets

The WDNR publication *Implementation and Interpretation of Lakes Assessment Data for the Upper Midwest* (PUB-SS-1044 2008) is an excellent source of data for comparing water quality from a given lake to lakes with similar features and lakes within specific regions of Wisconsin. Water quality among lakes, even among lakes that are located in close proximity to one another, can vary due to natural factors such as depth, surface area, the size of its watershed, and the composition of the watershed's land cover. For this reason, the water quality of Mirror Lake will be compared to lakes in the state with similar physical characteristics. The WDNR groups Wisconsin's lakes into 6 classifications (Figure 3.0-1).

First, the lakes are classified into two main groups: **shallow (mixed)** or **deep (stratified)**. Shallow lakes tend to mix throughout or periodically during the growing season and as a result, remain well-oxygenated. Further, shallow lakes often support aquatic plant growth across most or the entire lake bottom. Deep lakes tend to stratify during the growing season and have the potential to have low oxygen levels in the bottom layer of water (hypolimnion). Aquatic plants are usually restricted to the shallower areas around the perimeter of the lake (littoral zone). An equation developed by Lathrop and Lillie (1980) incorporates the maximum depth of the lake and the lake's

surface area to predict whether the lake is considered a shallow (mixed) lake or a deep (stratified) lake. The lakes are further divided into classifications based on their hydrology and watershed size:

Seepage Lakes have no permanent surface water inflow or outflow in the form of rivers and/or streams.

Drainage Lakes have surface water inflow and/or outflow in the form of rivers and/or streams.

Headwater drainage lakes have a watershed of less than 4 square miles.

Lowland drainage lakes have a watershed of greater than 4 square miles.

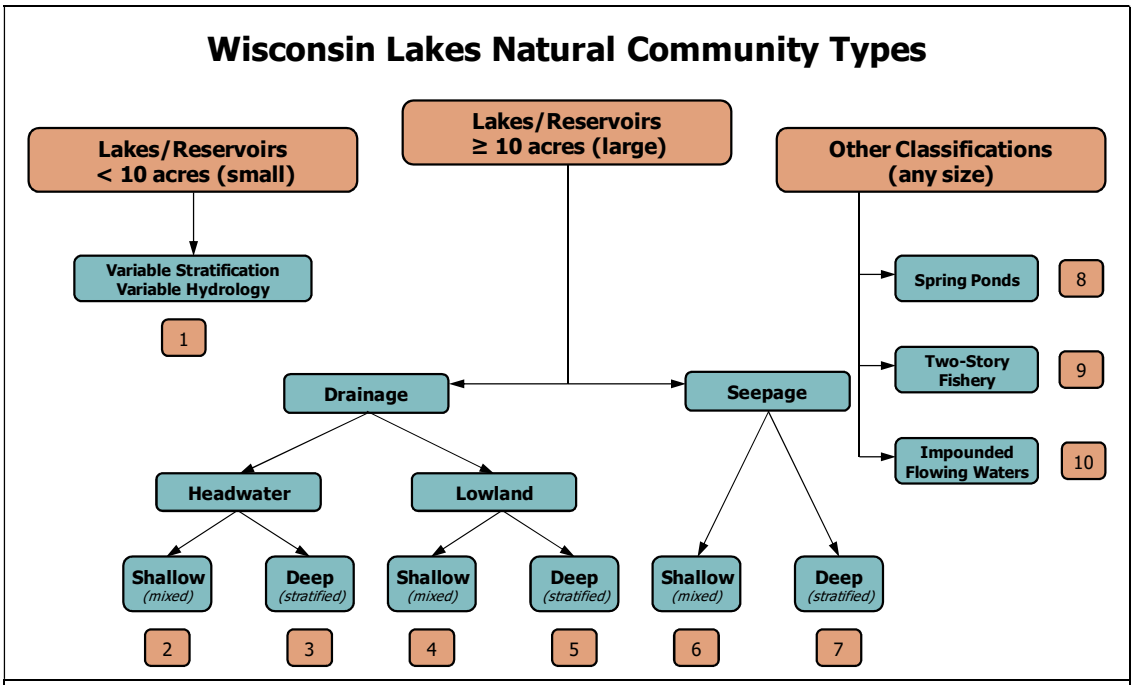

Figure 3.0-1. Wisconsin Lake Classifications. Mirror Lake is classified as a shallow (mixed), lowland drainage lake (Class 4). Adapted from WDNR 2017

Paul Garrison (Garrison, et al., 2008) developed statewide median values for total phosphorus, chlorophyll-*a*, and Secchi disk transparency for six of the lake classifications. Though they did not sample sufficient lakes to create median values for each classification within each of the state's ecoregions, they were able to create median values based on all of the lakes sampled within each ecoregion (Figure 3.0-2). Ecoregions are areas related by similar climate, physiography, hydrology, vegetation and wildlife potential. Comparing ecosystems in the same ecoregion is sounder than comparing systems within manmade boundaries such as counties, towns, or states. Mirror Lake is within the Driftless Area (DA) ecoregion.

The Wisconsin 2020 Consolidated Assessment and Listing Methodology document also helps stakeholders understand the health of their lake compared to other lakes within the state. Looking at pre-settlement diatom population compositions from sediment cores collected from numerous

lakes around the state, they were able to infer a reference condition for each lake's water quality prior to human development within their watersheds. Using these reference conditions and current water quality data, the assessors were able to rank phosphorus, chlorophyll-*a*, and Secchi disk transparency values for each lake class into categories ranging from excellent to poor.

These data along with data corresponding to statewide natural lake means, historic, current, and average data from Big Hills Lake is displayed in Figures 3.1-1 - 3.1-4. Please note that the data in these graphs represent concentrations and depths taken only during the growing season (April-October) or summer months (June-August). Furthermore, the phosphorus and chlorophyll-*a* data represent only surface samples. Surface samples are used because they represent the depths at which algae grow and depths at which phosphorus levels are not greatly influenced by phosphorus being released from bottom sediments.

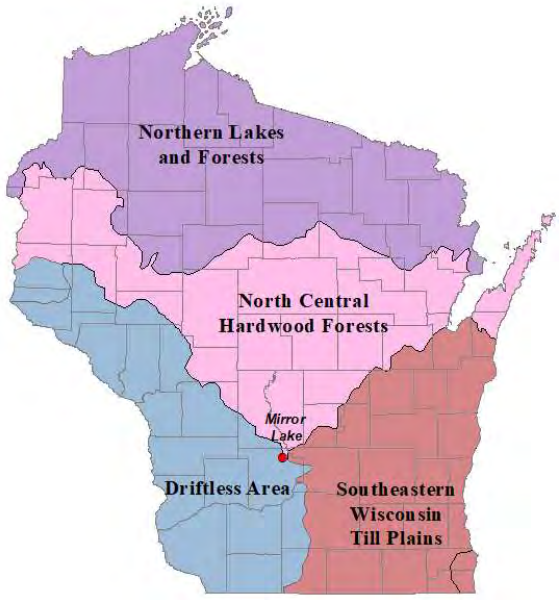

Figure 3.0-2. Location of Mirror Lake within the ecoregions of Wisconsin. After Nichols 1999.

3.1 Mirror Lake Trophic Parameter Summary

The historical water quality data that exist for Mirror Lake are sporadic and relatively limited. The data that were available when the last plan update was completed in 2014 were collected from two locations within the lake: one is located in the upstream-most portion of the lake (Upper Mirror Lake), while the other is located downstream near the Ishnala Restaurant (Lower Mirror Lake) (Map 1). The data collected from the most downstream location, in this case, Lower Mirror Lake, has not had any data collected since the last plan update in 2014. Therefore, that data from the most downstream location will not be included in this report update, as there is no new data from that site to report on. However, beginning in 2015, the Mirror Lake Management District began collecting data at another site located within Mirror Lake, this one being located in the southern basin of Mirror Lake near the state park boat landing (Map 1). This site has been the source of the lake's most recent data and will also be included within this report. The site for this data will be referenced as the "Southern Boat Landing". Within a lake like Mirror Lake, where there is a significant amount of flow throughout the lake's entirety, the data cannot be merged as one set of data, due to the sites where available data is collected being too far from each other.

Near-surface total phosphorus data are available from the Upper Mirror Lake sampling site from 1993-1994, 2004, 2012 and 2015. All of the total phosphorus concentrations measured over these time periods fall within the *Fair* and *Poor* categories for shallow, lowland drainage lakes (Figure 3.1-1). Growing season and summer total phosphorus concentrations measured in 2015 were the second highest recorded at this sampling location, averaging approximately 130 µg/L and falling within the *Poor* category. The weighted average summer near-surface total phosphorus concentrations for all years at the Upper Mirror Lake sampling site fall within the *Poor* category, and is nearly four times higher than the state-wide median total phosphorus concentration for

shallow, lowland drainage lakes. Total phosphorus concentrations measured from water near the lake bottom were similar to near-surface concentrations, indicating internal nutrient loading from bottom sediments is likely not occurring within Upper Mirror Lake. Because the total phosphorus data available from Upper Mirror Lake are limited and temporally sporadic, it is not possible to determine if trends (positive or negative) are occurring over time.

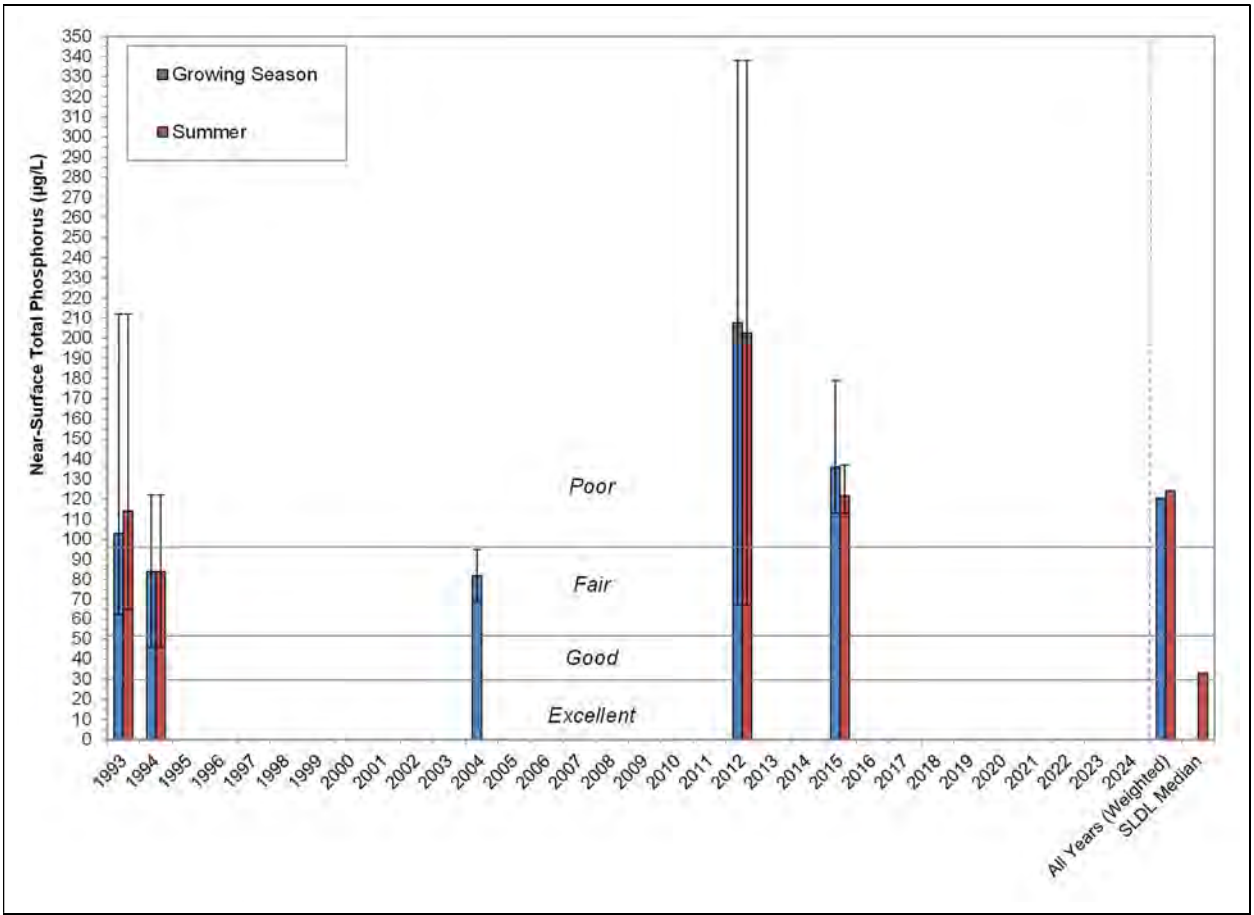

Figure 3.1-1. Upper Mirror Lake annual and state-wide shallow, lowland drainage lakes median total phosphorus concentrations. State-wide median values calculated with summer month surface sample data. Error bars indicate minimum and maximum values. Water Quality Index values adapted from WDNR PUB WT-913.

Near-surface total phosphorus data are available from the southern boat landing sampling site from 1993-1994, 1996, 2008-2009, 2012 and 2015-2024. All of the total phosphorus concentrations measured over these time periods except for the growing season in 1996, fall within the *Fair* and *Poor* categories for shallow, lowland drainage lakes (Figure 3.1-2). Growing season and summer total phosphorus concentrations measured in 2024 fell within the average of totals recorded at this sampling location, averaging approximately 67 µg/L and falling within the *Fair* category. The weighted average summer near-surface total phosphorus concentrations for all years at the southern boat landing sampling site fall within the *Fair* category and is nearly two and a half times higher than the state-wide median total phosphorus concentration for shallow, lowland drainage lakes. Total phosphorus concentrations measured from water near the lake bottom were similar to near-surface concentrations, indicating internal nutrient loading from bottom sediments is likely

not occurring within Upper Mirror Lake. The most recent years of data indicate that there are no significant positive or negative trends occurring recently within the area of Mirror Lake near the southern boat landing, and because the limited the total phosphorus data available from the southern boat landing are limited and temporally sporadic, it is not possible to determine if trends (positive or negative) are occurring over the long-term either.

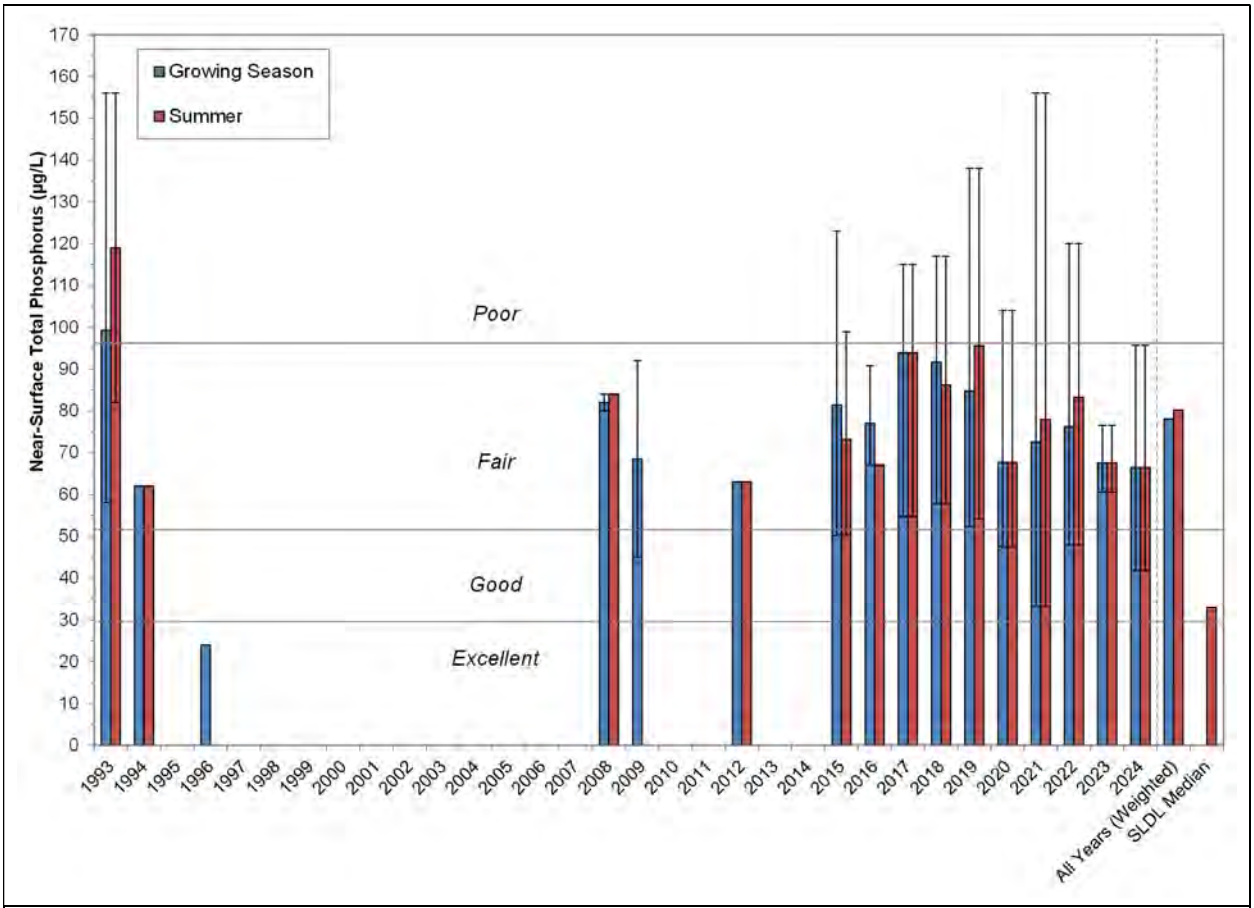

Figure 3.1-2. Southern boat landing annual and state-wide shallow, lowland drainage lakes median total phosphorus concentrations. State-wide median values calculated with summer month surface sample data. Error bars indicate minimum and maximum values. Water Quality Index values adapted from WDNR PUB WT-913.

Like total phosphorus, chlorophyll-*a* data from Mirror Lake is also limited and temporally sporadic. Most of the historical chlorophyll-*a* data is from the sampling location in Upper Mirror Lake, and are available from 1980, 1992-1994, 2001, 2004, 2012 and 2015 (Figure 3.1-3). The data collected from 1980 through 2004 are relatively consistent and fall within the *Excellent* or *Good* categories, with the exception of 2001, which fell in the *Fair* category. Average chlorophyll-*a* concentrations for 2012 were significantly higher than what has been recorded in the past, falling into the *Poor* category. However, the 2012 growing season and summer averages are being skewed by a single sampling event that occurred on August 28, 2012 and yielded a chlorophyll-*a* concentration of 229 µg/L. The chlorophyll-*a* concentration measured in August 2012 is not believed to due to an analysis error, as it correlates with a significant increase in total phosphorus. If the August 2012 sampling event is removed, the 2012 average growing season chlorophyll-*a* concentration straddles the *Good-Fair* threshold, while the average summer concentration falls within the *Fair* category.

In 2015, the data collected for chlorophyll-*a* was the lowest collected levels to date on Upper Mirror Lake, with the average concentration averaging only 2.5 µg/L. However, the weighted averages from all years available for chlorophyll-*a* in Upper Mirror Lake (minus the August 2012 data) fall within the *Good* category and are slightly higher than the median for shallow, lowland drainage lakes in Wisconsin.

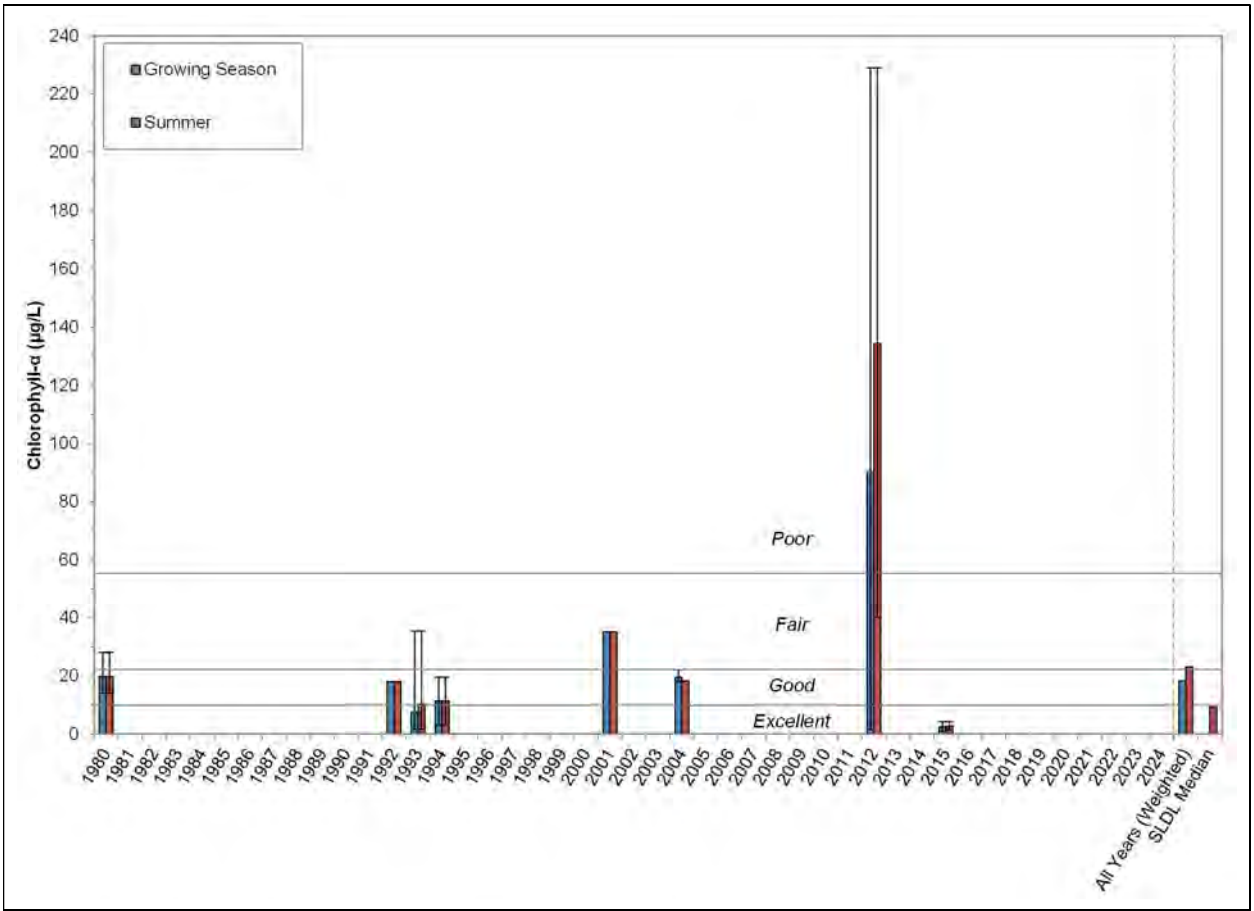

Figure 3.1-3. Upper Mirror Lake annual and state-wide shallow, lowland drainage lakes median chlorophyll-α concentrations. State-wide median values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Most of the recent historical chlorophyll-*a* data is from the sampling location near the southern boat landing, and are available from 1994, 1996, 2008-2009, 2012 and 2015-2024 (Figure 3.1-4). The data collected from 2015 through 2024 are relatively consistent and fall within the *Good* or *Fair* categories, with the exception of 2016, which fell in the *Poor* category. In 2024, the data collected for chlorophyll-*a* was within the average of the historical available data at the southern boat landing site, with the average concentration averaging 13 µg/L. The weighted averages from all years available for chlorophyll-*a* at the southern boat landing fall within the *Good* category and are slightly higher than the median for shallow, lowland drainage lakes in Wisconsin.

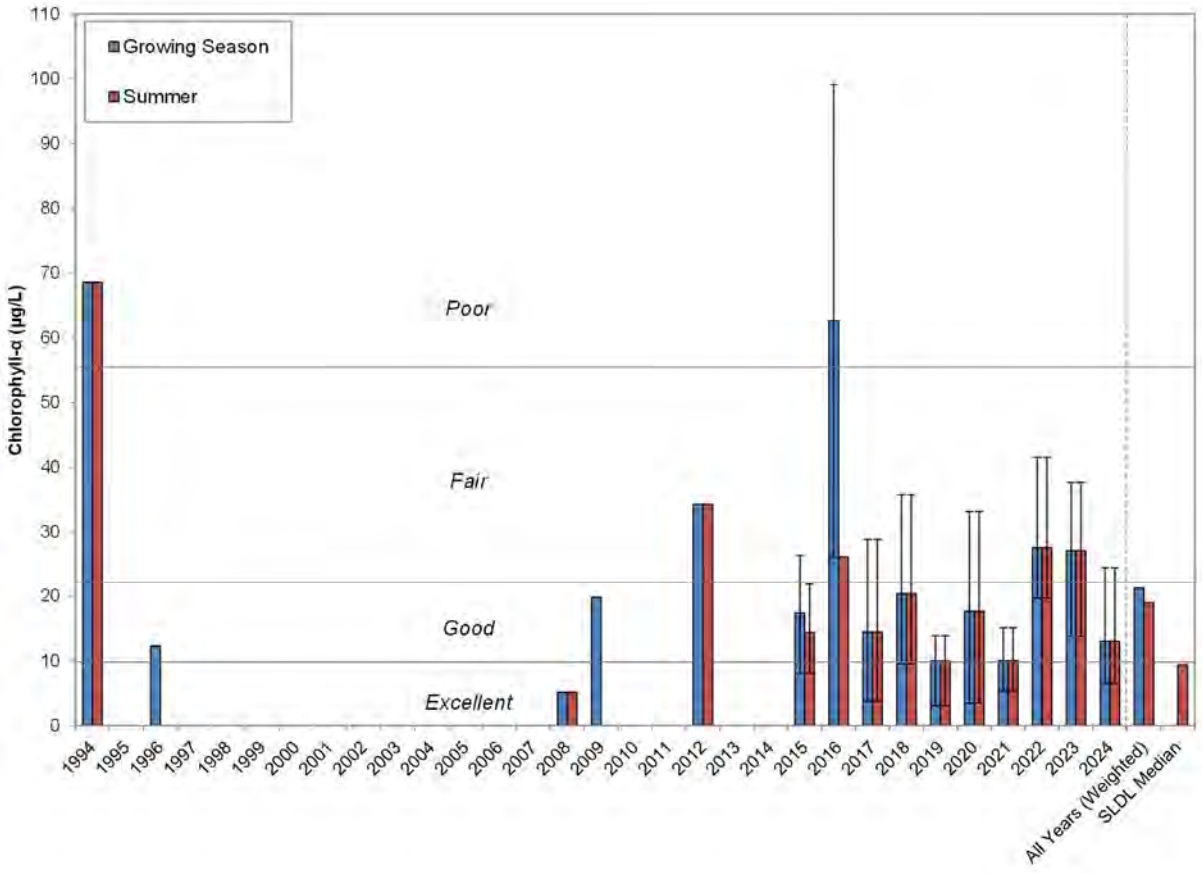

Figure 3.1-4. Southern boat landing annual and state-wide shallow, lowland drainage lakes median chlorophyll-α concentrations. State-wide median values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Despite having high nutrient concentrations, Mirror Lake has relatively low algal abundance, for which there are likely two main reasons. First, as mentioned, Mirror Lake has a very large watershed when compared to the size of the lake. Modeling (discussed in the Comprehensive Management Plan Watershed Section) indicates that Mirror Lake has a high flushing rate, as the water in the lake is estimated to be completely replaced on average every seven days. With a flushing rate this high, algae do not have sufficient time to grow and multiply before being carried downstream. On the other hand, WiLMS modeling of downstream Lake Delton which is larger and has a greater water volume than Mirror Lake, has an estimated flushing rate of approximately three weeks, which provides algae plenty of time to grow and multiply. Secondly, Mirror Lake has abundant growth of aquatic vascular plants (macrophytes) which remove nutrients from the water and make them unavailable to free-floating algae. With the limited chlorophyll-*a* data available from Mirror Lake, a determination as to whether or not a trend (positive or negative) in algal abundance is occurring over time cannot be made.

Of the historical water quality data that are available from Mirror Lake, Secchi disk transparency data are the most abundant. In Upper Mirror Lake, data are available from 1980, 1993-1994, 2001, 2007-2009, 2012 and 2015 (Figure 3.1-5). Water clarity from 1980 to 2012 varied insignificantly between 4.2 and 5.8 feet, with the exception of 2008 which was the year of a significant flooding event that drained Lake Delton. Water clarity measurements recorded in 2015 were similar to

what was recorded in the most recent years, with the growing season average falling in the *Good* category. There are no values for the summer averages since no data was collected during that period of time in 2015. The weighted average for all years of available data places Upper Mirror Lake in the *Good* category for shallow, lowland drainage lakes in Wisconsin.

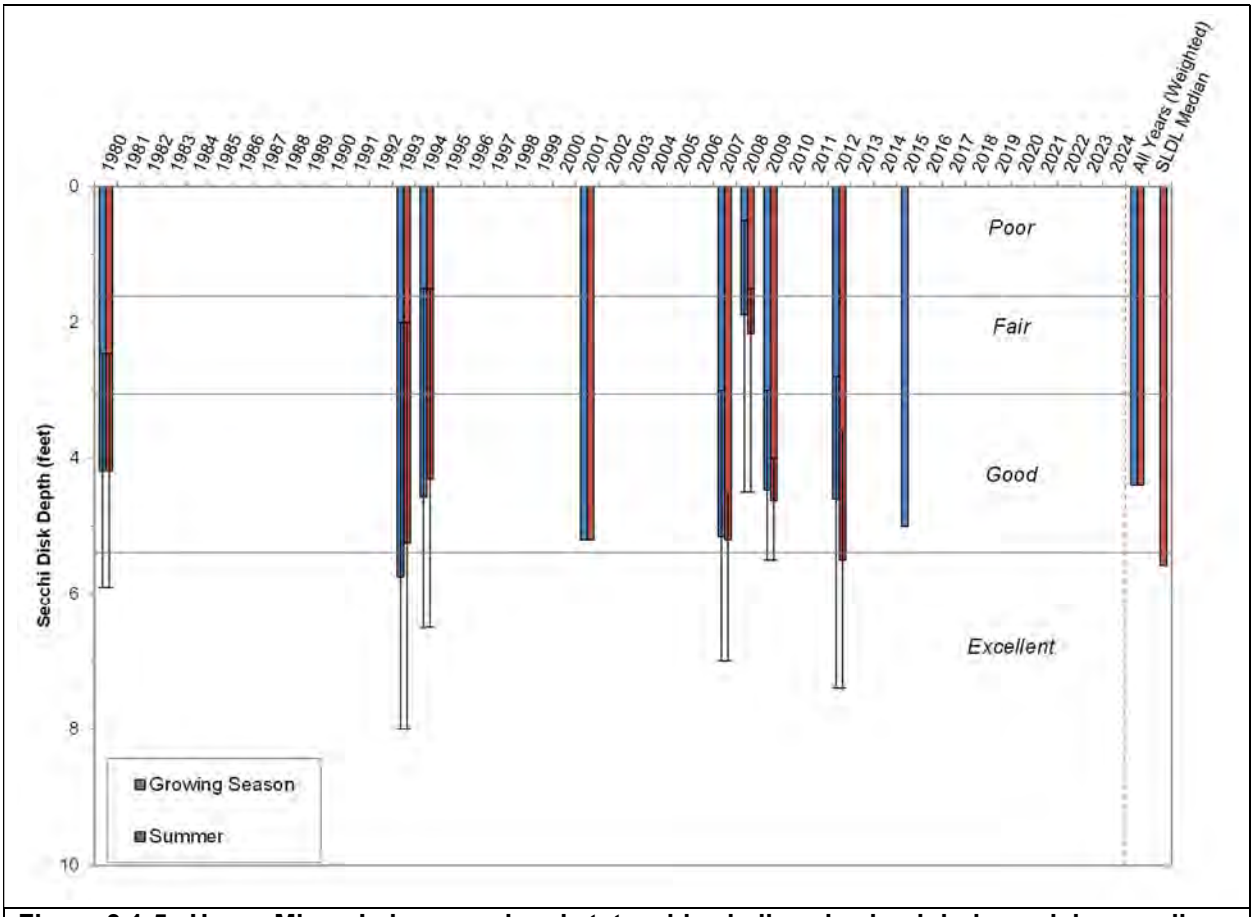

Figure 3.1-5. Upper Mirror Lake annual and state-wide shallow, lowland drainage lakes median Secchi disk transparency values. State-wide median values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

At the southern boat landing, data are available from 1987, 1993-1995, 2007-2009 and 2015-2024 (Figure 3.1-6). Water clarity from 2015 to 2024 varied insignificantly between 3.7 and 6.3 feet. Water clarity measurements recorded in 2024 were the best recorded measurements to date at the southern boat landing site, being only the second time the growing season average at that site fell in the *Excellent* category. The weighted average for all years of available data places the southern boat landing in the *Good* category for shallow, lowland drainage lakes in Wisconsin.

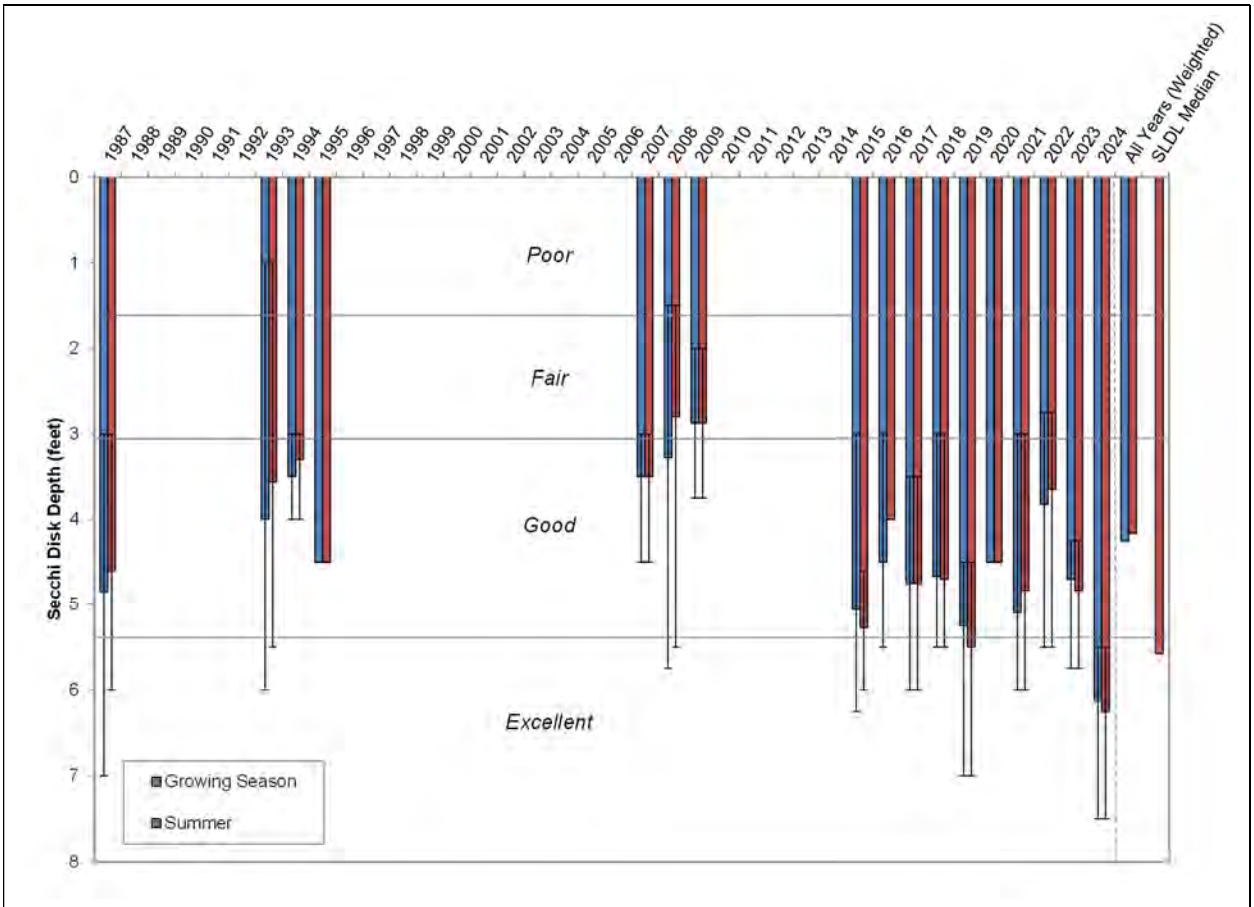

Figure 3.1-6. Southern boat landing annual and state-wide shallow, lowland drainage lakes median Secchi disk transparency values. State-wide median values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Mirror Lake Trophic State

Figure 3.1-4 contains the Trophic State Index (TSI) values calculated from data collected from Upper Mirror Lake. The TSI values are calculated with Secchi disk, chlorophyll-*a*, and total phosphorus values. In general, the best values to use in judging a lake's trophic state are ones relative to biological activity. Because water clarity can be influenced by other parameters other than algae, total phosphorus and chlorophyll-*a* are the best values to use. Using these parameters, it can be concluded that Mirror Lake is in an upper-eutrophic state. While Mirror Lake's chlorophyll-*a* levels fall within the eutrophic level, much of Mirror Lake's production is within the aquatic plant community, primarily the excessive growth of duckweed. In addition, most of the total phosphorus concentrations fall within the hypereutrophic level.

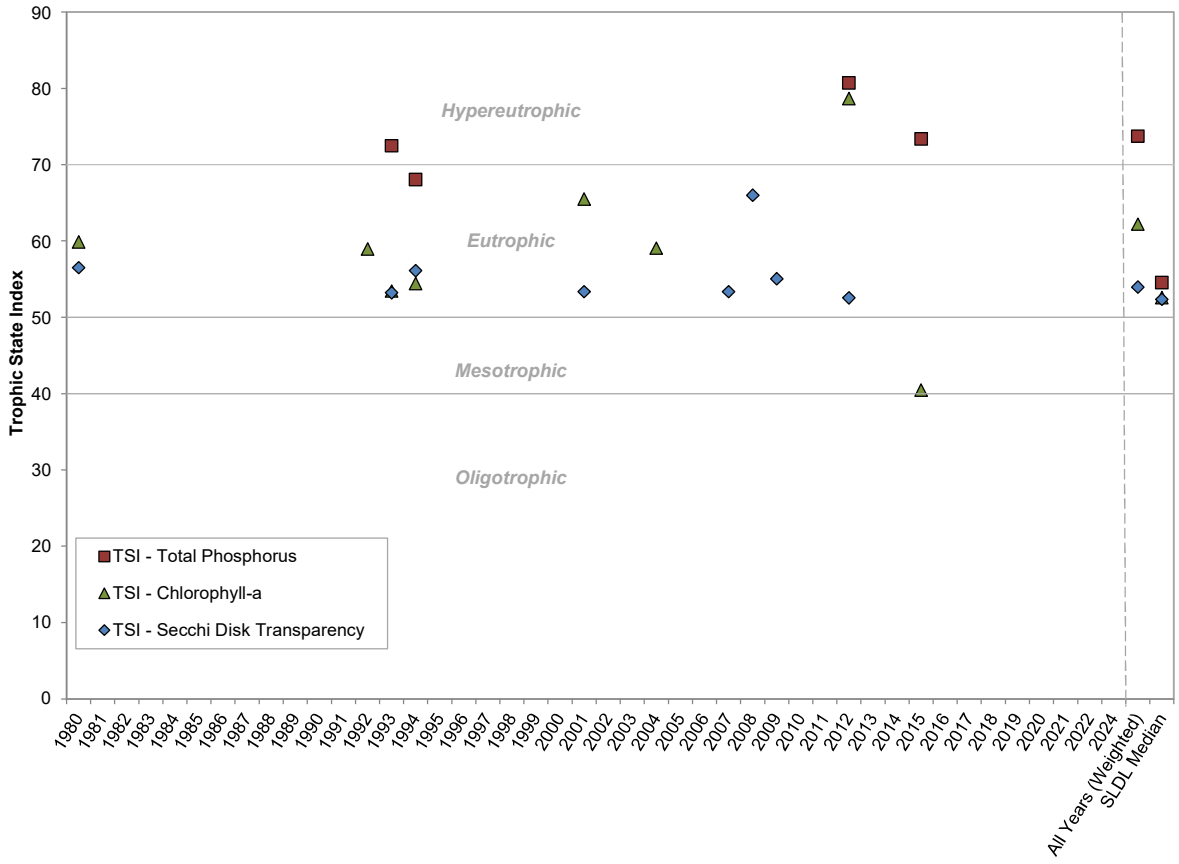

Figure 3.1-7. Upper Mirror Lake, state-wide class 3 lakes, and regional Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Figure 3.1-8 contains the Trophic State Index (TSI) values calculated from data collected from the southern boat landing site. The TSI values are calculated with Secchi disk, chlorophyll-*a*, and total phosphorus values. In general, the best values to use in judging a lake's trophic state are ones relative to biological activity. Because water clarity can be influenced by other parameters other than algae, total phosphorus and chlorophyll-*a* are the best values to use. Using these parameters, it can be concluded that Mirror Lake is in an upper-eutrophic state. While Mirror Lake's chlorophyll-*a* levels fall within the eutrophic level, much of Mirror Lake's production is within the aquatic plant community, primarily the excessive growth of duckweed. In addition, most of the total phosphorus concentrations fall within the upper-eutrophic level as well.

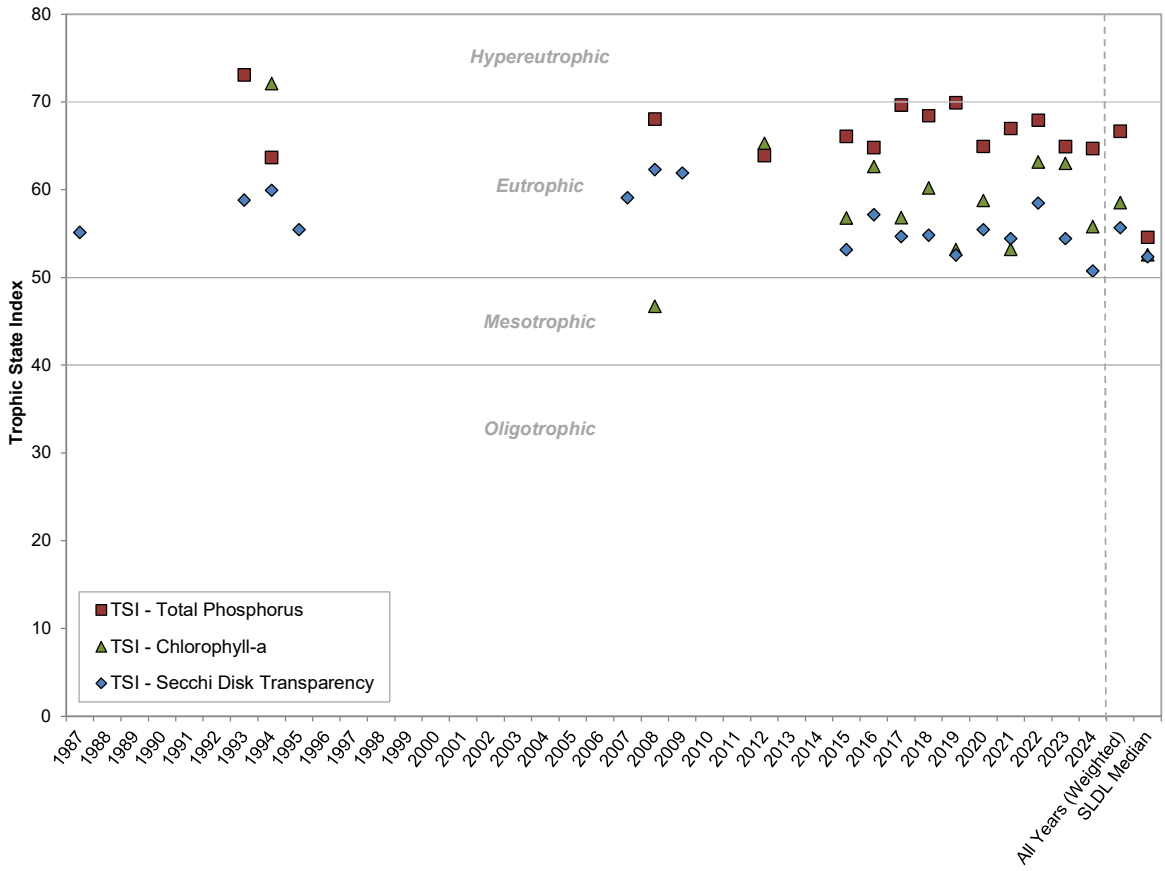

Figure 3.1-8. Southern boat landing, state-wide class 3 lakes, and regional Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

4.0 WATERSHED SUMMARY

Watershed Modeling

Two aspects of a lake's watershed are the key factors in determining the amount of phosphorus the watershed exports to the lake; 1) the size of the watershed, and 2) the land cover (land use) within the watershed. The impact of the watershed size is dependent on how large it is relative to the size of the lake. The watershed to lake area ratio (WS:LA) defines how many acres of watershed drains to each surface-acre of the lake. Larger ratios such as Mirror Lake (306:1) result in the watershed having a greater role in the lake's annual water budget and phosphorus load.

A lake's **flushing rate** is simply a determination of the time required for the lake's water volume to be completely exchanged. **Residence time** describes how long a volume of water remains in the lake and is expressed in days, months, or years. The parameters are related and both determined by the volume of the lake and the amount of water entering the lake from its watershed. Greater flushing rates equal shorter residence times.

The type of land cover that exists in the watershed determines the amount of phosphorus (and sediment) that runs off the land and eventually makes its way to the lake. The actual amount of pollutants (nutrients, sediment, toxins, etc.) depends greatly on how the land within the watershed is used. Vegetated areas, such as forests, grasslands, and meadows, allow the water to permeate the ground and do not produce much surface runoff. On the other hand, agricultural areas, particularly row crops, along with residential/urban areas, minimize infiltration and increase surface runoff. The increased surface runoff associated with these land cover types leads to increased phosphorus and pollutant loading, which, in turn, can lead to nuisance algal blooms, increased sedimentation, and/or overabundant macrophyte populations. For these reasons, it is important to maintain as much natural land cover (forests, wetlands, etc.) as possible within a lake's watershed to minimize the amount of runoff (nutrients, sediment, etc.) from entering the lake.

In systems with lower WS:LA ratios, land cover type plays a very important role in how much phosphorus is loaded to the lake from the watershed. In these systems, the occurrence of agriculture or urban development in even a small percentage of the watershed (less than 10%) can unnaturally elevate phosphorus inputs to the lake. If these land cover types are converted to a cover that does not export as much phosphorus, such as converting row crop areas to grass or forested areas, the phosphorus load and its impacts to the lake may be decreased. In fact, if the phosphorus load is reduced greatly, changes in lake water quality may be noticeable, (e.g. reduced algal abundance and better water clarity) and may even be enough to cause a shift in the lake's trophic state.

In systems with high WS:LA ratios, like those 10-15:1 or higher, the impact of land cover may be tempered by the sheer amount of land draining to the lake. Situations actually occur where lakes with completely forested watersheds have sufficient phosphorus loads to support high rates of plant production. In other systems with high ratios, the conversion of vast areas of row crops to vegetated areas (grasslands, meadows, forests, etc.) may not reduce phosphorus loads sufficiently to see a change in plant production. Both of these situations occur frequently in impoundments.

Regardless of the size of the watershed or the makeup of its land cover, it must be remembered that every lake is different and other factors, such as flushing rate, lake volume, sediment type, and many others, also influence how the lake will react to what is flowing into it. For instance, a

deeper lake with a greater volume can dilute more phosphorus within its waters than a less voluminous lake and as a result, the production of a lake is kept low. However, in that same lake, because of its low flushing rate (a residence time of years), there may be a buildup of phosphorus in the sediments that may reach sufficient levels over time and lead to a problem such as internal nutrient loading. On the contrary, a lake with a higher flushing rate (low residence time, i.e., days or weeks) may be more productive early on, but the constant flushing of its waters may prevent a buildup of phosphorus and internal nutrient loading may never reach significant levels.

A reliable and cost-efficient method of creating a general picture of a watershed's effect on a lake can be obtained through modeling. The WDNR created a useful suite of modeling tools called the Wisconsin Lake Modeling Suite (WiLMS). Certain morphological attributes of a lake and its watershed are entered into WiLMS along with the acreages of different types of land cover within the watershed to produce useful information about the lake ecosystem. This information includes an estimate of annual phosphorus load and the partitioning of those loads between the watershed's different land cover types and atmospheric fallout entering through the lake's water surface. WiLMS also calculates the lake's flushing rate and residence times using county-specific average precipitation/evaporation values or values entered by the user. Predictive models are also included within WiLMS that are valuable in validating modeled phosphorus loads to the lake in question and modeling alternate land cover scenarios within the watershed. Finally, if specific information is available, WiLMS will also estimate the significance of internal nutrient loading within a lake and the impact of shoreland septic systems.

The Mirror Lake comprehensive management planning project included a detailed modeling component, including scenario development. The section below includes a summary and discussion of how the Mirror Lake watershed's land cover has changed since the creation of the comprehensive management plan. It is a summary update that does not include the update of the Mirror Lake watershed model.

Mirror Lake Watershed Land Cover Changes

The Mirror Lake watershed is reassessed in this report utilizing two databases: 1) the National Land Cover Database (NLCD), and 2) the WDNR 2019 Digital Elevation Model (DEM). The NLCD is a spatial reference and descriptive database of the land cover for the conterminous United States, provided by the U.S. Geological Survey (USGS, 2023). Each 3-year update of the NLCD includes higher resolution delineations and increased classification of land cover types. The WDNR DEM utilizes county-based land elevations developed with Light Detection and Ranging (LiDAR). LiDAR is a remote sensing method of pulsed lasers, that can be used to chart the surface of the earth (NOAA, 2023). Overall, the WDNR DEM allows for much more precise delineation of watershed boundaries due to the high resolution of the elevation data.

Due to better watershed delineation technology with more accurate watershed boundaries since the 2014 plan, updated watershed boundaries are used in this report (Figure 4.0-1). This results in slightly different quantifications than what was included in the 2014 plan but are more accurate. The updated watershed outline as reported in 2024 (42,644 acres), is slightly smaller than that of the watershed outline reported 2014 (42,726 acres).

While the watershed assessments are included in the 2014 report, as well as this report, the land cover is determined using data from NLCD 2011 and NLCD 2023, respectively. The NLCD is

typically updated every three years, and each year that database is updated, as mentioned above, the resolution of the land cover delineation increases, as well as some of the classifications. As a result, comparing land cover delineations from the same lake from different time periods is not always like comparing "apples to apples". This is especially the case with Mirror Lake because the comparisons are being made between datasets that are over a decade apart.

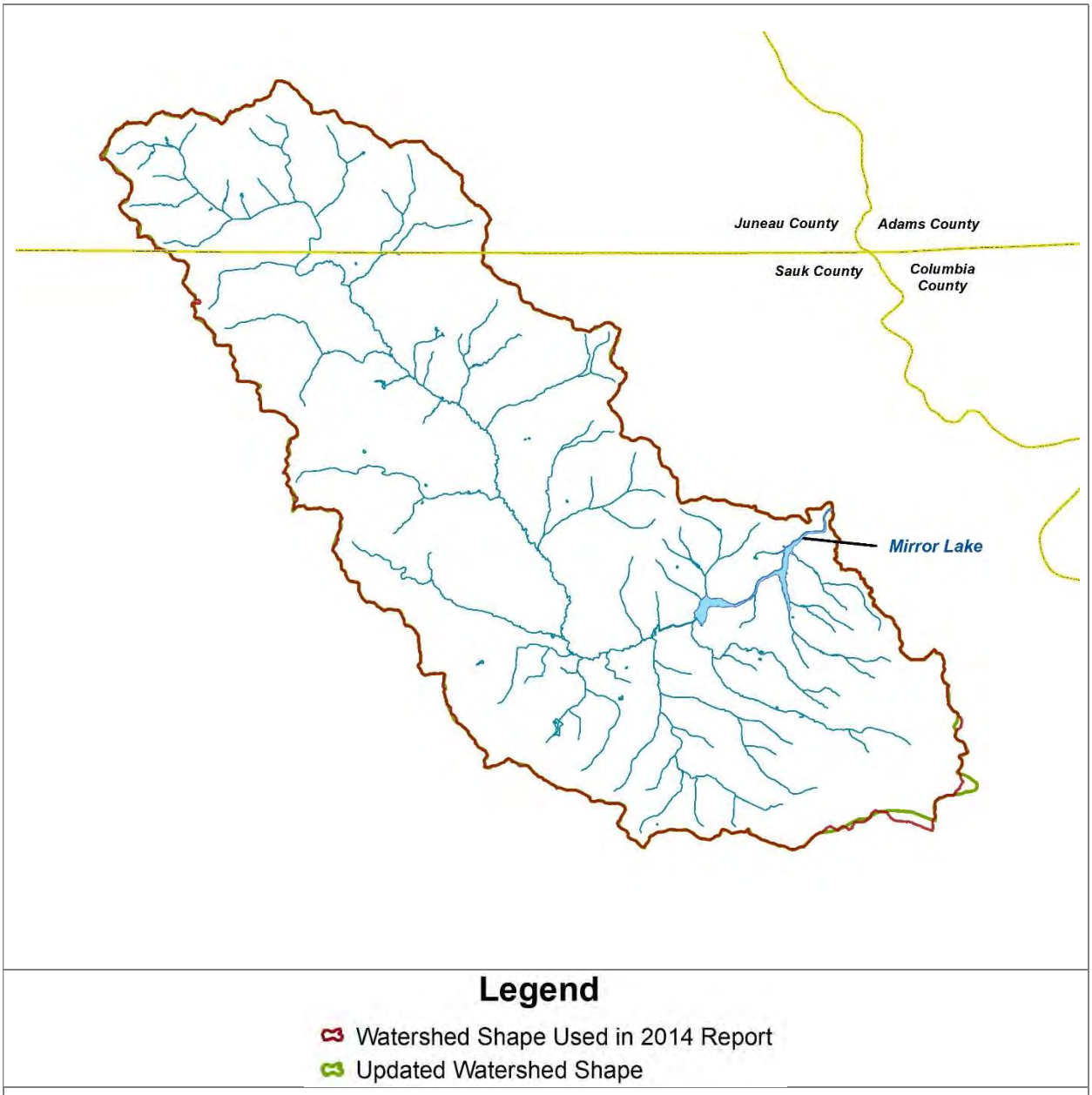

Figure 4.0-1. Mirror Lake watershed 2014 report versus 2025 report.

Using the updated watershed shape and 2011 NLCD data, Mirror Lake's watershed was found to be predominately *forest* (18,002 acres total) and included large areas of *row crops* (13,253 acres total) (Table 4.0-1). *Pasture/grass*, *wetland*, *urban - low intensity*, *urban - medium density*, *open water*, and *urban - high density* made up the remaining 11,423 acres of the watershed. A slight

rounding error during the "clipping" of landcover data in ArcGIS is the result of the 48 acre difference (0.1%) from watershed area to land cover area.

2023 land cover data showed some minor changes to the watershed as a whole when comparing the 2011 to 2023 NLCD land cover data. The classification type that exhibited the highest decrease from 2011 to 2023 was *row crops*, a 514 acre decrease to 12,739 acres. The highest increases were *urban - low intensity* with a 248 acre increase to 3,201 acres and *pasture/grass* with a 208 acre increase to 5,584 acres. The remaining land cover classification type changes were minimal (17 acres and lower) (Table 4.0-1). More details on the distribution of land cover types can be viewed in Map 4.

Land cover types are correlated with how much phosphorus is running off the land (phosphorus export) and as a result, making its way into the waterbody. Based on the analysis, it is likely that roughly 450 acres of row crops were converted into urban - low intensity and pasture/grass lands. Based on phosphorus export estimates, this change in land use decreased the phosphorus load to Mirror Lake. This is because the row crops generally produce a much higher phosphorus load than the urban - low intensity (~1/10 row crops) and pasture/grass (~1/3 row crops) lands do.

Some minor changes to the land cover observed in the NLCD data from 2011 to 2023 are likely attributed to an increased resolution and reclassification of landcover as described earlier. For instance, land that was mapped as forest in the 2011 watershed assessment has now been reclassified as wetland, meaning the 2023 mapping is able to detect forested wetlands instead of just classifying them as forests.

Table 4.0-1. Mirror Lake watershed land cover.

WiLMS Land Cover Classifications	2011 NLCD Acres	2023 NLCD Acres	Difference Acres
Forest	18002	18006	4
Row Crops	13253	12739	-514
Pasture/Grass	5376	5584	208
Wetland	2653	2664	11
Urban - Low Intensity	2952	3201	248
Urban - Medium Density	242	258	17
Open Water	146	139	-7
Urban - High Density	55	54	-1
Total	**42678**	**42644**	

The watershed exhibited little change as a whole and it is likely that the phosphorus levels in Mirror Lake would have exhibited little change as well. In other words, changes to the land cover types on the scale that was observed from the 2011 to 2023, in a large watershed like the Mirror Lake watershed, would not create a significant effect on the phosphorus load observed in the lake, and as a result, detectable changes in water quality.

5.0 AQUATIC PLANT MANGEMENT IMPLEMENTATION PLAN

The Mirror Lake Management District (MLMD) completed a *Comprehensive Management Plan* in August 2014, including investigations of aquatic plants, shoreland condition, water quality, watershed, and fisheries. This *Plan* can be found on the WDNR website located here:

https://apps.dnr.wi.gov/lakes/grants/project.aspx?project=53518409

The Implementation Plan Section (pg 72) of the *Comprehensive Management Plan* includes four strategic management goals, with a number of corresponding actions aimed at reaching the outlined goals. A summarized outline of the Implementation Plan is contained in Table 5.0-1.

Management Goal 1: Maintain and Enhance the Overall Ecological Health of Mirror Lake	
	Action: Update the Mirror Lake Management Plan in 2018.
	Action: Monitor water quality through WDNR Citizen Lake Monitoring Network.
	Action: The MLMD contracts with an environmental engineering firm to reassess the previously-dredged sedimentation basin in Upper Mirror Lake, the sedimentation basins created above the gullies around Mirror Lake, and to quantify the growth and potential removal of sand deltas at the mouths of the gullies.
Management Goal 2: Assure and Enhance the Communication of the Mirror Lake Management District with Lake Stakeholders	
	Action: The MLMD and Mirror Lake Association (MLA) will create and support a joint education committee comprised of both MLMD and MLA members to promote safe boating, water quality, public safety, and quality of life on Mirror Lake.
Management Goal 3: Control Aquatic Invasive Species in Mirror Lake and Prevent Future Introductions to and Spread from Mirror Lake	
	Action: Initiate volunteer-based monitoring of Eurasian water milfoil and curly-leaf pondweed and other non-native species in Mirror Lake.
	Action: Initiate Clean Boats Clean Waters watercraft inspections at Mirror Lake public boat landings.
Management Goal 4: Maintain Navigation in Open Water and Near-shore Areas on Mirror Lake	
	Action: Use district-owned mechanical harvester to maintain reasonable navigation on Mirror Lake.
	Action: Selectively remove course woody habitat that inhibits reasonable navigation and recreational safety on Mirror Lake.

Table 5.0-1. Implementation Plan from the 2014 Comprehensive Management Plan for Mirror Lake. Facilitated and authored by Onterra, LLC.

The objective of this project was to revisit the aquatic plant-related goals and actions of the 2014 *Plan* and adjust them appropriately based upon current best management practices (BMPs), the lessons learned during the years since the last plan was developed, and the information gathered during the Onterra studies completed to date. As a result, this project will only revisit what was Management Goals numbers 3 and 4 (Table 5.0-1). The MLMD, as appropriate, will continue to follow the remaining goals outlined in the 2014 *Comprehensive Management Plan.*

The updated Implementation Plan presented below was created through the collaborative efforts of MLMD Board of Commissioners, planning committee members, and ecologist/planners from Onterra. The Implementation Plan represents the path the MLMD will follow in order to meet their aquatic plant management goals. The goals detailed within the plan are realistic and based

upon the findings of the studies completed in conjunction with this planning project and the needs of the Mirror Lake stakeholders as portrayed by the members of the Board of Commissioners. The Implementation Plan is a living document that will be under constant review and adjustment depending on the condition of the lake, availability of funds, level of volunteer involvement, and needs of the stakeholders.

Management Goal 3: Control Aquatic Invasive Species in Mirror Lake and Prevent Future Introductions to and Spread from Mirror Lake

Management Action: ~~Initiate volunteer-based monitoring of Eurasian water milfoil and curly-leaf pondweed and other non-native species in Mirror Lake.~~

Update: This action is no longer supported by the MLMD because the concern over Eurasian watermilfoil and curly-leaf pondweed has subsided, and the district will rely upon periodic professional surveys to monitor AIS plant species in the lake.

Management Action: Continue Clean Boats Clean Waters watercraft inspections at Mirror Lake public boat landings.

Timeframe: Continuation of current action.

Facilitator: MLMD Board of Commissioners

Description: Although Mirror Lake already contains Eurasian water milfoil and curly-leaf pondweed, and the non-native Chinese mystery snail, it is still important to minimize the chance that additional AIS be introduced into the system and that AIS are not transported from Mirror Lake to other waterbodies. To that end, the MLMD will continue WDNR Clean Boats Clean Waters (CBCW) watercraft inspections at the two Mirror Lake public accesses.

Management Goal 4: Maintain Navigation in Open Water and Near-shore Areas on Mirror Lake

Management Action: Use district-owned mechanical harvester to maintain reasonable navigation on Mirror Lake.

Timeframe: Ongoing (Unchanged from 2014 Comprehensive Plan)

Facilitator: Mirror Lake Management District Board of Commissioners

Description: The purpose of mechanical harvesting is to allow navigation in certain areas of the lake that contain dense, nuisance levels of native and non-native aquatic plants. Map 2 displays the mechanical harvesting plan that was developed in conjunction with Onterra ecologists, WDNR staff, and district members. The map illustrates four types of harvesting areas; the primary harvest area which encompasses approximately 30 acres in Upper Mirror Lake, 50 and 30-foot wide navigational lanes which extend into Dell Creek, and a 30-foot duckweed harvesting lane in the narrows between Upper and Lower Mirror Lake.

The district will follow the cutting plan displayed on Map 2. The following conditions would apply to the harvesting:

1. A paper or electronic copy of the WDNR cover letter and permit will be on the harvester during harvesting activities.

2. Bottom sediments of the lake will not be disturbed during harvesting operations.

3. Harvesting will not be conducted in less than 3' water depths.

4. The harvester operator will watch for turtles on harvesting equipment and be sure to return any turtles found to the lake.

5. The district will submit an annual harvest record to the WDNR within 30 days of the last harvest operation of the year.

Action Steps:

1. District reapplies for a multiyear harvesting permit in 2030 (5 year).
2. District harvests in areas shown on Map 2 while following the plan listed above and restrictions indicated on the WDNR permit.
3. Harvest summary report is provided to the WDNR annually after each harvesting season.

Management Action: Selectively remove course woody habitat that inhibits reasonable navigation and recreational safety on Mirror Lake.

Timeframe: Ongoing

Facilitator: Mirror Lake Management District Board of Directors and Mirror Lake State Park

Description: As discussed in the Shoreline Condition Section, the majority of Mirror Lake's shoreline resides in the Mirror Lake State Park and is comprised of undeveloped, forested land. Trees falling into the lake are natural and are an important component of lake ecology, providing valuable structural habitat for fish and other wildlife. The 2012 course woody habitat survey revealed that Mirror Lake has a relatively high density of course woody habitat, with approximately 27 pieces of course woody habitat per shoreline mile. However, some trees that fall into the lake can impede navigation and present a recreational safety hazard for lake users, particularly in section of the lake locally known as the "Narrows" between Upper and Lower Mirror Lake. Trees that fall into or across the lake in this area often totally restrict navigation until the tree can be removed.

Since 2008, the MLMD has contracted with a local company to remove trees that impede navigation within the lake. Each year, members of the MLMD and employees from Mirror Lake State Park select trees for removal. The MLMD understands the ecological importance of

maintaining course woody habitat within the lake, and together with the Mirror Lake State Park, will only select trees for removal if they restrict reasonable navigation within the lake and/or present a safety hazard to lake users.

Action Steps:

1. Members of the MLMD and employees from Mirror Lake State Park survey the lake annually and select pieces of course woody habitat for removal if they inhibit reasonable navigation and/or present a safety hazard to lake users.
2. The MLMD contracts with a tree removal service to remove the selected trees.

6.0 LITERATURE CITED

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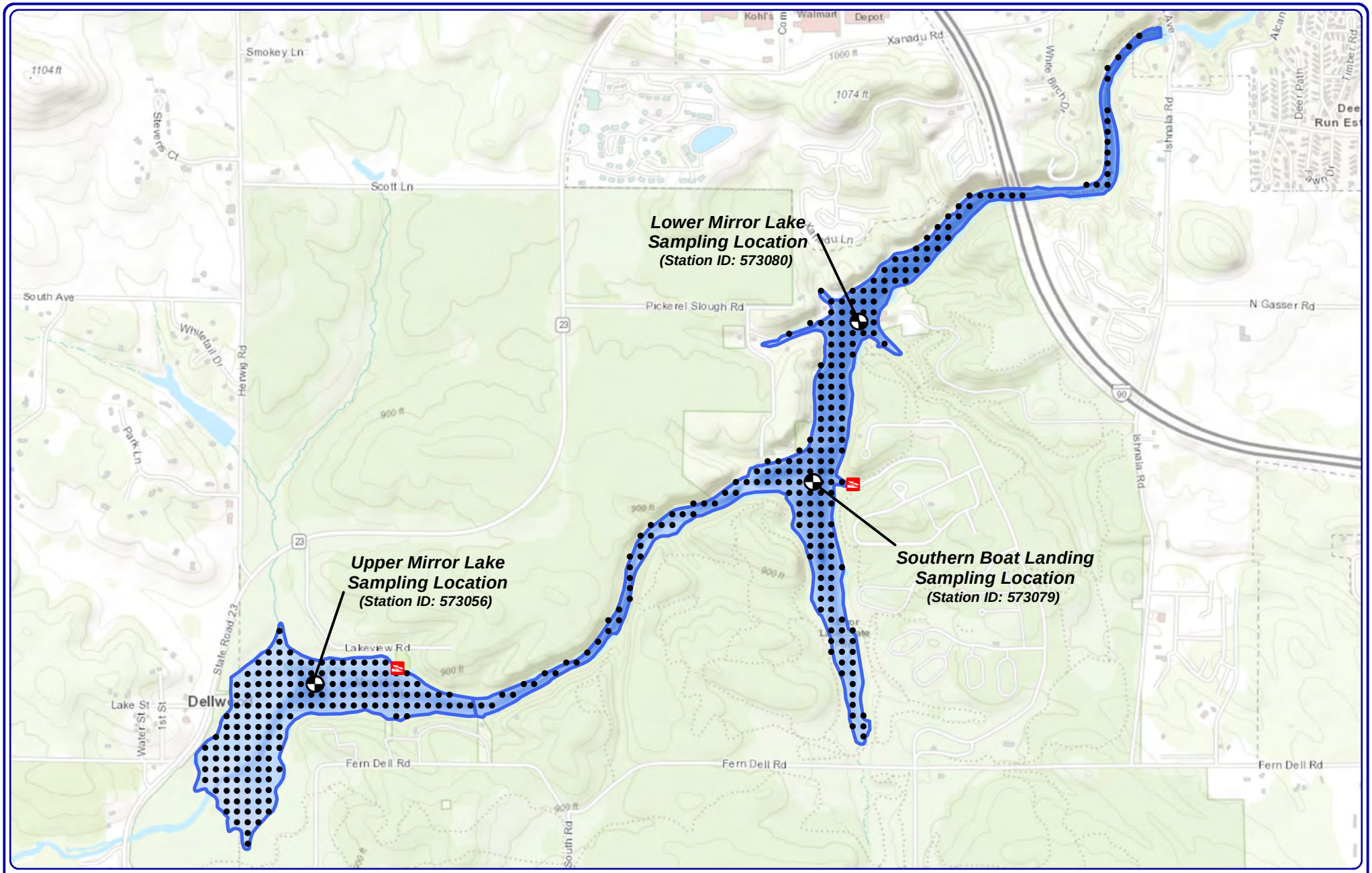

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1,400
Feet

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

Sources:
Basemap: ESRI AGOL
Roads and Hydro: WDNR
Bathymetry: Digitalized by Onterra
Map Date: April 24, 2025 - SCD

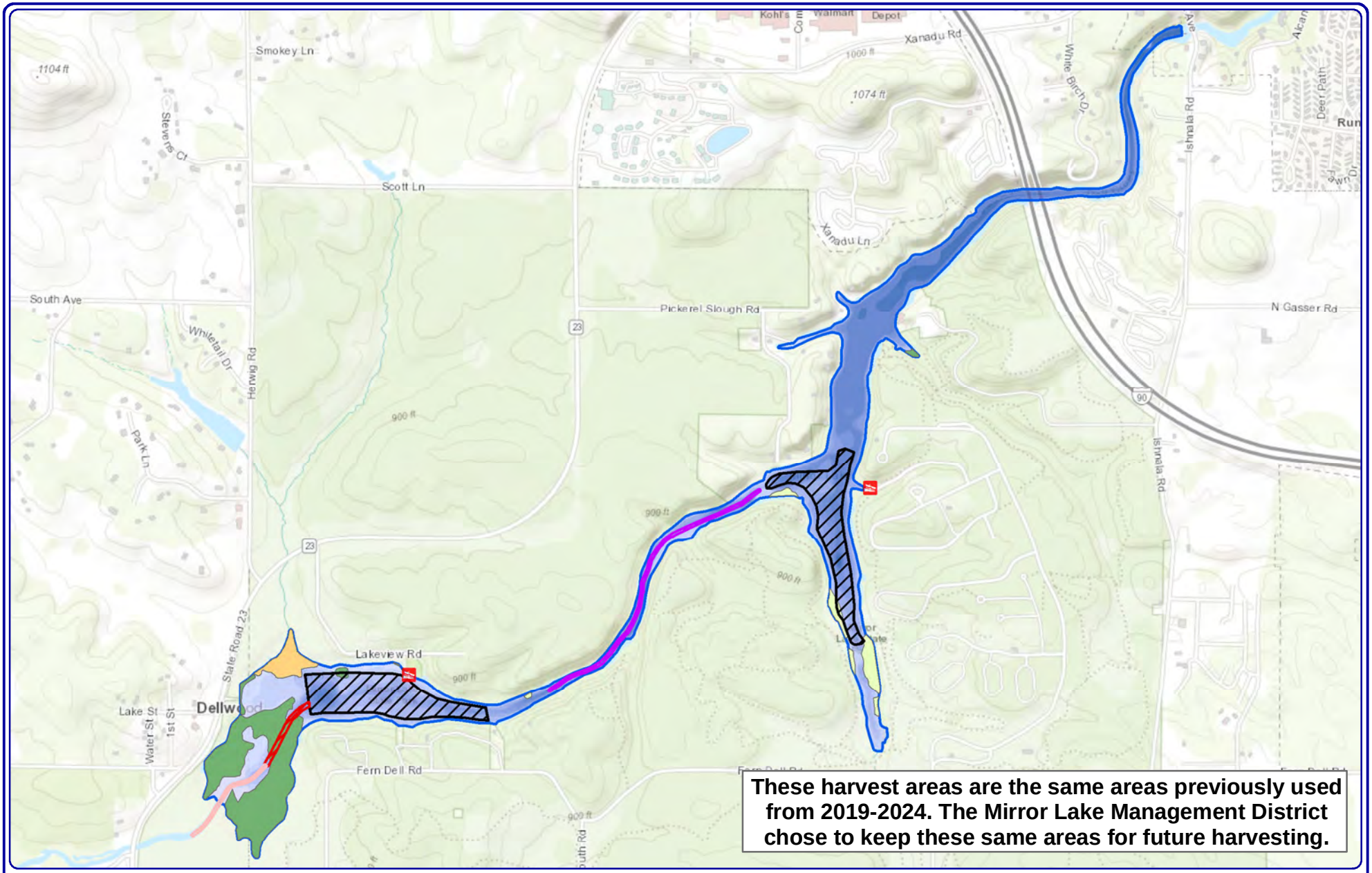
Project Location in Wisconsin

Legend

- Mirror Lake ~137 acres
  WDNR Definition
- Point-Intercept Survey Location
  37-meter spacing, 400 total points
- Water Quality Sampling Location
- Public Access

Map 1
Mirror Lake
Sauk County

Project Location & Lake Boundaries



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

Sources:
Basemap: ESRI
Roads and Hydro: WDNR
Bathymetry: Digitized by Onterra
Aquatic Plant Survey: Onterra, 2024
Map Date: April 30, 2025 - RMF

Project Location in Wisconsin

Harvesting Areas

- Primary Harvest Areas ~ 30 acres
- 30 ft Navigational Lane ~ 0.8 acres
- 50 ft Navigational Lane ~ 1.0 acres
- 30 ft Duckweed Harvesting Lane ~ 2.4 acres

2024 Large Emergent & Floating-leaf Aquatic Plant Communities

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

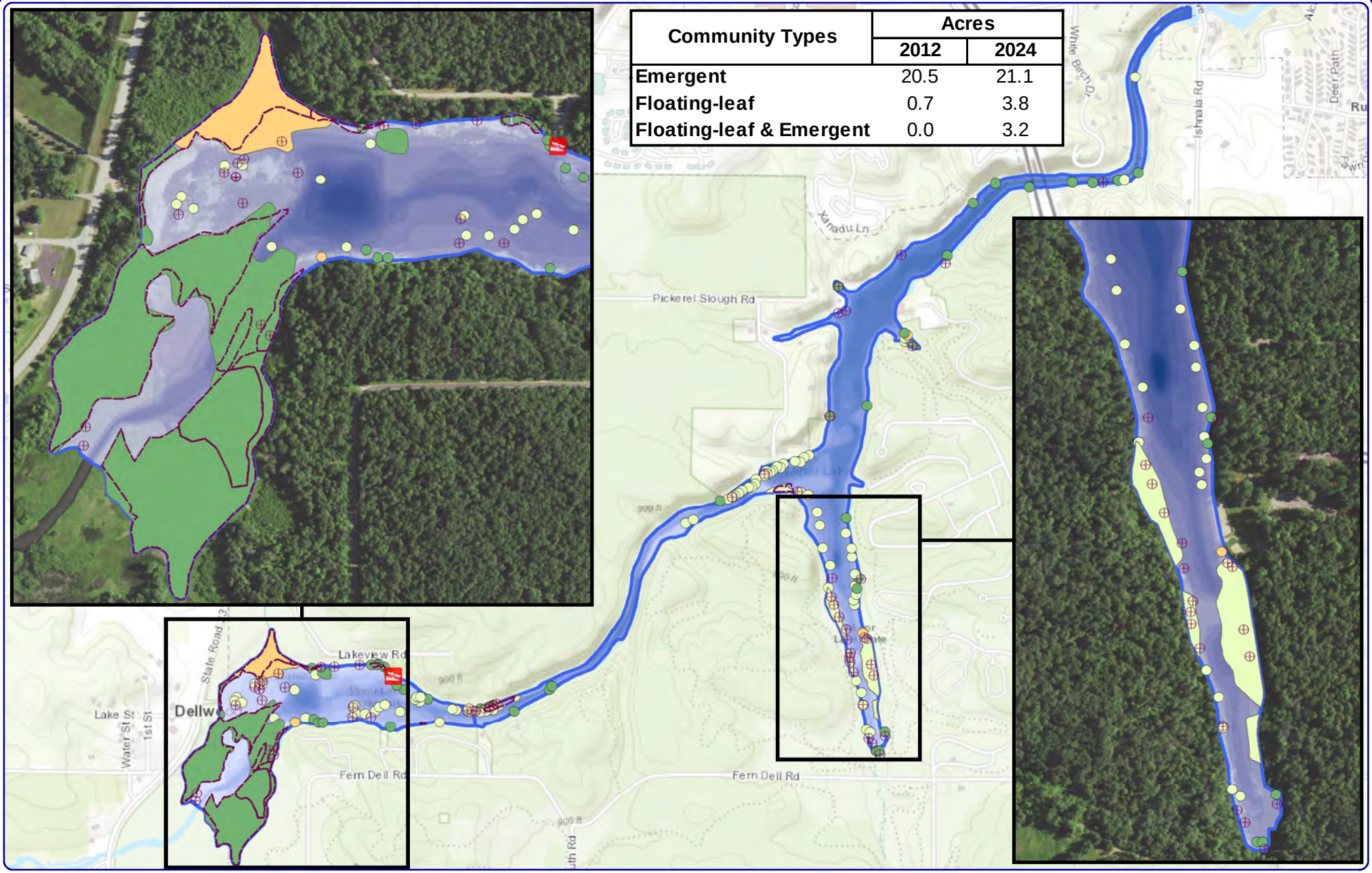
Map 2

Mirror Lake

Sauk County, Wisconsin

Mechanical Harvesting Plan

Community Types	Acres	
	2012	2024
Emergent	20.5	21.1
Floating-leaf	0.7	3.8
Floating-leaf & Emergent	0.0	3.2



1,000 Feet

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

Sources
Basemap: ESRI
Hydro and Bathy: WDNR, digitized by Onterra
Aquatic Plant Survey: Onterra, 2012, 2024
Map date: April 30, 2025 - RMF

Project Location in Wisconsin

Legend

Survey Results: (July 30, 2024)

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

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

- 2012 Small Community
- 2012 Large Community

Map 3

Mirror Lake

Sauk County, Wisconsin

Aquatic Plant Communities

Mirror Lake 2024 Emergent & Floating-Leaf Plant Species

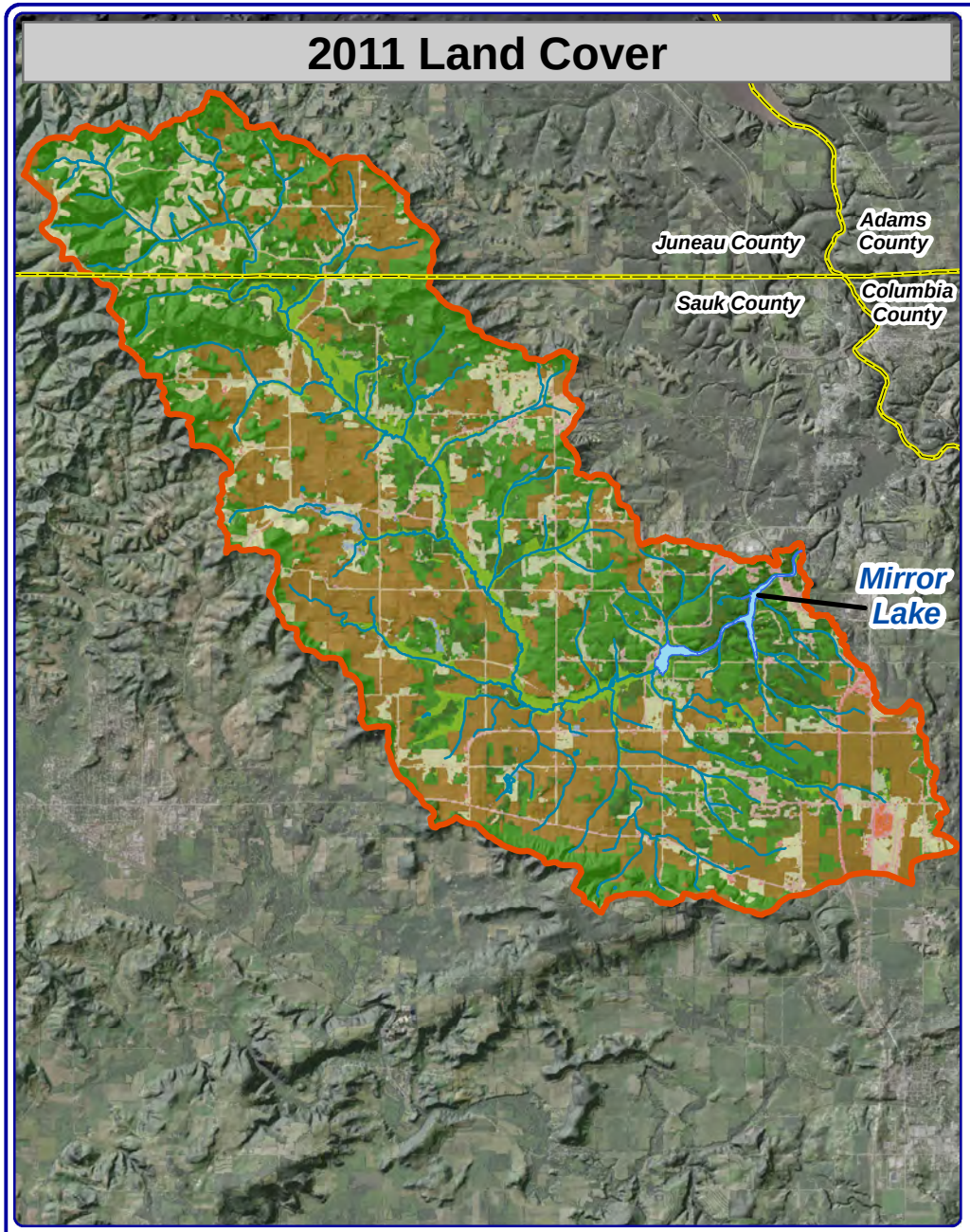
Corresponding Community Polygons and Points are displayed on Map 3

Large Plant Community (Polygons)					
Emergent	**Species 1**	**Species 2**	**Species 3**	**Species 4**	**Acres**
A	**Sedge sp. (sterile)**				0.32
B	**Sedge sp. (sterile)**	**Common arrowhead**	**Water arum**	Cattail sp.	0.17
C	**Wild rice sp.**	misc. wetland sp.			20.64
Floating-leaf	**Species 1**	**Species 2**	**Species 3**	**Species 4**	**Acres**
E	**White water lily**				3.77
Floating-leaf & Emergent	**Species 1**	**Species 2**	**Species 3**	**Species 4**	**Species 5**
D	**Wild rice sp.**	White water lily			3.21

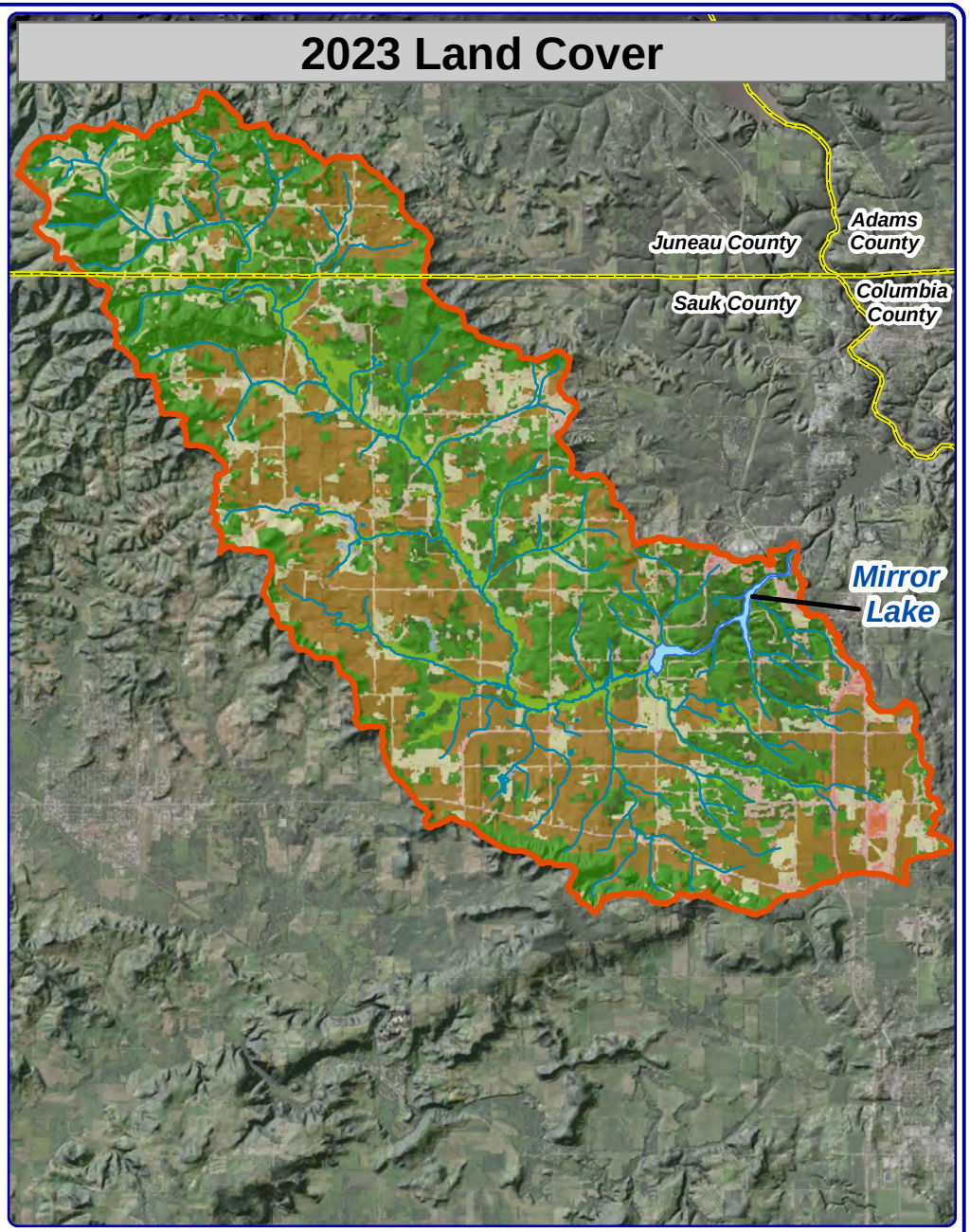
Small Plant Community (Points)				
Emergent	**Species 1**	**Species 2**	**Species 3**	**Species 4**
1	**Bur-reed sp. (sterile)**			
2	**Cattail sp.**			
3	**Cattail sp.**	**misc. wetland sp.**		
4	**Common arrowhead**	**misc. wetland sp.**		
5	**Creeping spikerush**			
6	**Creeping spikerush**	**Wool-grass**	**Sedge sp. (sterile)**	
7	**Iris sp (sterile)**			
8	**misc. wetland sp.**			
9	**Northern blue flag**			
10	**Sedge sp. (Sterile)**	**Cattail sp.**	**Common arrowhead**	misc. wetland sp.
11	**Softstem bulrush**			
13	**Three-square rush**			
14	**Water arum**			
15	**Water arum**	**misc. wetland sp.**		
16	**Wild rice sp.**			
Floating-leaf	**Species 1**	**Species 2**	**Species 3**	**Species 4**
17	**Water smartweed**			
18	**White water lily**			
19	**White water lily**	**Wild rice sp.**		
20	**Wild rice sp.**			
Floating-leaf & Emergent	**Species 1**	**Species 2**	**Species 3**	**Species 4**
12	**Softstem bulrush**	**Cattail sp.**	**Arrowhead sp. (sterile)**	White water lily
21	**Three-square rush**	White water lily		
22	**White water lily**	**Water arum**		

Species are listed in order of dominance within the community. Bolded species were the most abundant in the community while not bolded species were simply present; Scientific names can be found in the species list in Table 2.3-2

2011 Land Cover



2023 Land Cover



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Miles

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

Sources:
Hydro: WDNR, Digitized by Onterra
Hillshade: WDNR
Land Cover: NLCD, 2011 and 2023
Orthophoto: WDNR, 2022
Watershed Boundaries: WDNR
Map Date: April 21, 2025 - RMF

Project Location in Wisconsin

Legend

National Land Cover Database Classifications

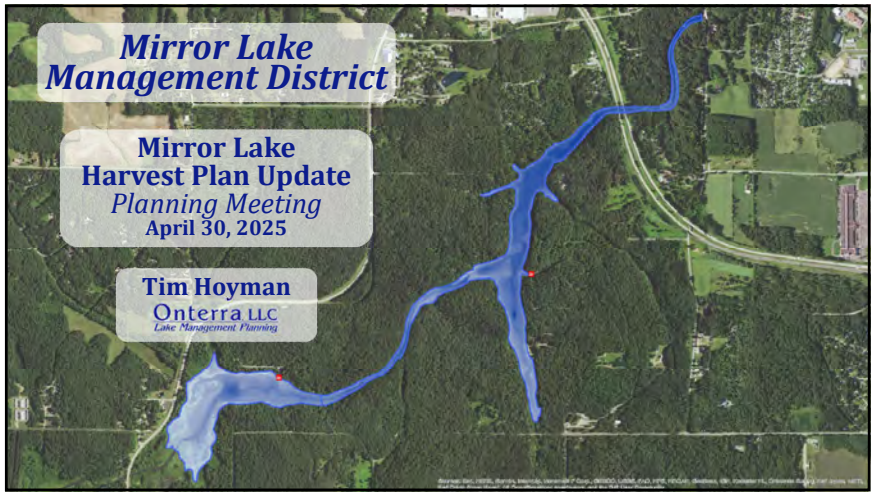
- Evergreen Forest
- Mixed Forest
- Deciduous Forest
- Woody Wetlands
- Grasslands/Herbaceous
- Emergent Herbaceous Wetland
- Pasture/Grass
- Barron (Rock/Sand/Clay)
- Cultivated Crops
- Developed - Open Space
- Developed - Low Intensity
- Developed - Medium Intensity
- Developed - High Intensity
- Shrub/Scrub
- Open Water
- River or Stream
- Mirror Lake Watershed Boundary
- Mirror Lake

Mirror Lake
Sauk County, Wisconsin
Watershed Boundaries & Land Cover Types

A

APPENDIX A

Mirror Lake Information and Planning Meeting Presentation
April 30, 2025



Presentation Outline

- Study Results
  - Watershed
  - Water Quality
  - Aquatic Plants
- "Big Picture"
- Harvest Plan Updates

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Lake Management Planning

Summary of Project Results

Water Quality

- Not a tremendous amount of data for the lake, but efforts over the last decade are changing this.
- Water quality trophic parameters fluctuate but overall have stayed about the same with no trends of better or worse.
- Residence time plays a primary role in the lake's algal content.

Watershed

- Slight change for the better in terms of land cover, but likely not a noticeable impact on lake water quality.

Aquatic Plant Community

- While the aquatic plant abundancies have fluctuated over the survey years, the same species continue to dominate the community.
- AIS plant species, while present do not appear to be dominant players in the community.

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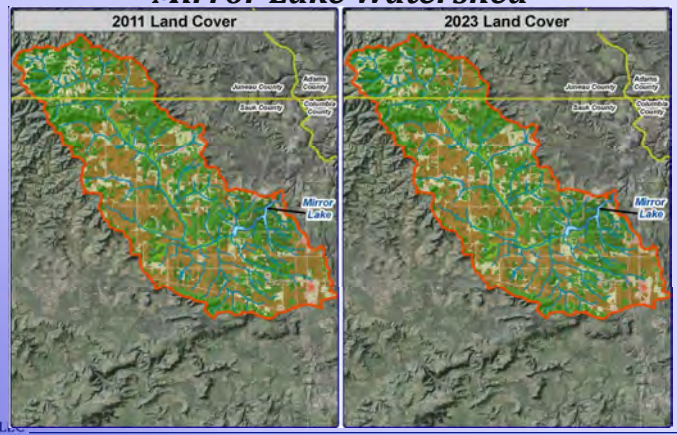
Mirror Lake Watershed



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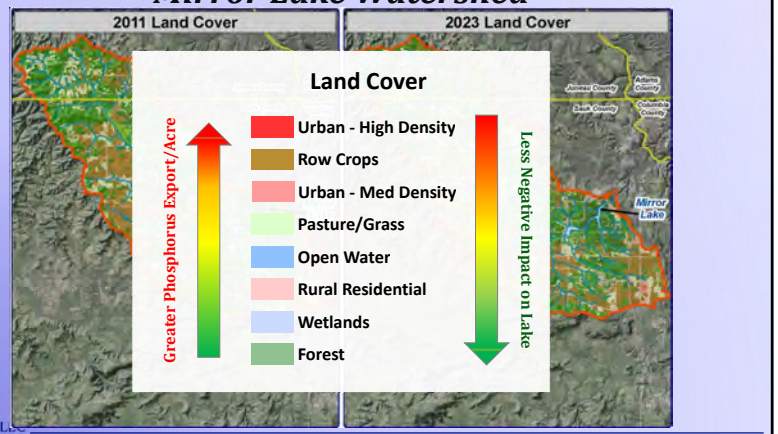
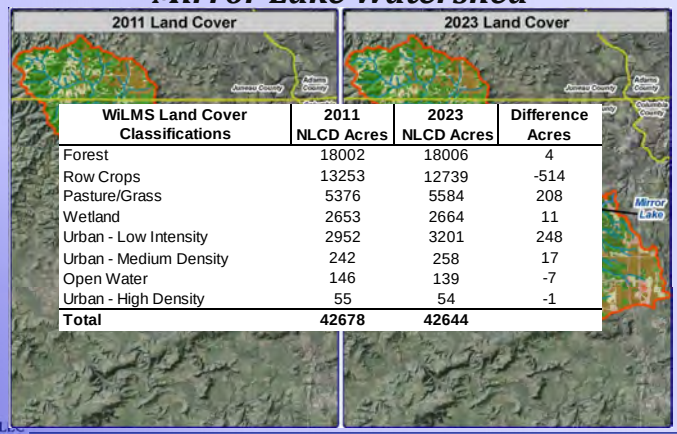
Mirror Lake Watershed



Onterra LLC Lake Management Planning

Mirror Lake Watershed



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Open Water	146	139	-7
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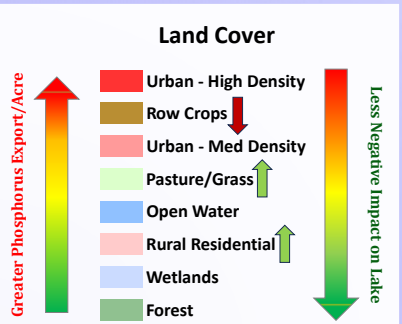
Total	**42678**	**42644**	

Onterra LLC Lake Management Planning

Mirror Lake Watershed



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Open Water	146	139	-7
Urban - High Density	55	54	-1
Total	**42678**	**42644**	

- Change in watershed cover types leads to less phosphorus entering lake.
- Likely not noticeable in water quality.
- Some switches maybe due to resolution of data between 2011 and 2023.
- Seeing a decrease in row crops is good.

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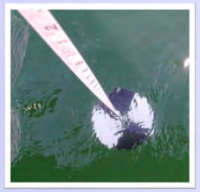
Lake Water Quality – Trophic Parameters

Phosphorus
Naturally occurring & essential for all life
Regulates phytoplankton biomass in **most** WI lakes
Most often 'limiting plant nutrient' (shortest supply) **N:P = 18:1**
Human activity often increases P delivery to lakes

Chlorophyll-*a*
Pigment used in photosynthesis
Used as surrogate for phytoplankton biomass



Secchi Disk Transparency
Measure of water clarity
Measured using a Secchi disk

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Mirror Lake Water Quality

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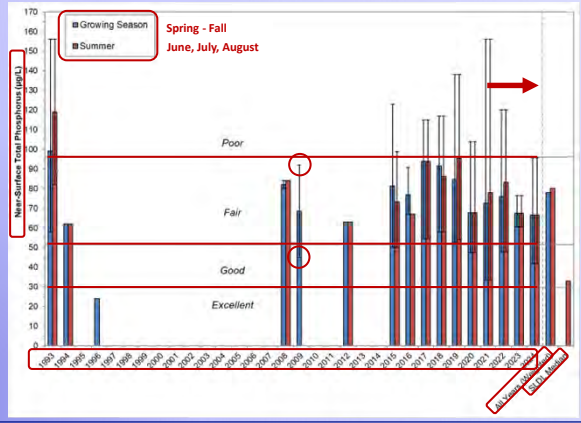
Mirror Lake Water Quality - Phosphorus



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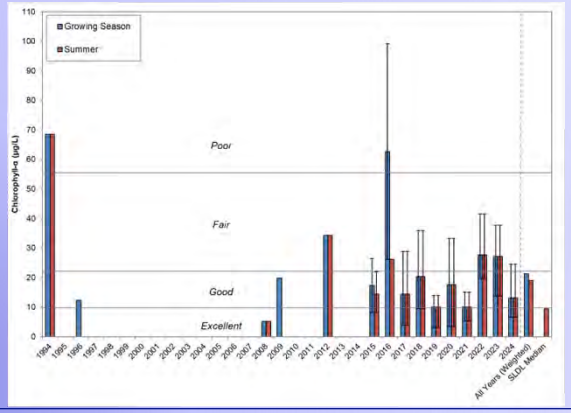
Mirror Lake Water Quality– Chlorophyll-a



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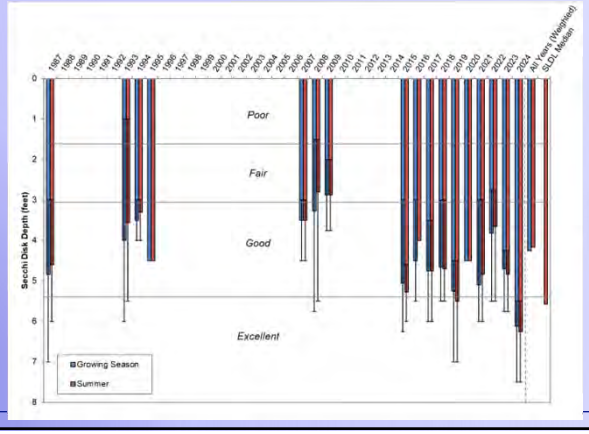
Mirror Lake Water Quality– Secchi Disk



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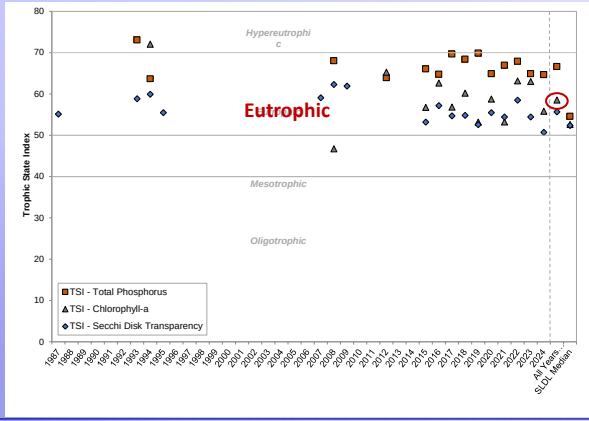
Mirror Lake Water Quality– Trophic State



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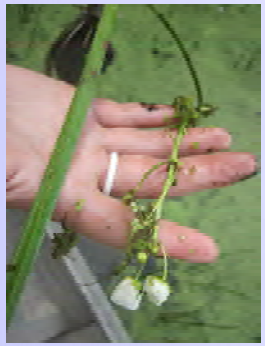
Aquatic Plant Surveys

- Assess both non-native & native species
- Two surveys completed in 2024
  - Whole-lake Point-Intercept Survey
    - Additional Data: 2012 & 2019
  - Emergent/Floating-leaf Community Mapping Survey



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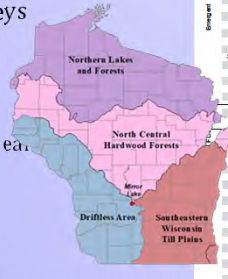
Plant Data Overview

- 34 aquatic plant species recorded over the three PI surveys
- 2 non-native species
  - Eurasian watermilfoil
  - Curly-leaf Pondweed
- 2 non-native species from ea were not located in 2024
  - Japanese knotweed
  - Pale-yellow iris



Growth Form	Scientific Name	Common Name	Status in Wisconsin	Coefficient of Conservatism	2012	2019	2024
Emergent	*Acorus calamus*	Sweetflag	Non-Native - Naturalized	NA	I	I	
	Calla palustris	Water arum	Native	9	X	I	I
	Carex comosa	Bristly sedge	Native	5	I	I	I
	Carex lurida	Shallow sedge	Native	8	I	I	
	Carex sp. 2	Sedge sp. 1	Native	NA			I
	Eleocharis obtusa	Blunt spikerush	Native	3		I	
	Eleocharis palustris	Creeping spikerush	Native	6			I
	Fallopia japonica	Japanese knotweed	Non-Native - Invasive	NA	I	I	
	Iris pseudacorus	Pale-yellow iris	Non-Native - Invasive	NA	I		
	Iris spp. (sterile)	Iris spp. (sterile)	Unknown (Sterile)	NA			I
	Iris versicolor	Northern blue flag	Native	5			I
	Juncus effusus	Soft rush	Native	4	I		
	Sagittaria latifolia	Common arrow-head	Native	3	X	I	I
	Sagittaria rigida	Stiff arrow-head	Native	8	I	I	
Schoenoplectus	*Schoenoplectus pungens*	Three-square rush	Native	5		I	
Scirpus	*Scirpus atrovirens*	Black bulrush	Native	3	I	I	
Scirpus	*Scirpus cyperinus*	Wool grass	Native	4	I	I	I
	Typha spp.	Cattail spp.	Unknown (Sterile)	NA	I	I	I
	Zizania aquatica	Southern wild rice	Native	8	X	X	
	Zizania spp.	Wild rice sp.	Native	8			I
Myriophyllum	*Myriophyllum odoratus*	White water lily	Native	6	I	X	X
Potamogeton	*Potamogeton amphibius*	Water smartweed	Native	5			
Sparganium	*Sparganium* sp.	Bur-reed sp.	Native	NA	I	I	I
Ceratophyllum	*Ceratophyllum demersum*	Coontail	Native	3	X	X	X
Ceratophyllum	*Ceratophyllum echinatum*	Spiny hornwort	Native	10			X
Chara	*Chara* spp.	Muskgrasses	Native	7		X	
Elodea	*Elodea canadensis*	Common waterweed	Native	3	X	X	X
Najas	*Najas flexilis*	Slender naiad	Native	6	X	X	X
Potamogeton	*Potamogeton amplifolius*	Large-leaf pondweed	Native	7	X	X	X
Potamogeton	*Potamogeton crispus*	Curly-leaf pondweed	Non-Native - Invasive	NA	X	X	X
Potamogeton	*Potamogeton epihydrus*	Ribbon-leaf pondweed	Native	8	X	X	
Potamogeton	*Potamogeton friesii*	Fries' pondweed	Native	8	X	X	X
Potamogeton	*Potamogeton nodosus*	Long-leaf pondweed	Native	5	X	X	X
Potamogeton	*Potamogeton strictifolius*	Stiff pondweed	Native	8	X	X	
Potamogeton	*Potamogeton zosteriformis*	Flat-stem pondweed	Native	6	X	X	X
Ranunculus	*Ranunculus aquatilis*	White water crowfoot	Native	8	X	X	X
Sagittaria	*Sagittaria* sp. (rosette)	Arrow-head sp. (rosette)	Native	NA			
Stuckenia	*Stuckenia pectinata*	Sago pondweed	Native	3	X	X	X
Vallisneria	*Vallisneria americana*	Wild celery	Native	6			X
SE	*Eleocharis acicularis*	Needle spikerush	Native	5			X
FF	*Lemna trisulca*	Forked duckweed	Native	6			X
	Lemna turionifera	Turion duckweed	Native	2	X	X	X
	Spirodela polyrhiza	Greater duckweed	Native	5	X	X	X
	Wolffia spp.	Watermeal spp.	Native	NA	X	X	X

X = Located on rake during point-intercept survey; I = Incidentally located; not located on rake during point-intercept survey
FL = Floating-leaf; E/E = Floating-leaf & Emergent; S/E = Submersed and/or Emergent; FF = Free-floating

Onterra LLC Lake Management Planning

Whole-Lake Point-Intercept Survey

Mirror Lake
37-meter resolution
400 total points
2012, 2019, & 2024

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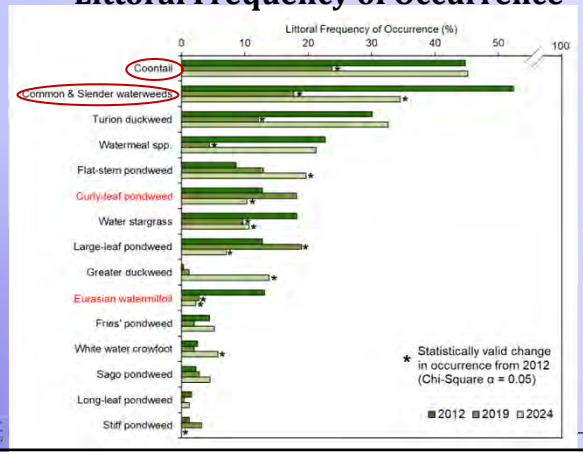
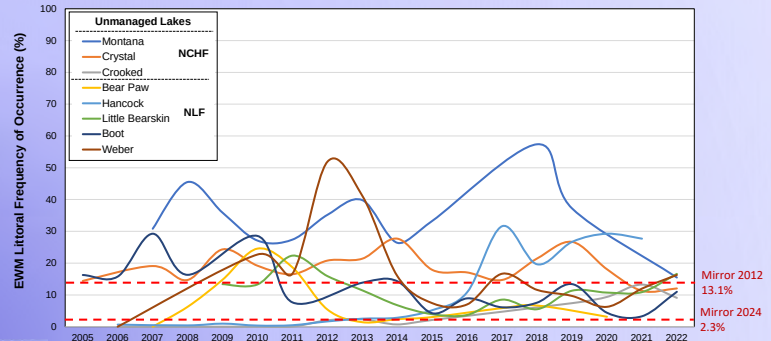
Littoral Frequency of Occurrence

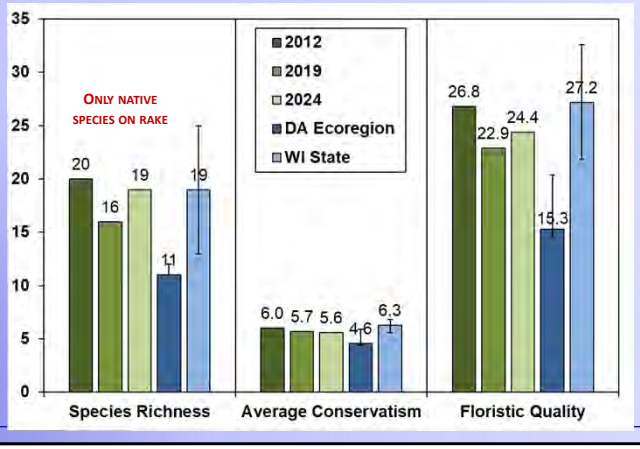


WDNR EWM Long-Term Monitoring Trends

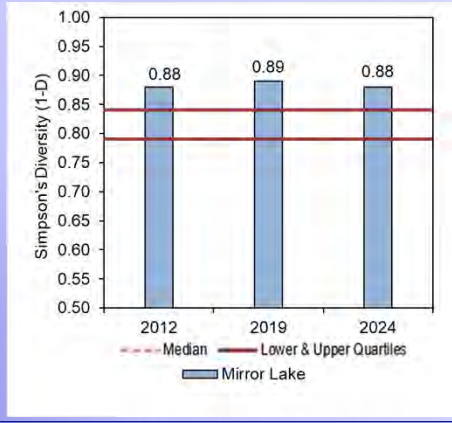
Unmanaged



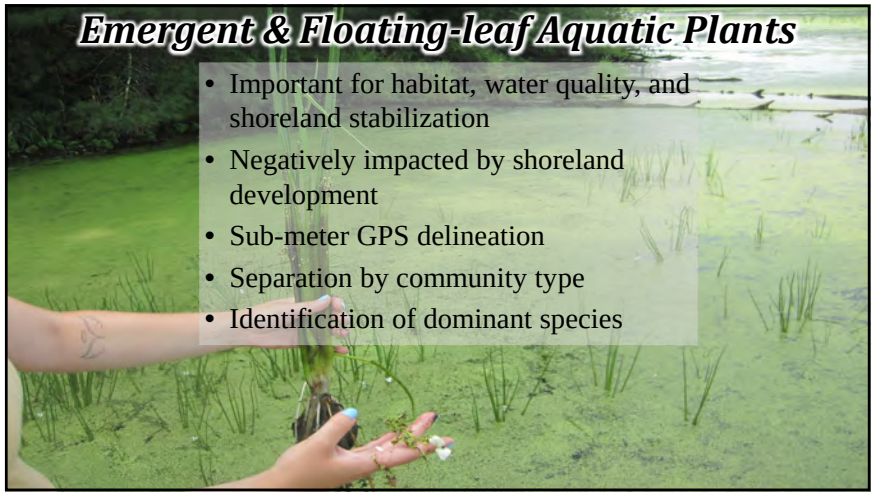
Floristic Quality Analysis



Simpson's Diversity

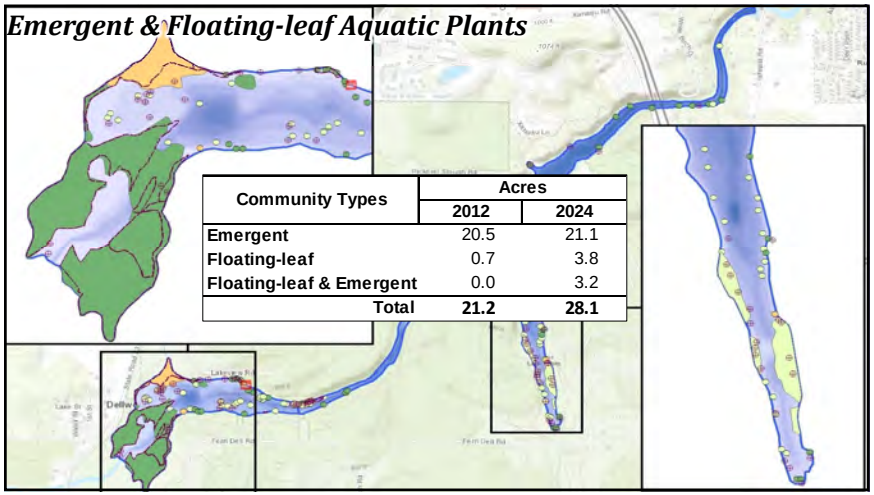


Emergent & Floating-leaf Aquatic Plants



- Important for habitat, water quality, and shoreland stabilization
- Negatively impacted by shoreland development
- Sub-meter GPS delineation
- Separation by community type
- Identification of dominant species

Emergent & Floating-leaf Aquatic Plants



Community Types	Acres	
	2012	2024
Emergent	20.5	21.1
Floating-leaf	0.7	3.8
Floating-leaf & Emergent	0.0	3.2
Total	21.2	28.1

Overarching Conclusions

Mirror Lake's water quality fluctuates greatly but there are no positive or negative trends in the trophic parameters.

Continued monitoring, either through the CLMN program or self-funded, is important so a long-term database can be created and analyzed.

The Mirror Lake aquatic plant community expanded in abundance from 2019 to be near similar the levels documented in 2012. Higher plant abundance is likely closer to normal than lower abundance, but the community will always be in a dynamic equilibrium.

Aquatic plant community metrics are very similar over the three point-intercept surveys.

EWM/CLP are not posing a threat to the lake's ecology and likely do not cause nuisance conditions impeding recreation throughout the open water season.

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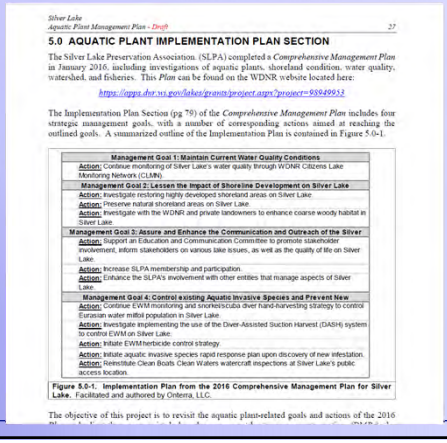
Updated Management Plan



Silver Lake
Aquatic Plant Management Plan - Draft 27

5.0 AQUATIC PLANT IMPLEMENTATION PLAN SECTION

The Silver Lake Preservation Association (SLPA) completed a *Comprehensive Management Plan* in January 2016, including investigations of aquatic plants, shoreland condition, water quality, watershed, and fisheries. This *Plan* can be found on the WDNR website located here:

https://apps.dnr.wi.gov/lakes/grants/project.aspx?project=93849953

The Implementation Plan Section (pg 79) of the *Comprehensive Management Plan* includes four strategic management goals, with a number of corresponding actions aimed at reaching the outlined goals. A summarized outline of the Implementation Plan is contained in Figure 5.0-1.

Management Goal 1: Maintain Current Water Quality Conditions
Action: Continue monitoring of Silver Lake's water quality through WDNR Citizens Lake Monitoring Network (CLMN).
Management Goal 2: Lessen the Impact of Shoreline Development on Silver Lake
Action: Investigate restoring highly developed shoreland areas on Silver Lake.
Action: Preserve natural shoreland areas on Silver Lake.
Action: Investigate with the WDNR and private landowners to enhance coarse woody habitat in Silver Lake.
Management Goal 3: Assure and Enhance the Communication and Outreach of the Silver
Action: Support an Education and Communication Committee to promote stakeholder involvement, inform stakeholders on various lake issues, as well as the quality of life on Silver Lake.
Action: Increase SLPA membership and participation.
Action: Enhance the SLPA's involvement with other entities that manage aspects of Silver Lake.
Management Goal 4: Control existing Aquatic Invasive Species and Prevent New
Action: Continue EWM monitoring and snorkel/scuba diver hand-harvesting strategy to control Eurasian water milfoil population in Silver Lake.
Action: Investigate implementing the use of the Diver-Assisted Suction Harvest (DASH) system to control EWM on Silver Lake.
Action: Initiate EWM herbicide control strategy.
Action: Initiate aquatic invasive species rapid response plan upon discovery of new infestation.
Action: Reinstitute Clean Boats Clean Waters watercraft inspections at Silver Lake's public access location.

Figure 5.0-1. Implementation Plan from the 2016 Comprehensive Management Plan for Silver Lake. Facilitated and authored by Onterra, LLC.

The objective of this project is to revisit the aquatic plant-related goals and actions of the 2016

Onterra LLC Lake Management Planning

2014 Management Plan

Management Goal 3: Control Aquatic Invasive Species in Mirror Lake and Prevent Future Introductions to and Spread from Mirror Lake

Management Action: Initiate volunteer-based monitoring of Eurasian water milfoil and curly-leaf pondweed and other non-native species in Mirror Lake.

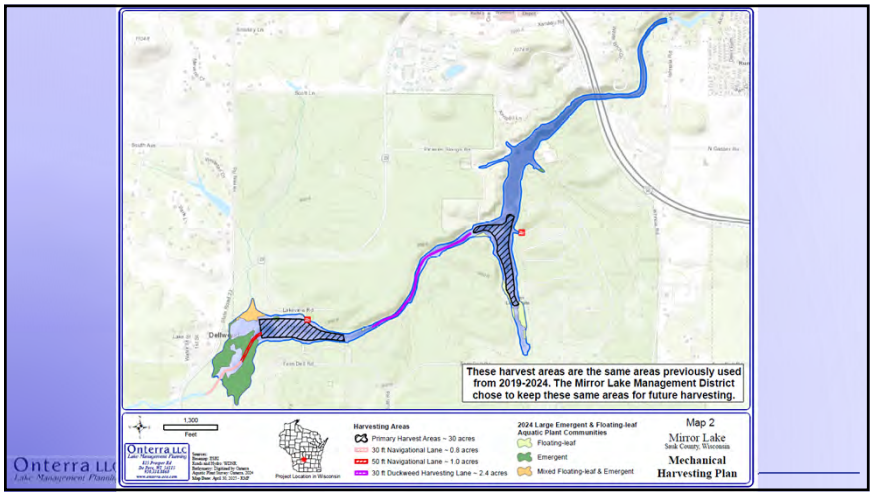
Management Action: Initiate Clean Boats Clean Waters watercraft inspections at Mirror Lake public boat landings.

Management Goal 4: Maintain Navigation in Open Water and Near-shore Areas on Mirror Lake

Management Action: Use district-owned mechanical harvester to maintain reasonable navigation on Mirror Lake.

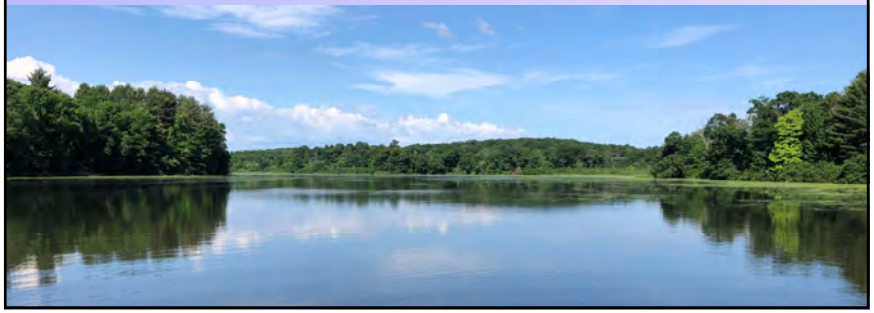
Management Action: Selectively remove course woody habitat that inhibits reasonable navigation and recreational safety on Mirror Lake.

Onterra LLC
Lake Management Planning



Thank You

Onterra LLC
Lake Management Planning



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APPENDIX B

WDNR Comment Response Document