DRAFT

Lawrence Lake

Marquette County, Wisconsin

Comprehensive Management Plan

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Official First Draft for Public Comment

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Lawrence Lake Planning Committee

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Wisconsin Dept. of Natural Resources

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1.0 INTRODUCTION

According to the 1966 recording sonar WDNR Lake Survey Map, Lawrence Lake is 220.5 acres. The WDNR website lists the lake as 217 acres. At the time of this report, the most current orthophoto (aerial photograph) was from the *National Agriculture Imagery Program* (NAIP) collected in 2022. Based on heads-up digitizing of the water level from that photo, the lake was determined to be 228.7 acres. Lawrence Lake is a shallow flowage in the Town of Westfield, WI with a maximum depth of 15 feet and an average depth of 8 feet. Water flows though Lawrence Creek, into Lawrence Lake and exits though the Lawrence Lake dam which marks the beginning of Westfield creek (Figure 1.0-1, Map 1). This eutrophic lake has a relatively large watershed when compared to the size of the lake. Lawrence Lake contains 36 native plant species, of which muskgrasses was the most common plant. Two exotic plant species are known to exist in Lawrence Lake.

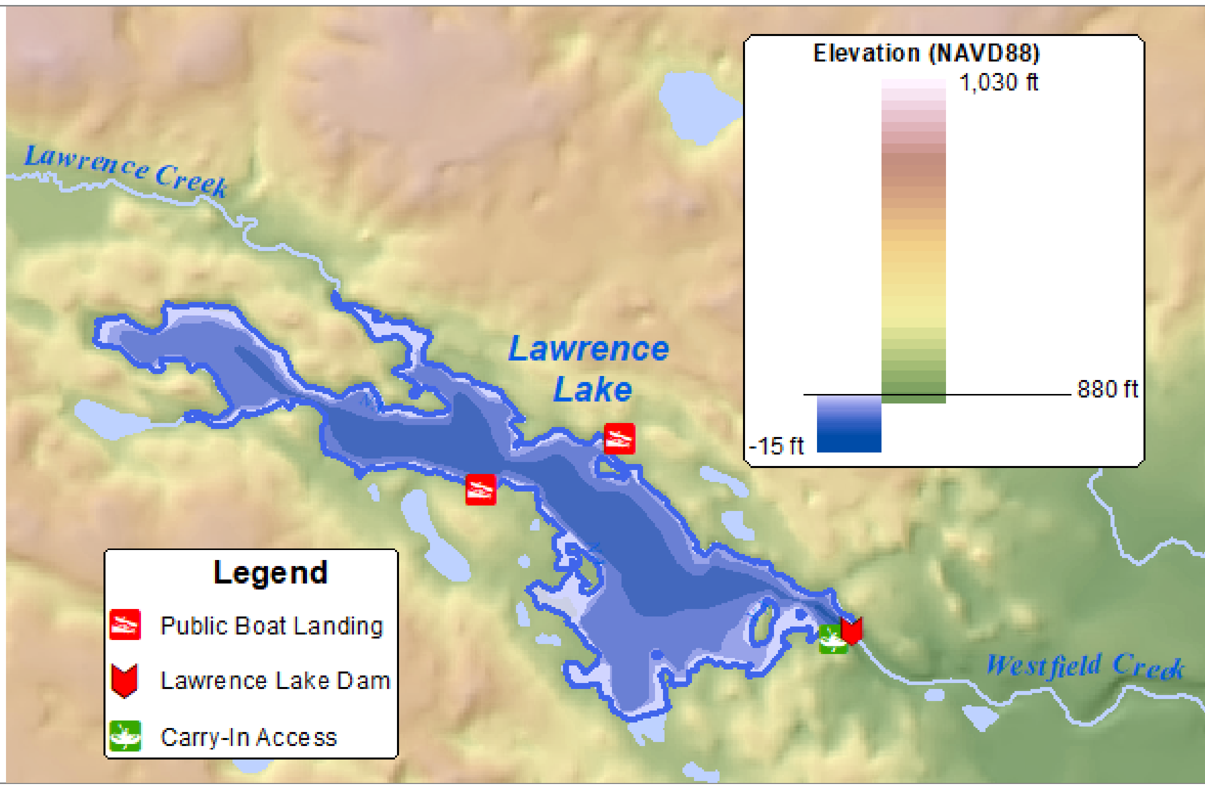


Figure 1.0-1 Lawrence Lake, Marquette County.

Lawrence Lake is managed by the Lawrence Lake Protection & Rehabilitation District (LLPRD) which was formed in 1987 by homeowners of the area after a failure of the spillway drained the lake. Their mission is to ensure the safety and soundness of the Lawrence Lake dam while maintaining and enhancing the quality of Lawrence Lake and to act as an advocate for the interests of all District Members. The LLPRD previously completed a comprehensive management planning project in 2005. Since that plan's development, the LLPRD has intermittently been controlling hybrid watermilfoil and nuisance native plants.

Lawrence Lake's water level is maintained by a dam at the outlet on the east side of the Lake which is currently owned and operated by the LLPRD (Figure 1.0-1). The spillway dam was rebuilt during the late 1980's after it had failed in 1987. The dam is inspected regularly by the LLPRD and every 10 years by the WDNR.

With Onterra's assistance, the LLPRD successfully applied for a WDNR grant in November of 2021 to update the LLPRD's 2005 management plan for the lake as well as consider changes that have occurred on the lake in nearly two decades. This was completed by gathering and analyzing historical and current ecological data, identifying threats, determine the goals and values of stakeholders, present feasible management actions, and increase the lake group's capacity to implement the management plan. Fieldwork for this effort was conducted during the summer of 2022, with planning discussions and public outreach occurring during the winter and spring of 2023.

2.0 STAKEHOLDER PARTICIPATION

Stakeholder participation is an important part of any management planning exercise. During this project, stakeholders were not only informed about the project and its results, but also introduced to important concepts in lake ecology. The objective of this component in the planning process is to accommodate communication between the planners and the stakeholders. The communication is educational in nature, both in terms of the planners educating the stakeholders and vice-versa. The planners educate the stakeholders about the planning process, the functions of their lake ecosystem, their impact on the lake, and what can realistically be expected regarding the management of the aquatic system. The stakeholders educate the planners by describing how they would like the lake to be, how they use the lake, and how they would like to be involved in managing it. All of this information is communicated through multiple meetings that involve the lake group as a whole or a focus group called a Planning Committee, and the completion of a stakeholder survey.

The highlights of this component are described below. Materials used during the planning process can be found in Appendix A.

General Public Meetings

The general public meetings were used to raise project awareness, gather comments, create the management goals and actions, and deliver the study results These meetings were open to anyone interested and were generally held during the summer, on a Saturday, to achieve maximum participation.

Kick-off Meeting

On July 9, 2022, a project kick-off meeting was held at the Town of Westfield Town Hall to introduce the project to the general public. The meeting was announced through a mailing and personal contact by Lawrence Lake Protection & Rehabilitation District board members. The approximately 30 attendees observed a presentation given by Tim Hoyman, an aquatic ecologist with Onterra. Tim's presentation started with an educational component regarding general lake ecology and ended with a detailed description of the project including opportunities for stakeholders to be involved. The presentation was followed by a question and answer session.

Project Wrap-up Meeting

Tim Hoyman provided an hour-long presentation covering the highlights of the study results and an outline of the management goals and actions at the LLPRD annual meeting on July 13, 2024. Approximately 45 district members were in attendance with several asking questions throughout and following the presentation. The district provided hard copies of the draft management plan's Summary & Conclusions and Implementation Plan sections to attendees. The availability of the full management plan document on the district's website was also announced and information was provided regarding the submittal or written comments as a part of the 21-day public review period.

Committee Level Meetings

Planning committee meetings, similar to general public meetings, were used to gather comments, create management goals and actions and to deliver study results. These two meetings were open only to the planning committee and were held during the week. The first, following the completion of the draft report sections of the management plan. The planning committee members were supplied with the draft report sections prior to the meeting and much of the meeting time was utilized to detail the results, discuss the conclusions and initial recommendations, and answer committee questions. The objective of the first meeting was to fortify a solid understanding of their lake among the committee members. The second planning committee meeting was held a few weeks after the first and concentrated on the development of management goals and actions that make up the framework of the implementation plan.

Planning Committee Meeting I

On June 7, 2023, Tim Hoyman and Todd Hanke of Onterra met with six members of the Lawrence Lake Planning Committee for nearly three hours. In advance of the meeting, attendees were provided an early draft of the study report sections to facilitate better discussion. The primary focus of this meeting was the delivery of the study results and conclusions to the committee. All study components including aquatic plant inventories, water quality analysis, and watershed modeling were presented and discussed. Many concerns were raised by the committee, including nuisance levels of aquatic plants, sedimentation, and lack of district member involvement.

Planning Committee Meeting II

On August 1, 2023, Tim Hoyman and Todd Hanke once again met with the members of the Planning Committee to discuss the stakeholder survey results, realistic use of harvesting and herbicides for the control of nuisance aquatic plants, the advantages and disadvantages of drawdowns and mechanical dredging, and to begin developing management goals and actions for the Lawrence Lake management plan.

Stakeholder Survey

As a part of this project, a stakeholder survey was distributed to Lawrence Lake Protection & Rehabilitation District members around Lawrence Lake. The survey was designed by Onterra staff and the Lawrence Lake Protection & Rehabilitation District planning committee and reviewed by a WDNR social scientist. During November and December of 2022, the nine-page, 40-question survey was posted online through Survey Monkey for survey-takers to answer electronically. If requested, a hard copy was sent with a self-addressed stamped envelope for returning the survey anonymously. The returned hardcopy surveys were entered into the online version by a third-party for analysis. Thirty percent of the surveys were returned. Please note that typically a benchmark of a 60% response rate is required to portray population projections accurately, and make conclusions with statistical validity. The data were analyzed and summarized by Onterra for use at the planning meetings and within the management plan. The full survey and results can be found in Appendix B, while discussion of those results is integrated within the appropriate sections of the management plan and a general summary is discussed below.

Based upon the results of the stakeholder survey, much was learned about the people who use and care for Lawrence Lake. According to the survey results, 18% of respondents indicated that they live on the lake during the summer months only, while 38% visit on weekends through the year, 39% are year-round residents, 4% is resort and rental property. As well, 42% of respondents have owned their property for over 11 years, and 27% have owned their property for over 25 years.

The following sections (Water Quality, Watershed, Aquatic Plants and Fisheries Data Integration) discuss the stakeholder survey data with respect these particular topics. Figures 2.0-1 and 2.0-2 highlight several other questions found within this survey. Of the survey respondents, 97% indicate that they use either a pontoon boat, larger motor boat, canoe/kayak, or a combination of these three vessels on Lawrence Lake (Question 14). Paddleboats were also a popular option. The importance of responsible boating activities is increased when personal and nonmotorized watercraft are in use. The need for responsible boating increases during weekends, holidays, and during times of nice weather or good fishing conditions as well, due to increased traffic on the lake. As seen on Question 8, several of the top recreational activities on the lake involve boat use.

A concern of stakeholders noted throughout the stakeholder survey (see Question 17 and survey comments – Appendix B) was sedimentation within Lawrence Lake. This topic is touched upon in the Summary & Conclusions section as well as within the Implementation Plan.

Question 8: Please rank up to three activities that are important reasons for owning your property on or near Lawrence Lake, with 1 being the most important.

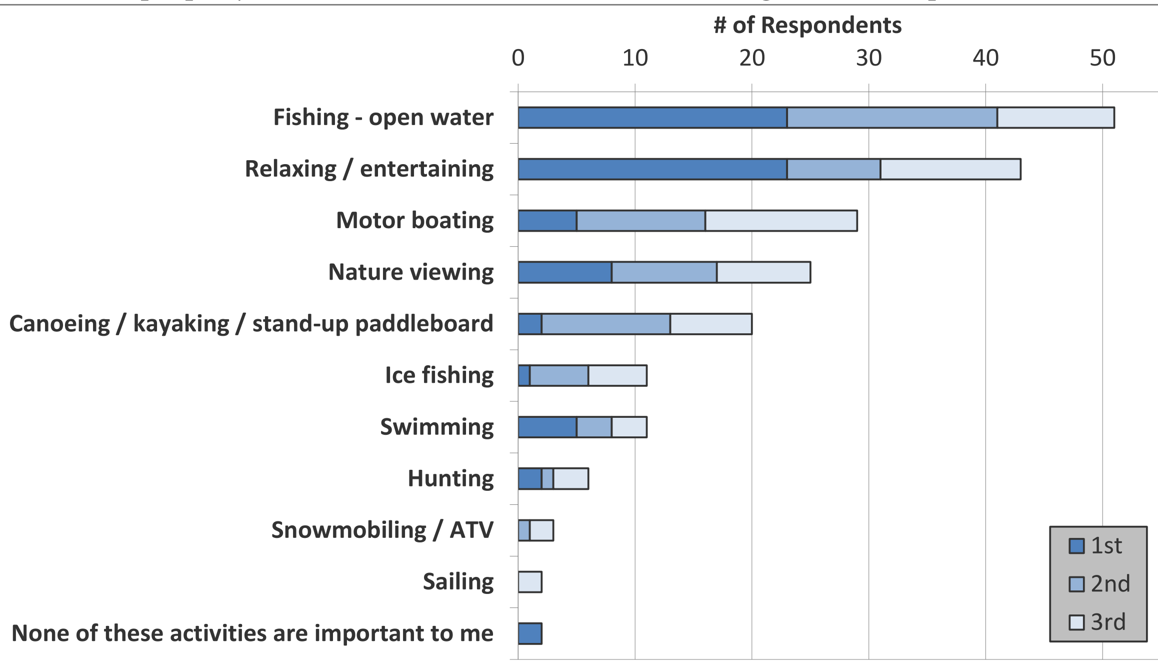


Figure 2.0-1. Select survey responses from the Lawrence Lake Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

Question 14: What types of watercraft do you currently use on Lawrence Lake?

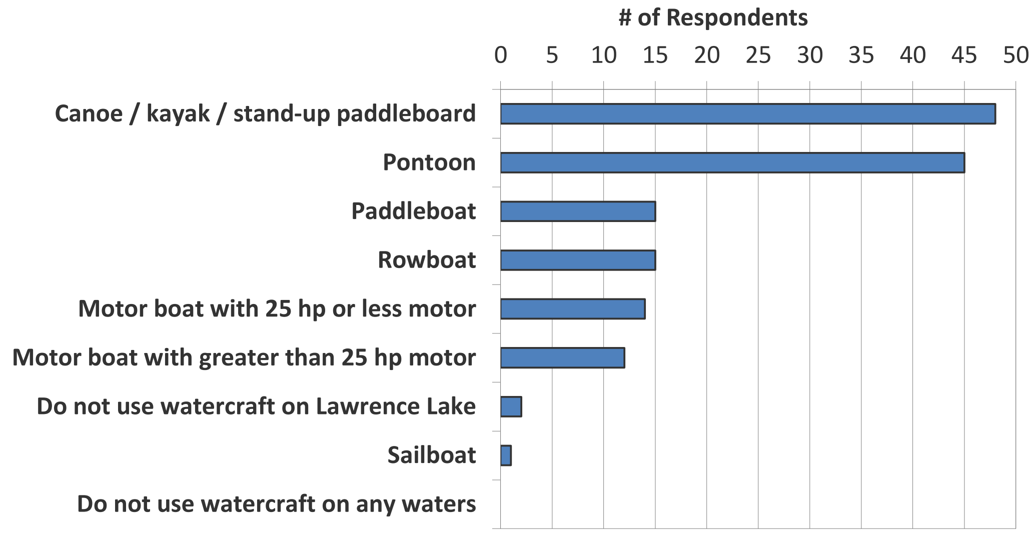


Figure 2.0-2. Select survey responses from the Lawrence Lake Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

Question 17: From the list below, please rank your top three concerns regarding Lawrence Lake, with 1 being your greatest concern.

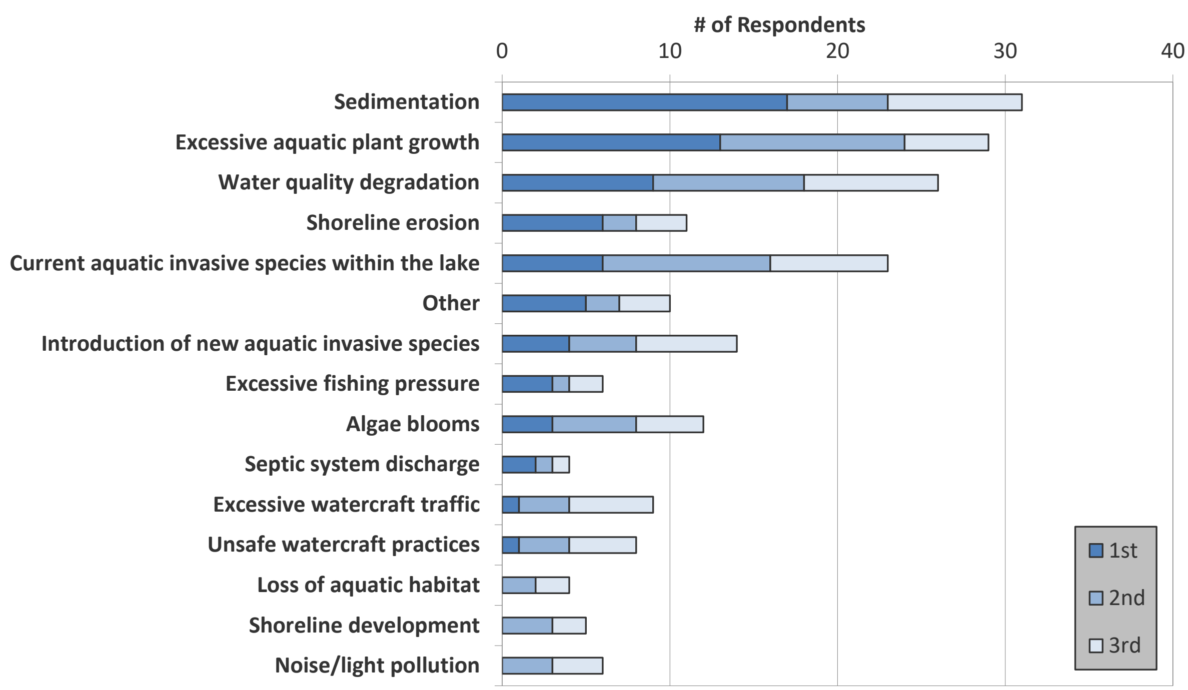


Figure 2.0-3. Select survey responses from the Lawrence Lake Stakeholder Survey, continued. Additional questions and response charts may be found in Appendix B.

Management Plan Review and Adoption Process

This will be completed in the final draft.

3.0 RESULTS & DISCUSSION

3.1 Lake Water Quality

Water Quality Data Analysis and Interpretation

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, water quality values that may be considered poor for one lake may be considered good for another because judging water quality is often subjective. 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 analyses 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 available analysis 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 Lawrence Lake is compared to other lakes in the state with similar characteristics as well as to lakes within the northern region (Appendix C). 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 are focused upon in the Lawrence Lake 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 quadrants (a Secchi disk) into the water and recording the depth just before it disappears from sight.

The parameters described above are interrelated. Phosphorus controls 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, Nelson, & Everett, 1994) (Dinius, 2007) (Smith, Cragg, & Croker, 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 more clear 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.

Limiting Nutrient

The limiting nutrient is the nutrient which is in shortest supply and controls the growth rate of algae and some macrophytes within the lake. This is analogous to baking a cake that requires four eggs, and four cups each of water, flour, and sugar. If the baker would like to make four cakes, he needs 16 of each ingredient. If he is short two eggs, he will only be able to make three cakes even if he has sufficient amounts of the other ingredients. In this scenario, the eggs are the limiting nutrient (ingredient).

In most Wisconsin lakes, phosphorus is the limiting nutrient controlling the production of plant biomass. As a result, phosphorus is often the target for management actions aimed at controlling plants, especially algae. The limiting nutrient is determined by calculating the nitrogen to phosphorus ratio within the lake. Normally, total nitrogen and total phosphorus values from the surface samples taken during the summer months are used to determine the ratio. Results of this ratio indicate if algal growth within a lake is limited by nitrogen or phosphorus. If the ratio is greater than 15:1, the lake is considered phosphorus limited; if it is less than 10:1, it is considered nitrogen limited. Values between these ratios indicate a transitional limitation between nitrogen and phosphorus.

Temperature and Dissolved Oxygen Profiles

Lake stratification occurs when temperature gradients are developed with depth in a lake. During stratification the lake can be broken into three layers: The epilimnion is the top layer of water which is the warmest water in the summer months and the coolest water in the winter months. The hypolimnion is the bottom layer and contains the coolest water in the summer months and the warmest water in the winter months. The metalimnion, often called the thermocline, is the middle layer containing the steepest temperature gradient.

Temperature and dissolved oxygen profiles are created simply by taking readings at different water depths within a lake. Although it is a simple procedure, the completion of several profiles over the course of a year or more provides a great deal of information about the lake. Much of this information relates to whether the lake thermally stratifies or not, which is determined primarily through the temperature profiles. Lakes that show strong stratification during the summer and winter months need to be managed differently than lakes that do not. Normally, deep lakes stratify to some extent, while shallow lakes (less than 17 feet deep) do not.

Dissolved oxygen is essential in the metabolism of nearly every organism that exists within a lake. For instance, fish kills are often the result of insufficient amounts of dissolved oxygen. However, dissolved oxygen's role in lake management extends beyond this basic need by living organisms. In fact, its presence or absence impacts many chemical process that occur within a lake. Internal nutrient loading is an excellent example that is described below.

Internal Nutrient Loading*

In lakes that support stratification, whether throughout the summer or periodically between mixing events, the hypolimnion can become devoid of oxygen both in the water column and within the sediment. When this occurs, iron changes from a form that normally binds phosphorus within the sediment to a form that releases it to the overlaying water. This can result in very high concentrations of phosphorus in the hypolimnion. Then, during turnover events, these high concentrations of phosphorus are mixed within the lake and utilized by algae and some macrophytes. In lakes that mix periodically during the summer (polymictic lakes), this cycle can *pump* phosphorus from the sediments into the water column throughout the growing season. In lakes that only mix during the spring and fall (dimictic lakes), this burst of phosphorus can support late-season algae blooms and even last through the winter to support early algal blooms the following spring. Further, anoxic conditions under the winter ice in both polymictic and dimictic lakes can add smaller loads of phosphorus to the water column during spring turnover that may support algae blooms long into the summer. This cycle continues year after year and is termed "internal phosphorus loading"; a phenomenon that can support nuisance algal blooms decades after external sources are controlled.

The first step in the analysis is determining if the lake is a candidate for significant internal phosphorus loading. Water quality data and watershed modeling are used to determine actual and predicted levels of phosphorus for the lake. When the predicted phosphorus level is well below the actual level, it may be an indication that the modeling is not accounting for all of the phosphorus sources entering the lake. Internal nutrient loading may be one of the additional contributors that may need to be assessed with further water quality analysis and possibly additional, more intense studies.

Non-Candidate Lakes

- Lakes that do not experience hypolimnetic anoxia.
- Lakes that do not stratify for significant periods (i.e. days or weeks at a time).
- Lakes with hypolimnetic total phosphorus values less than 200 µg/L.

Candidate Lakes

- Lakes with hypolimnetic total phosphorus concentrations exceeding 200 µg/L.
- Lakes with epilimnetic phosphorus concentrations that cannot be accounted for in watershed phosphorus load modeling.

Specific to the final bullet-point, during the watershed modeling assessment, the results of the modeled phosphorus loads are used to estimate in-lake phosphorus concentrations. If these estimates are much lower than those actually found in the lake, another source of phosphorus must be responsible for elevating the in-lake concentrations. Normally, two possibilities exist: 1) shoreland septic systems, and 2) internal phosphorus cycling. If the lake is considered a candidate for internal loading, modeling procedures are used to estimate that load.

Comparisons with Other Datasets

The WDNR document *Wisconsin 2020 Consolidated Assessment and Listing Methodology* (WDNR, 2019) 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 Lawrence Lake will be compared to lakes in the state with similar physical characteristics. The WDNR groups Wisconsin's lakes into ten natural communities (Figure 3.1-1).

First, the lakes are classified into three main groups: (1) lakes and reservoirs less than 10 acres, (2) lakes and reservoirs greater than or equal to 10 acres, and (3) a classification that addresses special waterbody circumstances. The last two categories have several sub-categories that provide attention to lakes that may be shallow, deep, play host to cold water fish species or have unique hydrologic patterns. Overall, the divisions categorize lakes based upon their size, stratification characteristics, and hydrology. An equation developed by Lathrop and Lillie (Lathrop & Lillie, 1980), which incorporates the maximum depth of the lake and the lake's surface area, is used 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 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.

Because of its depth, relatively large watershed, and hydrology, Lawrence Lake is classified as a shallow lowland drainage lake (category 4 on Figure 3.1-1).

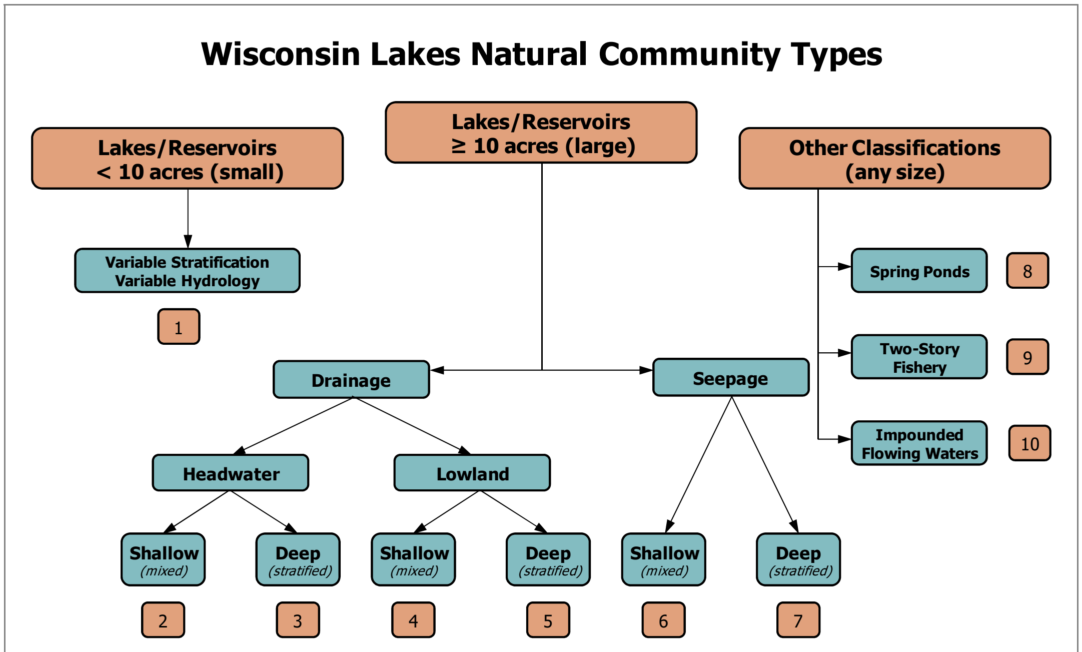


Figure 3.1-1. Wisconsin Lake Natural Communities. Adapted from WDNR 2017.

(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 3.1-2). 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. Lawrence Lake is within the North Central Hardwood Forests (NCHF) ecoregion.

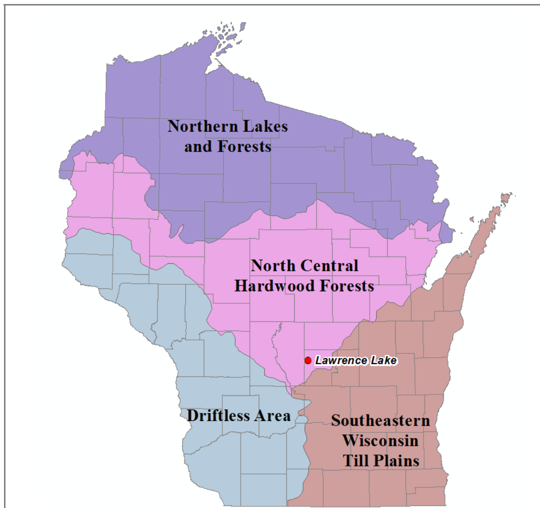


Figure 3.1-2. Location of Lawrence Lake within the ecoregions of Wisconsin. After Nichols 1999.

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 Lawrence Lake is displayed in Figures 3.1-3 - 3.1-7. 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.

Lawrence Lake Water Quality Analysis

Lawrence Lake Long-term Trends

The timespan of the trophic parameter data (total phosphorus, chlorophyll-*a*, and Secchi disk transparency) extends back to the early 1970s; however, large data gaps and low annual counts of data exist for all three parameters. Unfortunately, this makes legitimate long-term trends analysis and comparisons between the parameters impossible.

Total phosphorus data were collected in the early 1970s, once in 2004, and as a part of this project in 2022 (Figure 3.1-3). The early 1970s means primarily include only two or three samplings per year. A few concentrations extend into the *Good* category, but the bulk remain within the *Excellent* category. The weighted growing season and summer averages for all available data fall within the *Excellent* category. The summer means for all years are lower than the median value for Wisconsin shallow lowland drainage lakes and other lakes with the NCHF ecoregion.

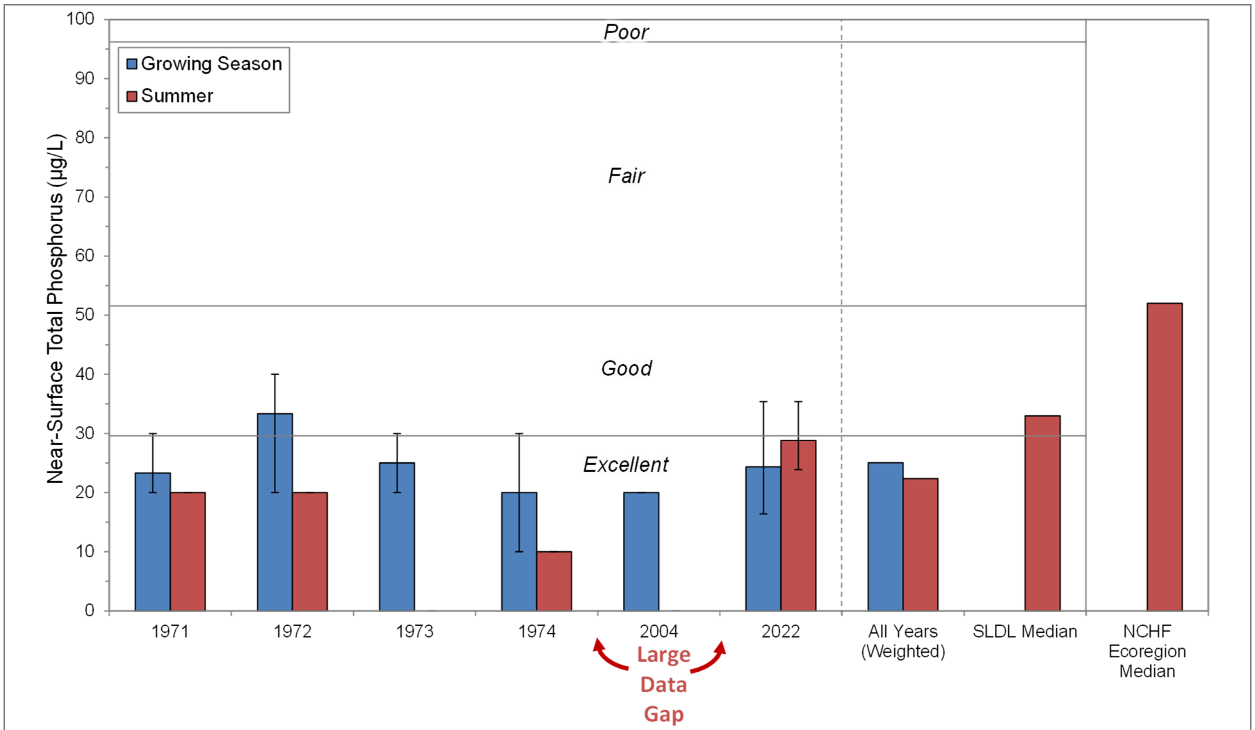


Figure 3.1-3. Lawrence Lake, statewide class 4 lakes, and regional total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

The least amount of annual data is available for chlorophyll-*a*, and consists of ten samplings during 1994 growing season and six during the growing season of 2022 (Figure 3.1-4). Several of the results found for 1994 were collected at different times during the same day. There were all surface samples, so all were utilized to create the 1994 average value.

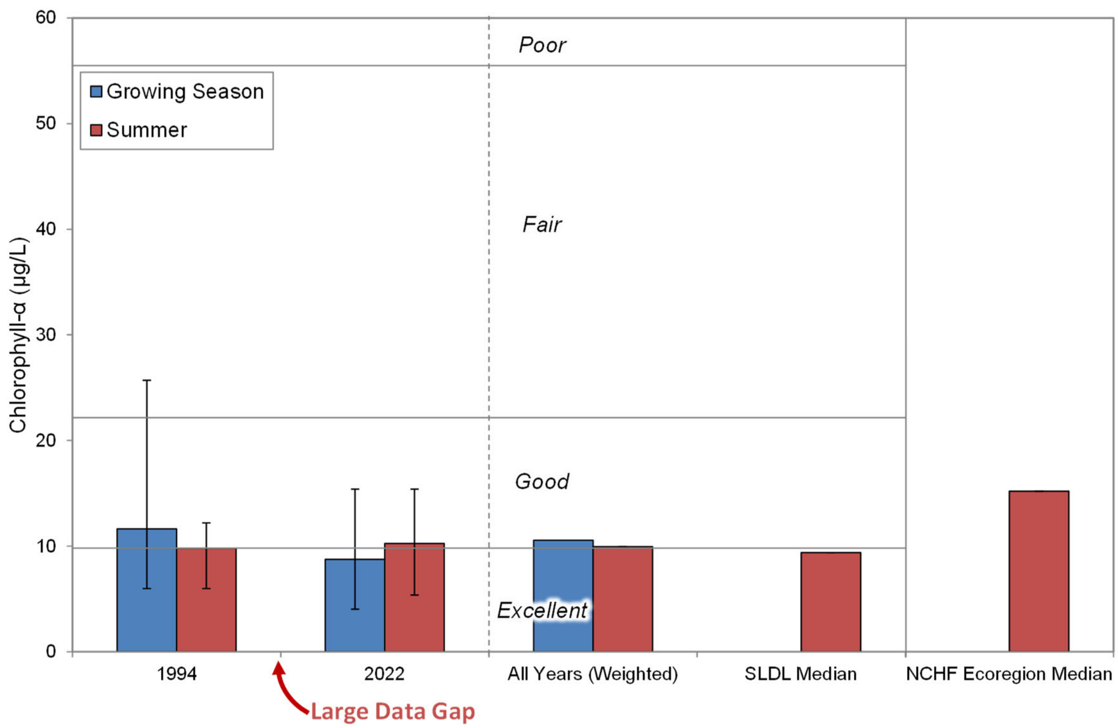


Figure 3.1-4. Lawrence Lake, statewide class 4 lakes, and regional chlorophyll-a concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Most chlorophyll-*a* values fall within the *Good* or *Excellent* category. The summer weighted average falls right on the boarder of the two categories and is slightly higher than the median values for other shallow lowland drainage lakes in the state, and well below the median value for other lakes in the ecoregion.

The most data exists for Secchi disk transparency, although large gaps do exist within the dataset (Figure 3.1-5). Most years have at least three readings, but 1972 and 1974 only have two, while 2002 has only a single reading. Like many flowages, the annual means fluctuate greatly and are likely somewhat related to precipitation over the winter, spring, and summer. Most annual means fall with the *Excellent* category, and the weighted means created from all available data are with the *Excellent* category as well. The weighted summer mean is slightly deeper than the median values from other shallow lowland drainage lakes in Wisconsin and all lakes within the NCHF ecoregion.

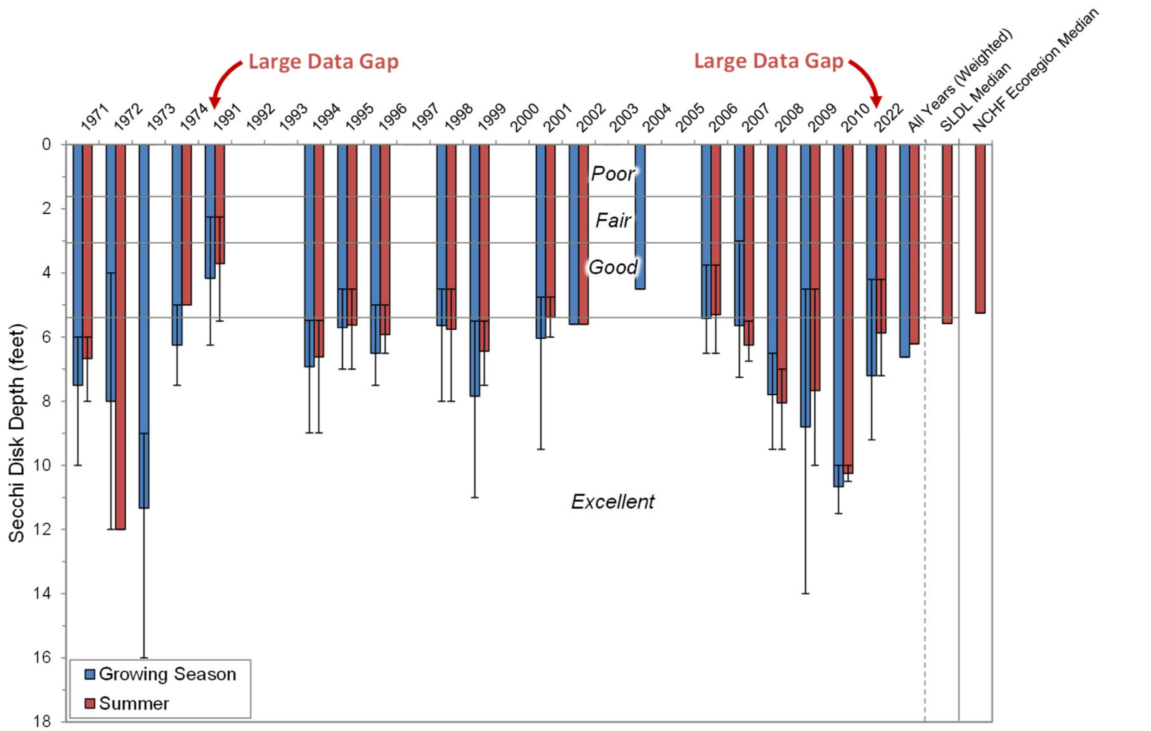


Figure 3.1-5. Lawrence Lake, statewide class 4 lakes, and regional Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Limiting Plant Nutrient of Lawrence Lake

Using midsummer nitrogen and phosphorus concentrations from Lawrence Lake, a nitrogen:phosphorus ratio of 92:1 was calculated. This finding indicates that Lawrence Lake is indeed phosphorus limited as are the vast majority of Wisconsin lakes. In general, this means that cutting phosphorus inputs may limit phytoplankton growth within the lake.

Lawrence Lake Trophic State

Figure 3.1-6 contain the TSI values for Lawrence Lake. The TSI values calculated with Secchi disk, chlorophyll-*a*, and total phosphorus values range in values spanning from oligotrophic to upper eutrophic. Relying primarily on the 2022 values, which is the only year with all three TSI values, it can be concluded that Lawrence Lake is in a lower eutrophic state. This state is also supported by the large amount of plant growth within the lake.

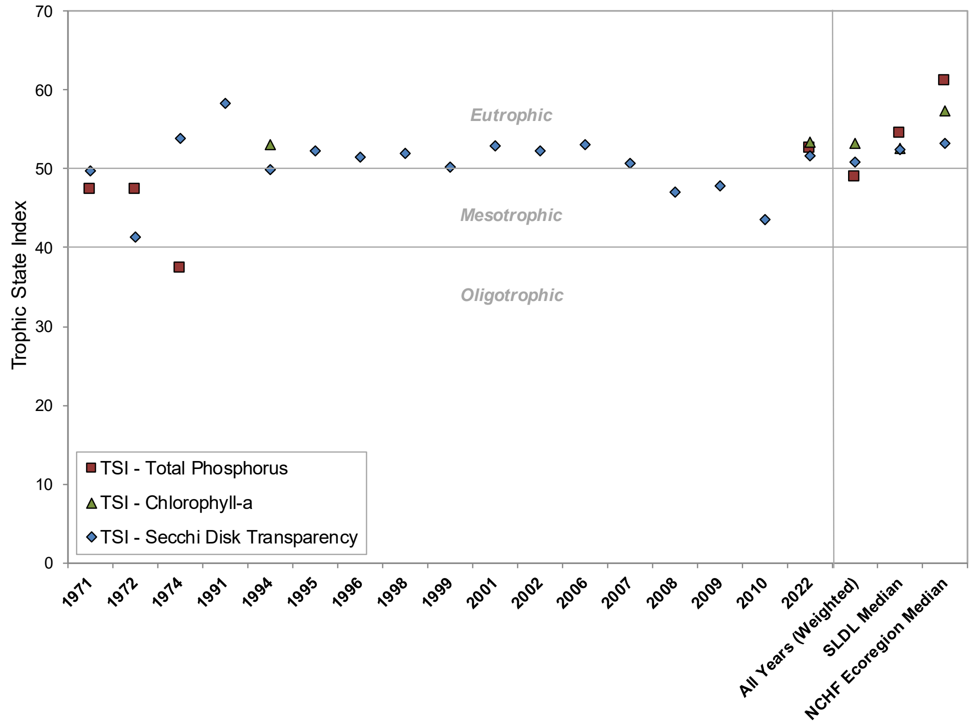


Figure 3.1-6. Lawrence Lake, statewide class 4 lakes, and regional Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Additional Water Quality Data Collected at Lawrence Lake

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

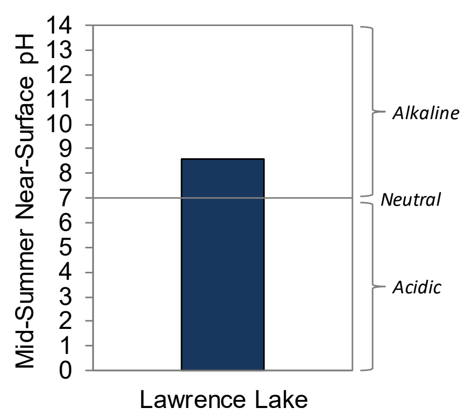


Figure 3.1-7. Lawrence Lake mid-summer near-surface pH value.

The pH scale ranges from 0 to 14 and indicates the concentration of hydrogen ions (H^+) within the lake's water and is an index of the lake's acidity. Water with a pH value of 7 has equal amounts of hydrogen ions and hydroxide ions (OH^-), and is considered to be neutral. Water with a pH of less than 7 has higher concentrations of hydrogen ions and is considered to be acidic, while values greater than 7 have lower hydrogen ion concentrations and are considered basic or alkaline. The pH scale is logarithmic; meaning that for every 1.0 pH unit the hydrogen ion concentration changes tenfold. The normal range for lake water pH in Wisconsin is about 5.2 to 8.4, though values lower than 5.2 can be observed in some acid bog lakes and higher than 8.4 in some marl lakes. In lakes with a pH of 6.5 and lower, the spawning of certain fish species such as walleye becomes inhibited (Shaw & Nimphius, 1985). The pH of the water in Lawrence Lake was found to be slightly alkaline with a value of 8.6, and falls within the normal range for Wisconsin Lakes (Figure 3.1-7).

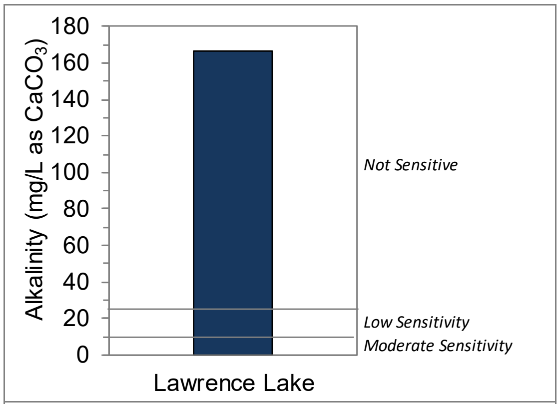


Figure 3.1-8. Lawrence Lake average growing season total alkalinity and sensitivity to acid rain. Samples collected from near-surface.

Alkalinity is a lake's capacity to resist fluctuations in pH by neutralizing or buffering against inputs such as acid rain. The main compounds that contribute to a lake's alkalinity in Wisconsin are bicarbonate (HCO_3^-) and carbonate (CO_3^-), which neutralize hydrogen ions from acidic inputs. These compounds are present in a lake if the groundwater entering it comes into contact with minerals such as calcite ($CaCO_3$) and/or dolomite ($CaMgCO_3)_2$). A lake's pH is primarily determined by the amount of alkalinity. Rainwater in northern Wisconsin is slightly acidic naturally due to dissolved carbon dioxide from the atmosphere with a pH of around 5.0. Consequently, lakes with low alkalinity have lower pH due to their inability to buffer against acid inputs. The alkalinity in Lawrence Lake was measured at 166.5 (mg/L as $CaCO_3$), indicating that the lake has a substantial capacity to resist fluctuations in pH and has a low sensitivity to acid rain (Figure 3.1-8).

Like associated pH and alkalinity, the concentration of calcium within a lake's water depends on the geology of the lake's watershed. Recently, the combination of calcium concentration and pH has been used to determine what lakes can support zebra mussel populations if they are introduced. The commonly accepted pH range for zebra mussels is 7.0 to 9.0, so Lawrence Lake's pH of 8.6 falls within this range. Lakes with calcium concentrations of less than 12 mg/L are considered to have very low susceptibility to zebra mussel establishment. The calcium concentration of Lawrence Lake was found to be 33.7 mg/L, falling well within the optimal range for zebra mussels (Figure 3.1-9).

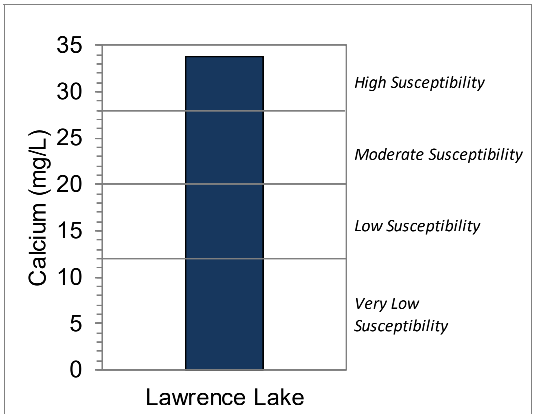


Figure 3.1-9. Lawrence Lake spring calcium concentration and zebra mussel susceptibility. Samples collected from the near-surface.

Zebra mussels (*Dreissena polymorpha*) are small bottom-dwelling mussels, native to Europe and Asia, that found their way to the Great Lakes region in the mid-1980s. They are thought to have come into the region through ballast water of ocean-going ships entering the Great Lakes, and they have the capacity to spread rapidly. Zebra mussels can attach themselves to boats, boat lifts, and docks, and can live for up to five days after being taken out of the water. These mussels can be identified by their small size, D-shaped shell and yellow-brown striped coloring. Once zebra mussels have entered and established in a waterway, they are nearly impossible to eradicate. Best practice methods for cleaning boats that have been in zebra mussel infested waters is inspecting and removing any attached mussels, spraying your boat down with diluted bleach, power-washing, and letting the watercraft dry for at least five days.

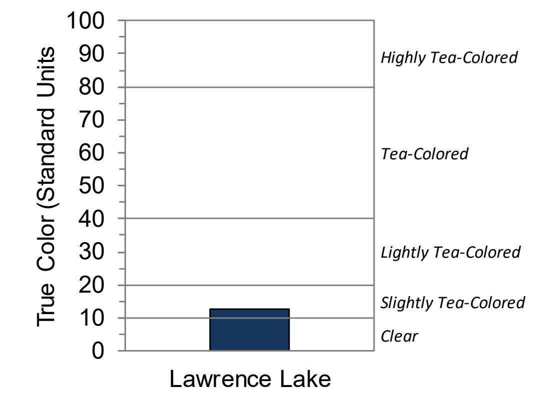


Figure 3.1-10. Lawrence Lake 2022 near-surface true color value.

A measure of water clarity once all of the suspended material (i.e., phytoplankton and sediments) have been removed, is termed *true color*, and measures how the clarity of the water is influenced by dissolved components. True color was measured at 5 SU (standard units) in April and 20 SU in July of 2022, indicating the lake's water was *slightly tea-colored* in 2022 (Figure 3.1-10).

Dissolved Oxygen and Temperature in Lawrence Lake

Dissolved oxygen and temperature were measured during water quality sampling visits to Lawrence Lake by Onterra staff. Profiles depicting these data are displayed in Figure 3.1-11. It appears that the lake began to stratify in mid-June, but was partially broken up, likely by incoming tributary water in July. Weak stratification was apparent in August and turnover began prior to late October.

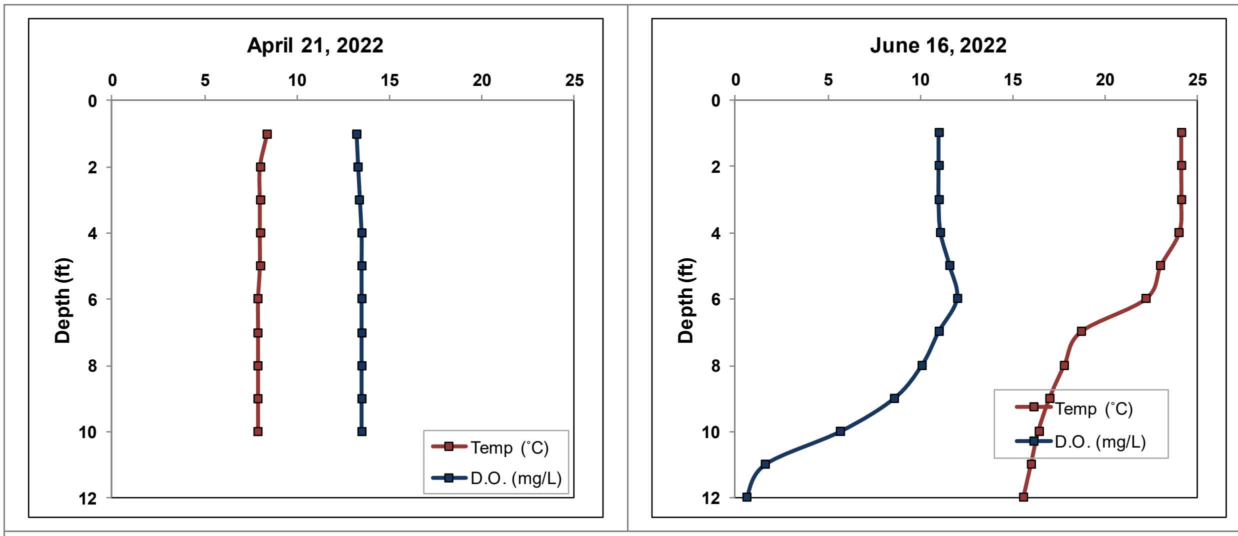


Figure 3.1-11. Lawrence Lake dissolved oxygen and temperature profiles.

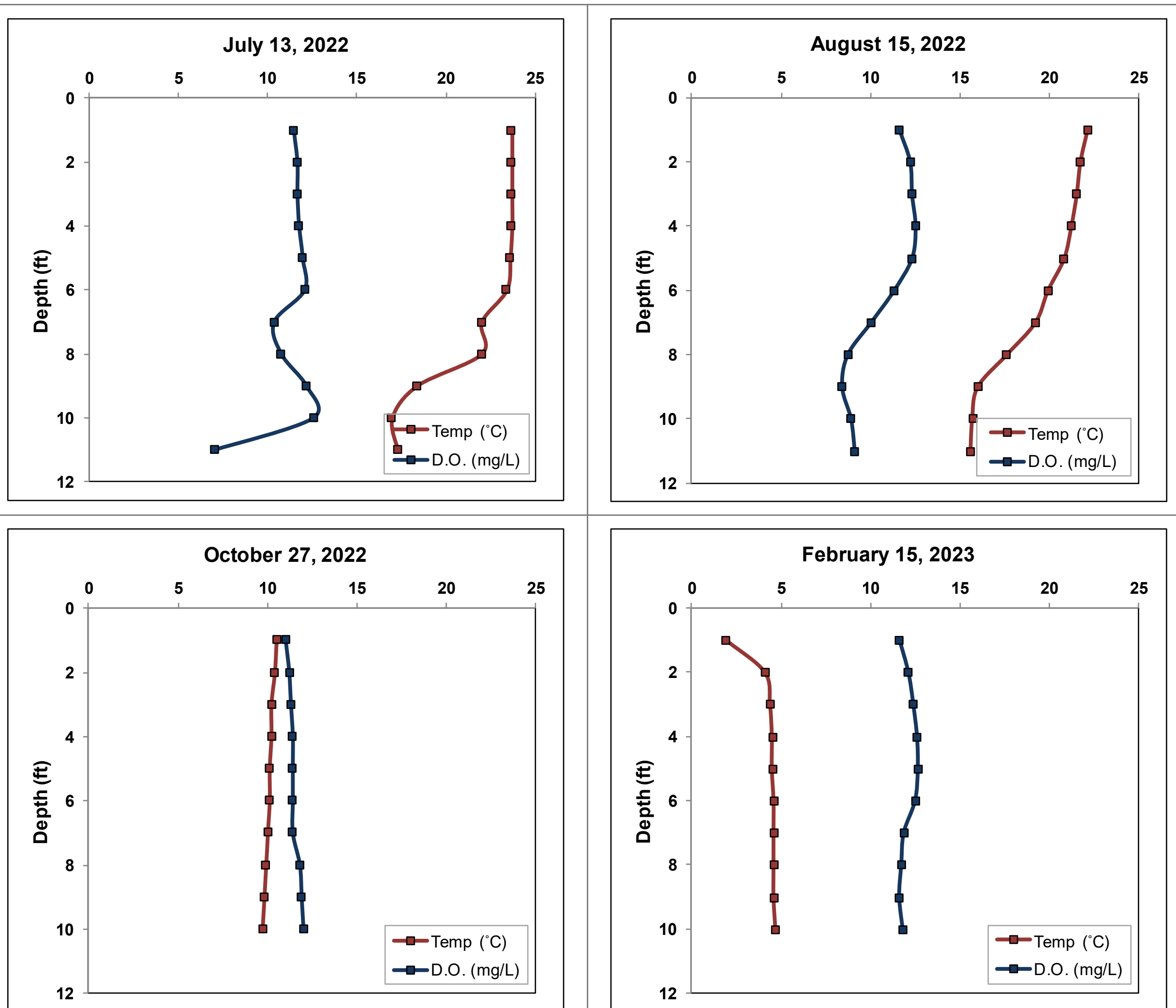


Figure 3.1-11 (con't). Lawrence Lake dissolved oxygen and temperature profiles.

Onterra staff visited the lake in mid-February and sampled water quality through the ice. During that time, excellent oxygen levels were found throughout the water column.

Stakeholder Survey Responses to Lawrence Lake Water Quality

As discussed in section 2.0, the stakeholder survey asks many questions pertaining to perception of the lake and how it may have changed over the years. Figures 3.1-12 and 3.1-13 display the responses of members of Lawrence Lake stakeholders to questions regarding water quality and how it has changed over their years visiting Lawrence Lake.

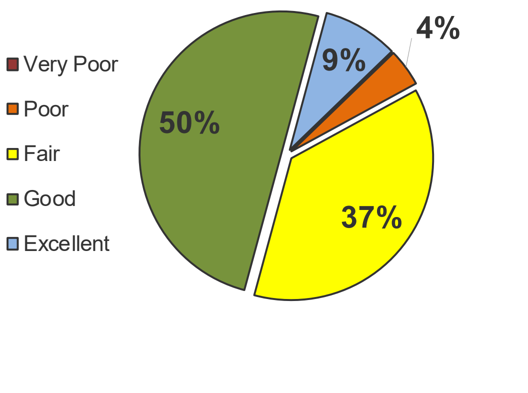


Figure 3.1-12. Stakeholder survey response Question #18. How would you describe the current water quality of Lawrence Lake?

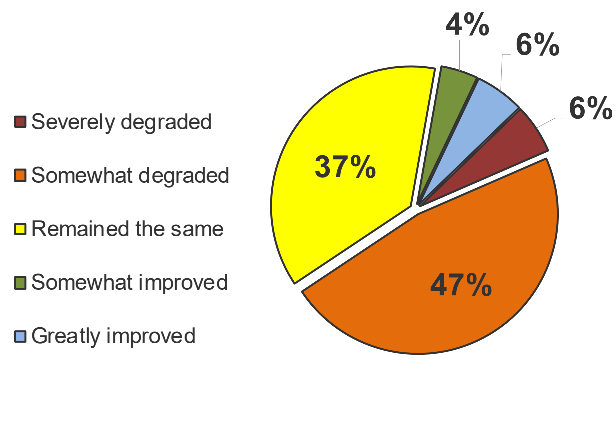


Figure 3.1-13. Stakeholder survey response Question #19. How has the water quality changed in Lawrence Lake since you first visited the lake?

3.2 Watershed Assessment

Watershed Modeling

> 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.

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 result in the watershed having a greater role in the lake's annual water budget and phosphorus load.

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 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.

Lawrence Lake Watershed Assessment – TMDL Model

Section 303(d) of the Federal Clean Water Act (CWA) requires US states to identify waters within their boundaries that are not meeting state water quality standards. For these impaired waterbodies, Section 303(d) further requires EPA and states to develop a Total Maximum Daily Load (TMDL) for the pollutant(s) violating or causing violation of water quality standards. A TMDL defines the loading capacity which is the maximum amount of the pollutant that a waterbody can assimilate while continuing to meet water quality standards. A TMDL also allocates the maximum allowable pollutant load between point and nonpoint sources of the pollutant (WDNR, 2020).

A TMDL provides a framework for EPA, states, and partner organizations to establish and implement pollution control and management plans, with the ultimate goal described in Section 101(a)(2) of the CWA: "water quality which provides for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water, wherever attainable (WDNR, 2020)."

This report presents TMDLs for total phosphorus (TP) and sediment (as Total Suspended Solids, TSS) for surface waters in the Upper Fox and Wolf Basins in Wisconsin. This TMDL is designed to both address impaired waters that are not meeting water quality standards and to protect waters from being listed as impaired by having the loading capacity meet water quality standards for both listed and unlisted waters (WDNR, 2020)."

The Upper Fox and Wolf Basins (UFWB) are located in east-central Wisconsin. Surface waters in the UFWB are impaired by excessive phosphorus and sediment loading, which leads to nuisance algae growth, oxygen depletion, fish kills, reduced submerged aquatic vegetation, water clarity problems, and degraded habitat. These impairments adversely affect fish and aquatic life, drinking water supplies, recreation, and potentially navigation (WDNR, 2020)."

The UFWB is also subject to excess sediment loading to surface waters. Excess sediment in streams, rivers, and lakes scatters and absorbs sunlight, reducing the amount of light available to submerged aquatic vegetation for growth and potentially increasing water temperature. The loss of submerged aquatic plants 2 is problematic because within an aquatic ecosystem they act to release dissolved oxygen, provide food and habitat for fish and other aquatic life, stabilize bottom sediments, protect shorelines from erosion, and utilize nutrients that would otherwise be available for nuisance algae growth (WDNR, 2020).

Within the Wolf River watershed is the subbasin Westfield Creek (Figure 3.2-1), where Lawrence Lake's watershed is located. This watershed lies in Marquette and Adams counties and covers over 3,778 acres, or 6 square miles. The watershed drains 11 miles of named and unnamed streams until its confluence with the Westfield Creek. This watershed resides in the Central Sands ecological landscape of Wisconsin (WDNR, 2015) which is characterized by a patchy mixture of forest, wetland, agriculture, and urban areas. Although the climate is suitable for agricultural row crops, small grains, and pastures, the sandy soils somewhat limit agricultural potential.

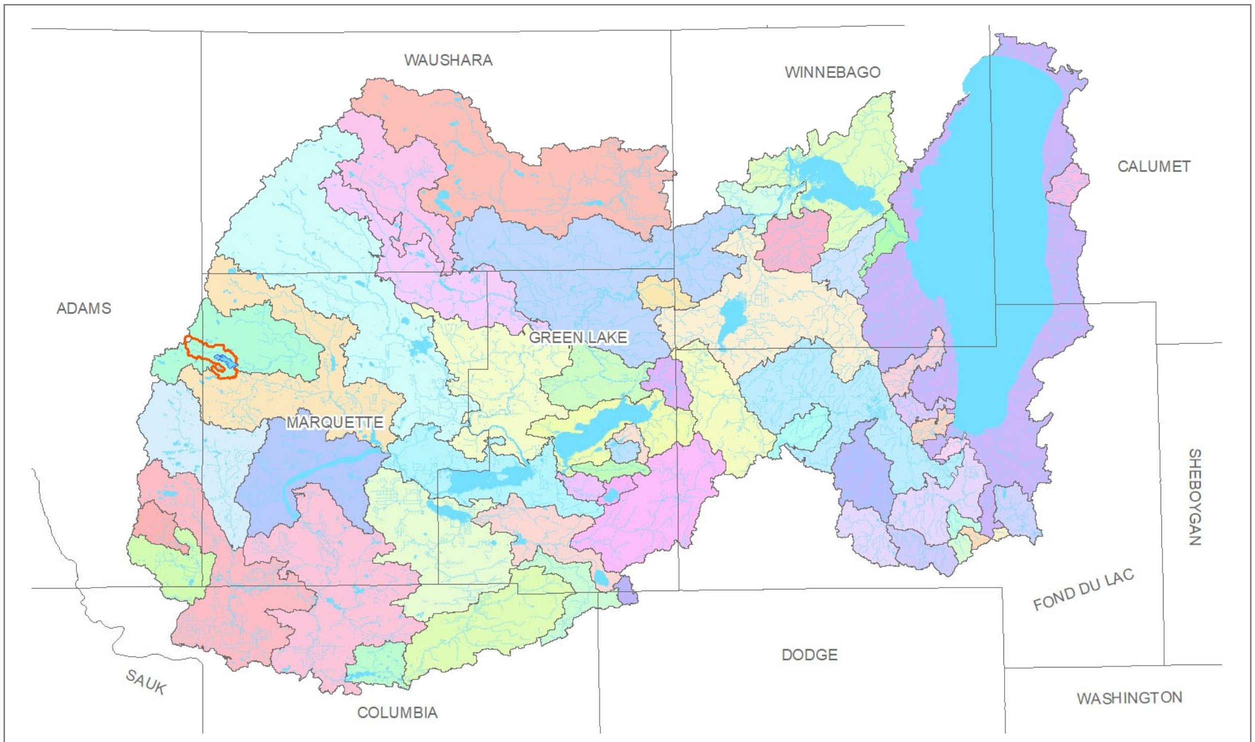


Figure 3.2-1. Lawrence Lake watershed within the Upper Fox portion of the UFWB TMDL.

Lawrence Lake Watershed Assessment – WiLMS Model

Lawrence Lake's entire surface watershed encompasses an area of approximately 13,718 acres (Figure 3.2-2), or about 21.4 sq.mi. However, that drainage basin includes several self-contained subwatersheds that primarily drain to seepage lakes. While that land is technically in the Lawrence Lake surface watershed, the subbasins would essentially need to fill with water before spilling over into Lawrence Lake. During winter 2023, the possibility of flow from the suspected self-contained subwatersheds were visually inspected by Onterra staff at the locations shown in Figure 3.2-2. Without a catastrophic precipitation event, it is of course impossible for the subwatersheds to fill, so those basins are not included in Lawrence Lake's *direct* watershed.

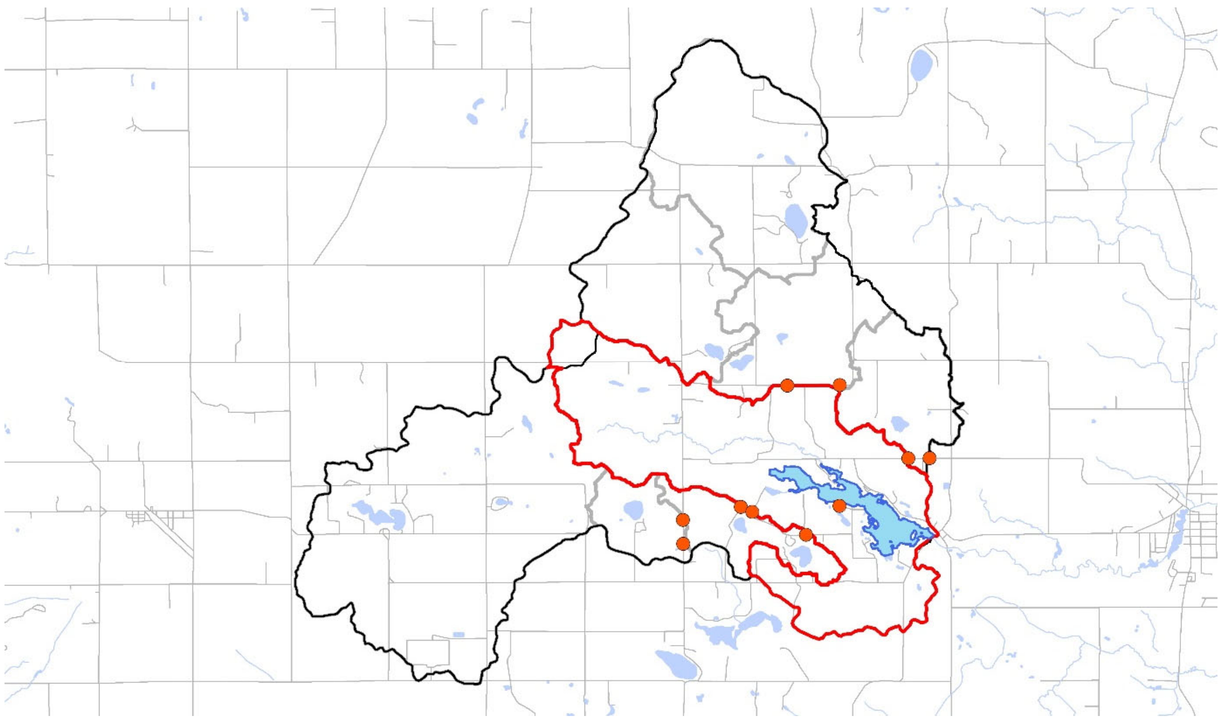


Figure 3.2-2. Lawrence Lake Full Surface Watershed and Direct Watershed. The black line denotes the full surface watershed of Lawrence Lake, while the red line indicates the direct watershed area used in this project's modeling. The red dots indicate areas that were inspected by Onterra staff to confirm whether or not surface flow was crossing self-contained subwatershed boundaries into Lawrence Lake's direct watershed.

Different types of landcover export varying amounts of phosphorus as water runs off the land and makes its way to a lake. Row crop agriculture and high-density development export the highest levels of phosphorus per acre, while forested areas and wetlands export the least. Map 2 shows the partitioning of landcover types within Lawrence Lake's 3,778 acres (5.9 sq.mi.) direct watershed. Forest, pasture/grass, wetlands, and Lawrence Lake itself, which are all considered relatively low contributors of phosphorus make up about 88% of the total watershed area (Figure 3.2-3). Landcover types such as urbanized areas and agricultural row crops occupy just over a third of the watershed area. Fortunately, the row crop areas are not near the lake.

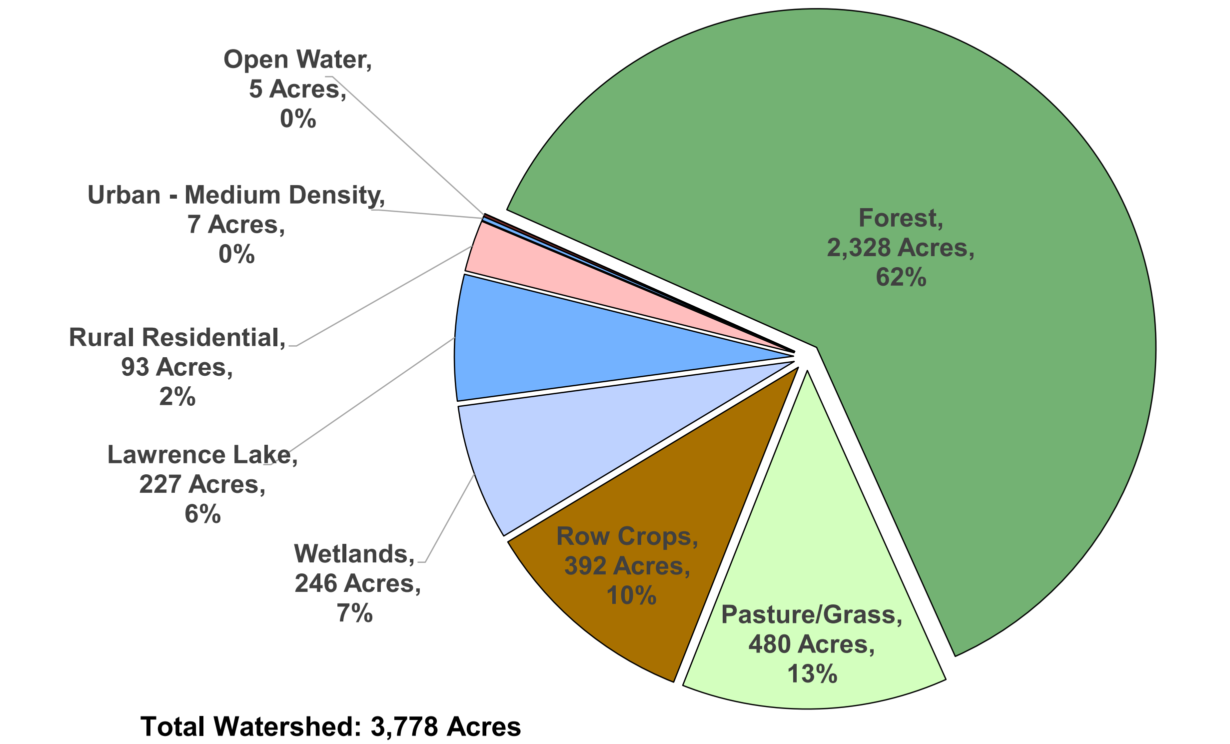


Figure 3.2-3 Lawrence Lake watershed land cover types in acres. Based upon 2019 National Land Cover Database.

Figure 3.2-4 displays the annual estimated load of phosphorus to Lawrence Lake from each of the categories discussed above. Row crop agriculture and urbanized areas make up less than a third of the watershed acreage, but they account for nearly half of Lawrence Lake's annual phosphorus load, while forested areas, pasture/grass, and wetlands provide under 45% of the load. Shoreline septic systems are estimated to provide about three percent of the lakes phosphorus each year, which would be considered essentially negligible.

The modeling estimated that approximately 784 lbs. of phosphorus is added to Lawrence Lake via its surface watershed on an annual basis. Predictive equations developed with other temperate waterbodies in the U.S. estimate a likely growing season mean phosphorus concentration of approximately 42 µg/L and a range of 25-75 µg/L overall. Lawrence Lake's actual growing season mean phosphorus concentration is 25 µg/L and falls within the low range of the predicted values. Lawrence Lake's measured phosphorus level being on the very low side of the modeled range is not surprising considering the large amount of wetland and forested areas that surround the lake and the fact that much of the lake's surface flow originates in headwater tributaries.

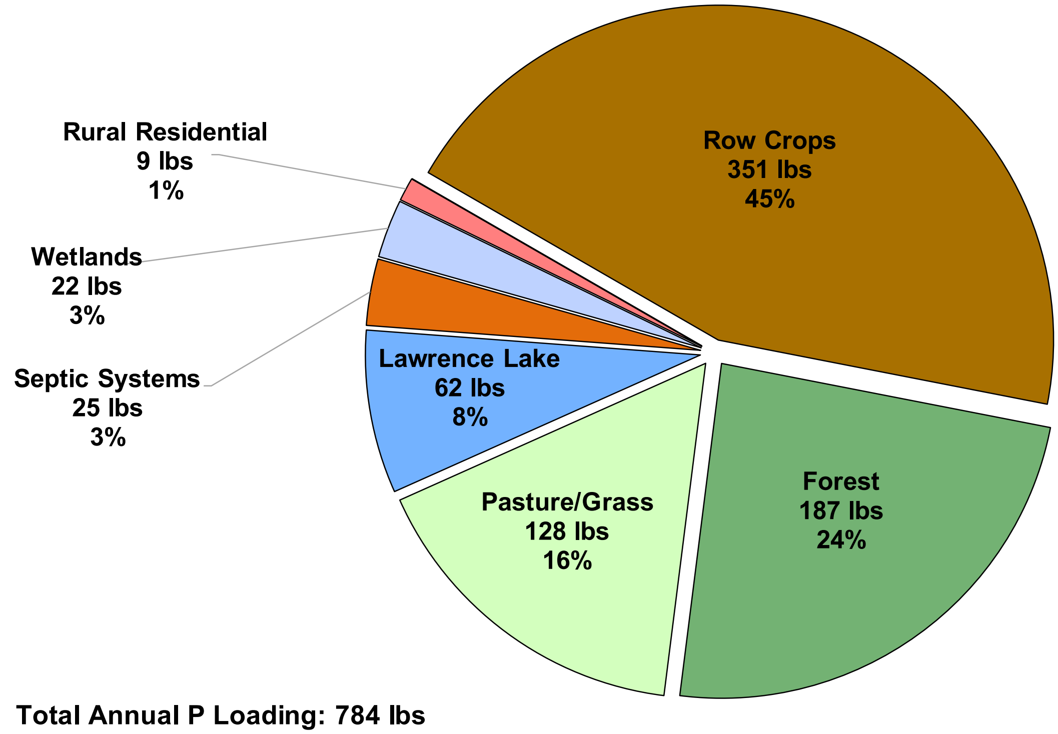


Figure 3.2-4. Lawrence Lake watershed phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

3.3 Shoreland Condition

Lake Shoreland Zone and its Importance

One of the most vulnerable areas of a lake's watershed is the immediate shoreland zone (approximately from the water's edge to at least 35 feet inland). When a lake's shoreland is developed, the increased impervious surface, removal of natural vegetation, and other human practices can severely increase pollutant loads to the lake while degrading important habitat. Limiting these anthropogenic (man-made) effects on the lake is important in maintaining the quality of the lake's water and habitat.

The intrinsic value of natural shorelands is found in numerous forms. Vegetated shorelands prevent polluted runoff from entering lakes by filtering this water or allowing it to slow to the point where particulates settle. The roots of shoreland plants stabilize the soil, thereby preventing shoreland erosion. Shorelands also provide habitat for both aquatic and terrestrial animal species. Many species rely on natural shorelands for all or part of their life cycle as a source of food, cover from predators, and as a place to raise their young. Shorelands and the nearby shallow waters serve as spawning grounds for fish and nesting sites for birds. Thus, both the removal of vegetation and the inclusion of development reduces many forms of habitat for wildlife.

Some forms of development may provide habitat for less than desirable species. Disturbed areas are often overtaken by invasive species, which are sometimes termed "pioneer species" for this reason. Some waterfowl, such as geese, prefer to linger upon open lawns near waterbodies because of the lack of cover for potential predators. The presence of geese on a lake resident's beach may not be an issue; however, the feces the geese leave are unsightly and pose a health risk. Geese feces may become a source of fecal coliforms as well as flatworms that can lead to swimmers' itch. Development such as rip rap or masonry, steel or wooden seawalls completely remove natural habitat for most animals, but may also create some habitat for snails; this is not desirable for lakes that experience problems with swimmers' itch, as the flatworms that cause this skin reaction utilize snails as a secondary host after waterfowl.

In the end, natural shorelines provide many ecological and other benefits. Between the abundant wildlife, the lush vegetation, and the presence of native flowers, shorelands also provide natural scenic beauty and a sense of tranquility for humans.

Shoreland Zone Regulations

Wisconsin has numerous regulations in place at the state level which aim to enhance and protect shorelands. Additionally, counties, townships and other municipalities have developed their own (often more comprehensive or stronger) policies. At the state level, the following shoreland regulations exist:

Wisconsin-NR 115: Wisconsin's Shoreland Protection Program

Wisconsin's shoreland zoning rule, NR 115, sets the minimum standards for shoreland development. First adopted in 1966, the code set a deadline for county adoption of January 1, 1968. By 1971, all counties in Wisconsin had adopted the code and were administering the shoreland ordinances it specified. Interestingly, in 2007 it was noted that many (27) counties had recognized inadequacies within the 1968 ordinance and had actually adopted stricter shoreland ordinances. Revised in February of 2010, and again in October of 2014, the finalized NR 115 allowed many standards to remain the same, such as lot sizes, shoreland setbacks and buffer sizes. However, several standards changed as a result of efforts to balance public rights to lake use with private property rights. The regulation sets minimum standards for the shoreland zone, and requires all counties in the state to adopt shoreland zoning ordinances. Counties were previously able to set their own, stricter, regulations to NR 115 but as of 2015, all counties have to abide by state regulations. Minimum requirements for each of these categories are described below.

- Vegetation Removal: For the first 35 feet of property (shoreland zone), no vegetation removal is permitted except for: sound forestry practices on larger pieces of land, access and viewing corridors (may not exceed 35 percent of the shoreline frontage), invasive species removal, or damaged, diseased, or dying vegetation. Vegetation removed must be replaced by replanting in the same area (native species only).

- Impervious surface standards: In general, the amount of impervious surface is restricted to 15% of the total lot size, on lots that are within 300 feet of the ordinary high-water mark of the waterbody. If a property owner treats their run off with some type of treatment system, they may be able to apply for an increase in their impervious surface limit, up to 30% for residential land use. Exceptions to this limit do exist if a county has designated highly-developed areas, so it is recommended to consult county-specific zoning regulations for this standard.

- Nonconforming structures: Nonconforming structures are structures that were lawfully placed when constructed, but do not comply with distance of water setback. Originally, structures within 75 ft of the shoreline had limitations on structural repair and expansion. Language in NR-115 allows construction projects on structures within 75 feet. Other specifications must be met as well, and local zoning regulations should be referenced.

Mitigation requirements: Language in NR-115 specifies mitigation techniques that may be incorporated on a property to offset the impacts of impervious surface, replacement of nonconforming structure, or other development projects. Practices such as buffer restorations along the shoreland zone, rain gardens, removal of fire pits, and beaches all may be acceptable mitigation methods. Mitigation requirements are county-specific and any such projects should be discussed with local zoning to determine the requirements.

Wisconsin Act 31

While not directly aimed at regulating shoreland practices, the State of Wisconsin passed Wisconsin Act 31 in 2009 in an effort to minimize watercraft impacts upon shorelines. This act prohibits a person from operating a watercraft (other than personal watercraft) at a speed in excess of slow-no-wake speed within 100 feet of a pier, raft, buoyed area or the shoreline of a lake. Additionally, personal watercraft must abide by slow-no-wake speeds while within 200 feet of these same areas. Act 31 was put into place to reduce wave action upon the sensitive shoreland zone of a lake. The legislation does state that pickup and drop off areas marked with regulatory markers and that are open to personal watercraft operators and motorboats engaged in waterskiing/a similar activity may be exempt from this distance restriction. Additionally, a city, village, town, public inland lake protection and rehabilitation district or town sanitary district may provide an exemption from the 100-foot requirement or may substitute a lesser number of feet.

Shoreland Research

Studies conducted on nutrient runoff from Wisconsin lake shorelands have produced interesting results. For example, a USGS study on several Northwoods Wisconsin lakes was conducted to determine the impact of shoreland development on nutrient (phosphorus and nitrogen) export to these lakes (Graczyk, Hunt, Greb, Buchwald, & Krohelski, 2003). During the study period, water samples were collected from surface runoff and ground water and analyzed for nutrients. These studies were conducted on several developed (lawn covered) and undeveloped (undisturbed forest) areas on each lake. The study found that nutrient yields were greater from lawns than from forested catchments, but also that runoff water volumes were the most important factor in determining whether lawns or wooded catchments contributed more nutrients to the lake. Groundwater inputs to the lake were found to be significant in terms of water flow and nutrient input. Nitrate plus nitrite nitrogen and total phosphorus yields to the ground-water system from a lawn catchment were three or sometimes four times greater than those from wooded catchments.

A separate USGS study was conducted on the Lauderdale Lakes in southern Wisconsin, looking at nutrient runoff from different types of developed shorelands – regular fertilizer application lawns (fertilizer with phosphorus), non-phosphorus fertilizer application sites, and unfertilized sites (Garn, 2002). One of the important findings stemming from this study was that the amount of dissolved phosphorus coming off of regular fertilizer application lawns was twice that of lawns with non-phosphorus or no fertilizer. Dissolved phosphorus is a form in which the phosphorus molecule is not bound to a particle of any kind; in this respect, it is readily available to algae. Therefore, these studies show us that it is a developed shoreland that is continuously maintained in an unnatural manner (receiving phosphorus rich fertilizer) that impacts lakes the greatest. This understanding led former Governor Jim Doyle into passing the Wisconsin Zero-Phosphorus Fertilizer Law (Wis Statue 94.643), which restricts the use, sale, and display of lawn and turf fertilizer which contains phosphorus. Certain exceptions apply, but after April 1 2010, use of this type of fertilizer is prohibited on lawns and turf in Wisconsin. The goal of this action is to reduce the impact of developed lawns, and is particularly helpful to developed lawns situated near Wisconsin waterbodies.

Shorelands provide much in terms of nutrient retention and mitigation, but also play an important role in wildlife habitat. Woodford and Meyer found that green frog density was negatively correlated with development density in Wisconsin lakes (Woodford & Meyer, 2003). As development increased, the habitat for green frogs decreased and thus populations became significantly lower. Common loons, a bird species notorious for its haunting call that echoes across Wisconsin lakes, are often associated more so with undeveloped lakes than developed lakes (Lindsay, Gillum, & Meyer, 2002). And studies on shoreland development and fish nests show that undeveloped shorelands are preferred as well. In a study conducted on three Minnesota lakes, researchers found that only 74 of 852 black crappie nests were found near shorelines that had any type of dwelling on it (Reed, 2001). The remaining nests were all located along undeveloped shoreland.

Photograph 3.3-1. Example of coarse woody habitat in a lake.

Emerging research in Wisconsin has shown that coarse woody habitat (sometimes called "coarse woody debris"), often stemming from natural or undeveloped shorelands, provides many ecosystem benefits in a lake. Coarse woody habitat describes habitat consisting of trees, limbs, branches, roots and wood fragments at least four inches in diameter that enter a lake by natural or human means. Coarse woody habitat provides shoreland erosion control, a carbon source for the lake, prevents suspension of sediments and provides a surface for algal growth which is important for aquatic macroinvertebrates (Sass, 2009). While it impacts these aspects considerably, one of the greatest benefits coarse woody habitat provides is habitat for fish species.

Coarse woody habitat has shown to be advantageous for fisheries in terms of providing refuge, foraging area, as well as spawning habitat (Hanchin, Willis, & St. Stauver, 2003). In one study, researchers observed 16 different species occupying coarse woody habitat areas in a Wisconsin lake (Newbrey, Bozek, Jennings, & Cook, 2005). Bluegill and bass species in particular are attracted to this habitat type; largemouth bass stalk bluegill in these areas while the bluegill hide amongst the debris and often feed upon many macroinvertebrates found in these areas, who themselves are feeding upon algae and periphyton growing on the wood surface. Newbrey et al. 2005 found that some fish species prefer different complexity of branching on coarse woody habitat, though in general some degree of branching is preferred over coarse woody habitat that has no branching.

With development of a lake's shoreland zone, much of the coarse woody habitat that was once found in Wisconsin lakes has disappeared. Prior to human establishment and development on lakes (mid to late 1800's), the amount of coarse woody habitat in lakes was likely greater than under completely natural conditions due to logging practices. However, with changes in the logging industry and increasing development along lake shorelands, coarse woody habitat has decreased substantially. Shoreland residents are removing woody debris to improve aesthetics or for recreational opportunities such as boating, swimming, and ironically, fishing.

National Lakes Assessment

Unfortunately, along with Wisconsin's lakes, waterbodies within the entire United States have shown to have increasing amounts of developed shorelands. The National Lakes Assessment (NLA) is an Environmental Protection Agency sponsored assessment that has successfully pooled together resource managers from all 50 U.S. states in an effort to assess waterbodies, both natural and man-made, from each state. Through this collaborative effort, over 1,000 lakes were sampled in 2007, pooling together the first statistical analysis of the nation's lakes and reservoirs.

Through the National Lakes Assessment, a number of potential stressors were examined, including nutrient impairment, algal toxins, fish tissue contaminants, physical habitat, and others. The 2007 NLA report states that "*of the stressors examined, poor lakeshore habitat is the biggest problem* *in the nation's lakes; over one-third exhibit poor shoreline habitat condition*" (USEPA, 2009). Furthermore, the report states that "*poor biological health is three times more likely in lakes with poor lakeshore habitat.*" These results indicate that stronger management of shoreline development is absolutely necessary to preserve, protect, and restore lakes. Shoreland protection will become increasingly important as development pressure on lakes continues to grow.

Native Species Enhancement

The development of Wisconsin's shorelands has increased dramatically over the last century and with this increase in development a decrease in water quality and wildlife habitat has occurred. Many people that move to or build in shoreland areas attempt to replicate the suburban landscapes they are accustomed to by converting natural shoreland areas to the "neat and clean" appearance of manicured lawns and flowerbeds. The conversion of these areas immediately leads to destruction of habitat utilized by birds, mammals, reptiles, amphibians, and insects (Jennings, E., Hatzenbeler, Edwards, & Bozek, 2003). The maintenance of the newly created area helps to decrease water quality by considerably increasing inputs of phosphorus and sediments into the lake. The negative impact of human development does not stop at the shoreland. Removal of native plants and dead, fallen timbers from shallow, near-shore areas for boating and swimming activities destroys habitat used by fish, mammals, birds, insects, and amphibians, while leaving bottom and shoreland sediments vulnerable to wave action caused by boating and wind (Jennings, E., Hatzenbeler, Edwards, & Bozek, 2003) (Radomski & Goeman, 2001) (Elias & Meyer, 2003). Many homeowners significantly decrease the number of trees and shrubs along the water's edge in an effort to increase their view of the lake. However, this has been shown to locally increase water temperatures, and decrease infiltration rates of potentially harmful nutrients and pollutants. Furthermore, the dumping of sand to create beach areas destroys spawning, cover and feeding areas utilized by aquatic wildlife (Scheuerell & Schindler, 2004).

Photograph 3.3-2. Example of a biolog restoration site.

In recent years, many lakefront property owners have realized increased aesthetics, fisheries, property values, and water quality by restoring portions of their shoreland to mimic its unaltered state. An area of shore restored to its natural condition, both in the water and on shore, is commonly called a shoreland buffer zone. The shoreland buffer zone creates or restores the ecological habitat and benefits lost by traditional suburban landscaping. Simply not mowing within the buffer zone does wonders to restore some of the shoreland's natural function.

Enhancement activities also include additions of submergent, emergent, and floating-leaf plants within the lake itself. These additions can provide greater species diversity and may compete against exotic species.

Wisconsin's Healthy Lakes & Rivers Action Plan

Starting in 2014, a program was enacted by the WDNR and UW-Extension to promote riparian landowners to implement relatively straight-forward shoreland restoration activities. This program provides education, guidance, and grant funding to promote installation of best management practices aimed to protect and restore lakes and rivers in Wisconsin. The program has identified five best practices aimed at improving habitat and water quality (Figure 3.3-1).

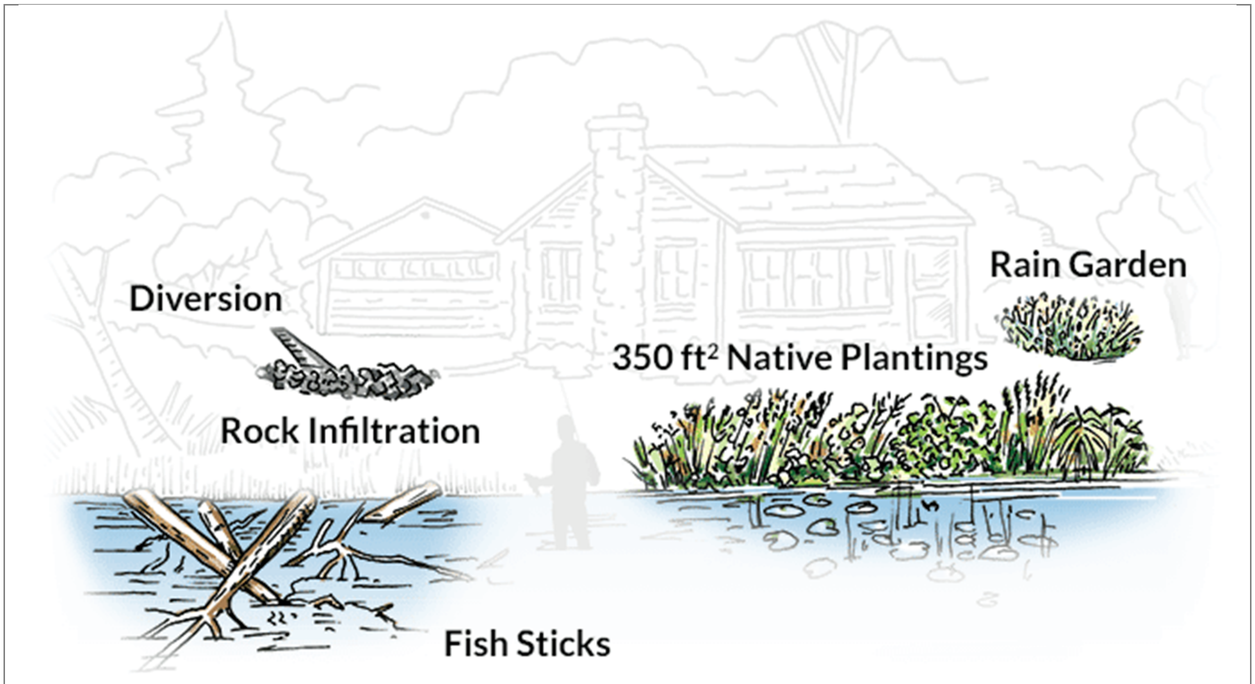


Figure 3.3-1. Healthy Lakes & Rivers 5 Best Practices. Illustration by Karen Engelbretson, extracted from healthylakeswi.com.

- Rain Gardens: This upland best practice consists of a landscaped and vegetated shallow depression aimed at capturing water runoff and allowing it to infiltrate into the soil.
- Rock Infiltration: This upland best practice is an excavated pit or trench, filled with rock, that encourages water to infiltrate into the soil. These practices are strategically placed at along a roof line or the downward sloping area of a driveway.
- Diversion: This best practice can occur in the transition or upland zone. These practices use berms, trenches, and/or treated lumber to redirect water that would otherwise move downhill into a lake. Water diversions may direct water into a Rock Infiltration or Rain Garden to provide the greatest reductions in runoff volumes.
- Native Plantings: This best practice aims to installing native plants within at least 350 square-foot shoreland transition area. This will slow runoff water and provide valuable habitat. One native planting per property per year is eligible.
- Fish Sticks: These in-lake best practices (not eligible for rivers) are woody habitat structures that provide feeding, breeding, and nesting areas for wildlife. Fish sticks consist of multiple whole trees grouped together and anchored to the shore. Trees are not felled from the shoreline, as existing trees are valuable in place, but brought from a short distance or dragged across the ice. In order for this practice to be eligible, an existing vegetated buffer or pledge to install one is required.

The Healthy Lakes and Rivers Grant Program allows partial cost coverage for implementing best practices. Competitive grants are available to eligible applicants such as lake associations and lake districts. The program allows a 75% state cost share up to $1,000 per practice. Multiple practices can be included per grant application, with a $25,000 maximum award per year. Eligible projects need to be on shoreland properties within 1,000 feet of a lake or 300 feet from a river. The landowner must sign a Conservation Commitment pledge to leave the practice in place and provide continued maintenance for 10 years. More information on this program can be found here:

https://healthylakeswi.com/

It is important to note that this grant program is intentionally designed for relatively simple, low-cost, and shovel-ready projects, limiting 10% of the grant award for technical assistance. Larger and more complex projects, especially those that require engineering design components may seek alternative funding sources potentially through the County. Small-Scale Lake Planning Grants can provide up to $3,000 to help build a Healthy Lakes and Rivers project. Eligible expenses in this grant program are surveys, planning, and design.

Lawrence Lake Shoreland Zone Condition

Shoreland Development

The entire shoreline of Lawrence Lake was surveyed on May 24, 2022. A draft WDNR Lake Shoreland & Shallows Habitat Monitoring Field Protocol (WDNR, Lake Shoreland & Shallows Habitat Monitoring Field Protocol, 2020) was utilized to evaluate the shoreland zone on a parcel-by-parcel basis beginning at the estimated high-water level mark and extending inland 35 feet. The immediate shoreline was surveyed and classified based upon its potential to negatively impact the system due to development and other human impacts. Within the shoreland zone the natural vegetation (canopy cover, shrub/herbaceous) was given an estimate of the percentage of the plot which is dominated by each category (Photo 3.3-3). Human disturbances (impervious surface, manicured lawn, agriculture, number of buildings, boats on shore, piers, boat lifts, sea wall length and other similar categories) were also recorded by number of occurrence or percentage during the survey.

Photograph 3.3-3. Example of canopy, shrub and herbaceous layers.

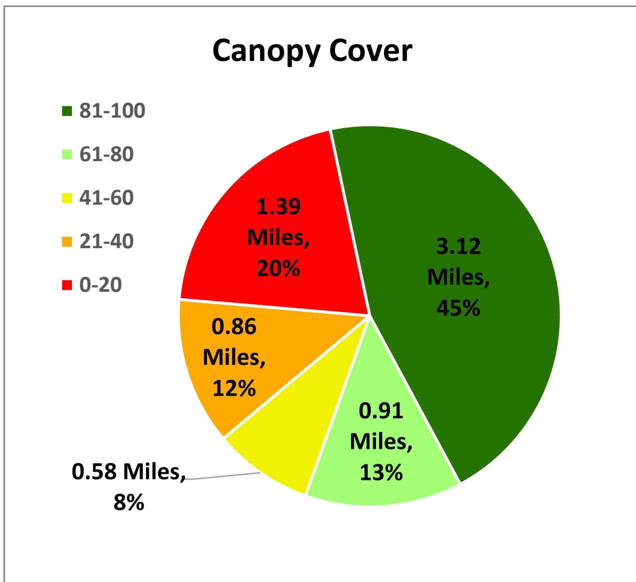
For this management plan, the percent canopy cover, percent shrub/herbaceous, percent manicured lawn and percent impervious surfaces are primarily focused upon to assess the shoreline for development and determine a need for restoration. In general, developed shorelands impact a lake ecosystem in a negative manner, while definite benefits occur from shorelands that are left in their natural state or a near-natural state.

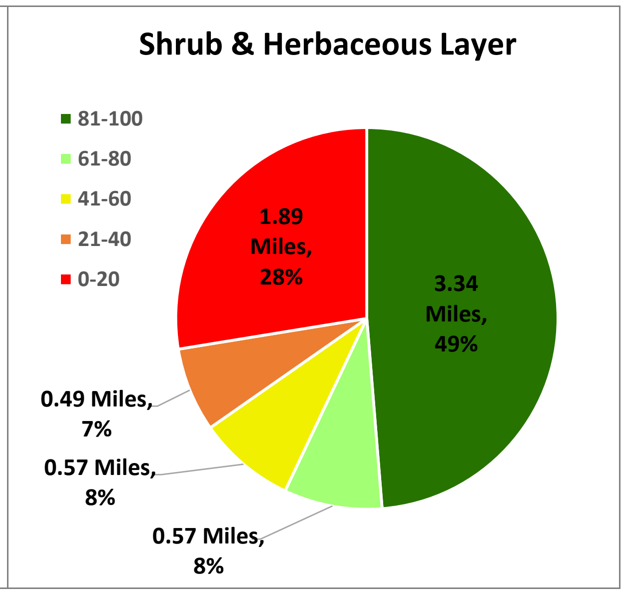
Canopy cover was defined as an area which is shaded by trees that are at least 16 feet tall (Photograph 3.3-3). The majority (66%) of Lawrence Lake's shoreline has more than 40% canopy cover (Figure 3.3-2). Undeveloped parcels, such as wetland areas, that naturally do not have a canopy present are also factored into this result (Map 3).

Shrub and herbaceous layers are small trees and plants without woody stems less than 16 feet tall (Photograph 3.3-3). The shoreland assessment survey indicates that 3.34 miles, or 49% Lawrence Lake's parcels contained between 81-100% shrub and herbaceous layers (Figure 3.3-2, Map 4). Another 1.89 miles (28%) only had between 0 and 20% shrub and herbaceous layer present on the parcel.

A manicured lawn is defined as grass that is mowed short and is direct evidence of urbanization. Having a manicured lawn poses a risk as runoff will carry pollutants, such as lawn fertilizers, into the lake. Approximately 46% of the parcels around the lake had no manicured lawn within the shoreland zone and another 16% of parcels had between 1-25% of the shoreland zone containing manicured lawn (Figure 3.3-2, Map 5). Approximately 8% of the shoreland parcels contained manicured lawn on 76% or greater of the shoreland zone.

Impervious surface is an area that releases all or a majority of the precipitation that falls onto it (e.g., rooftops, concrete, stairs, boulders and boats flipped over on shore). Approximately 95% of the shoreline had parcels with less than 24% of impervious surface within the shoreland zone (Figure 3.3-2, Map 6).





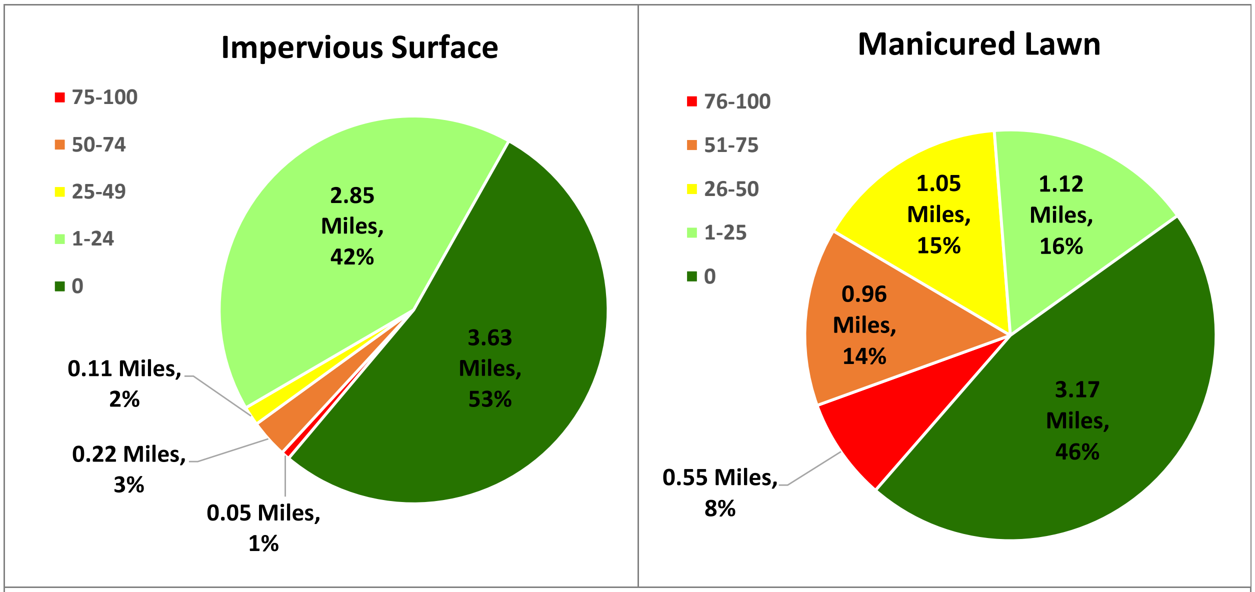


Figure 3.3-2. Lawrence shoreland parcel canopy cover, shrub-herbaceous cover, impervious surface, and manicured lawn. Data from Onterra 2022 Survey.

While producing a completely natural shoreland is ideal for a lake ecosystem, it is not always practical from a human's perspective. However, riparian property owners can take small steps in ensuring their property's impact upon the lake is minimal. Choosing an appropriate landscape position for lawns is one option to consider. Placing lawns on flat, un-sloped areas or in areas that do not terminate at the lake's edge is one way to reduce the amount of runoff a lake receives from a developed site. And, allowing tree falls and other natural habitat features to remain along a shoreline may result not only in reducing shoreline erosion, but creating wildlife habitat also.

Coarse Woody Habitat

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

During this survey, 107 total pieces of coarse woody habitat were observed along 6.87 miles of shoreline (Map 7), which gives Lawrence Lake a coarse woody habitat to shoreline mile ratio of 16:1 (Figure 3.4-4). The majority of these pieces cross the high-water level, meaning they were not between the shoreline and the two-foot depth contour. A total of 18 pieces were classified as a full canopy. Considering the large amount of wooded shoreline on the lake, it is unusual that Lawrence Lake has such a considerably low amount of coarse woody habitat in it.

There has been 63 completed coarse woody habitat surveys utilizing the WDNR protocol throughout Wisconsin since 2017. The number of coarse woody habitat pieces per shoreline mile on Lawrence Lake falls at the 17th percentile for these lakes (Figure 3.3-3). To put this into perspective, Wisconsin researchers have found that in completely undeveloped lakes, an average of 345 coarse woody habitat structures may be found per mile (Christensen, Herwig, Schindler, & Carpenter, 1996). Please note the methodologies between the surveys done on Lawrence Lake and those cited in this literature comparison are different, but still provide a valuable insight into what undisturbed shorelines may have in terms of coarse woody habitat.

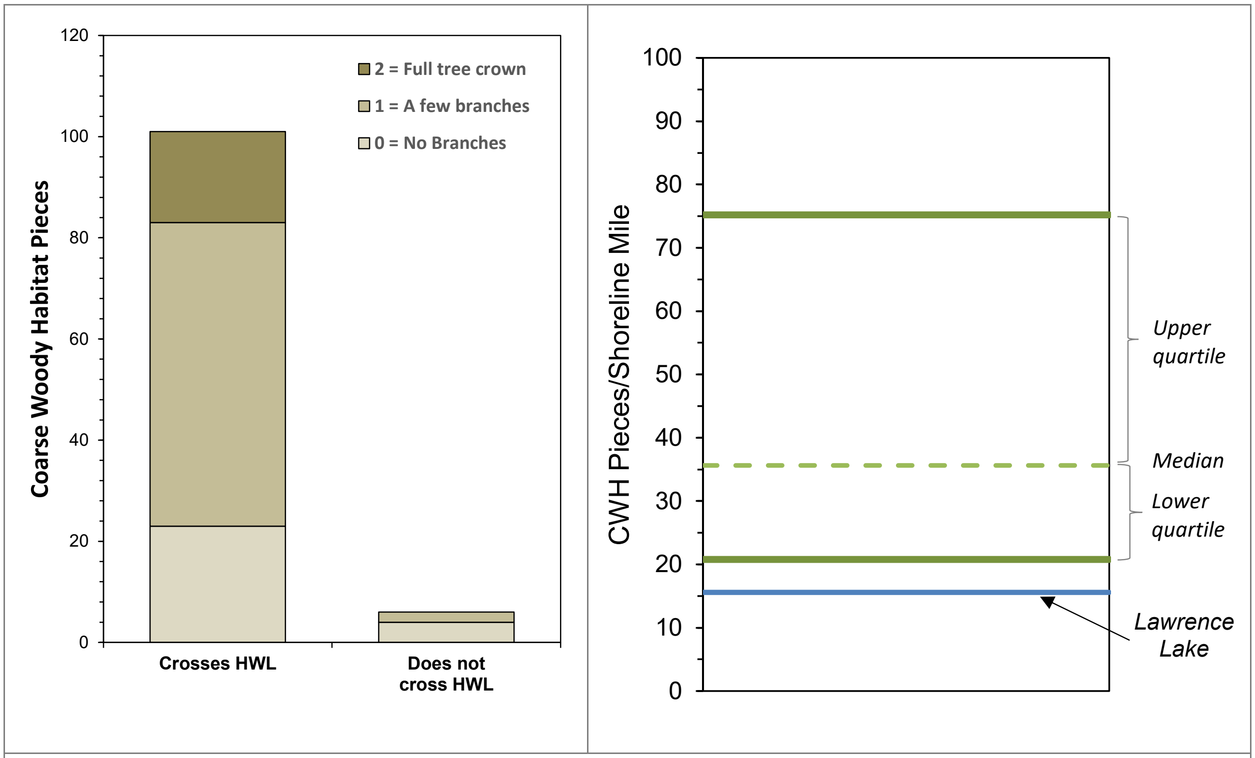


Figure 3.3-3. Lawrence Lake coarse woody habitat survey results. Based upon a Summer 2022 survey. Locations of the Lawrence Lake coarse woody habitat can be found on Map 7.

3.4 Aquatic Plants

Introduction

Although the occasional lake user may consider aquatic macrophytes to be "weeds" and a nuisance to the recreational use of the lake, the plants are actually an essential element in a healthy and functioning lake ecosystem. It is very 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 3.4-1. Example of emergent and floating-leaf communities.

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 wild rice (*Zizania aquatica* and *Z. palustris*) both serve as excellent food sources for ducks and geese. 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. The 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 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 plant nutrient levels that may lead to algae blooms. Lake plants also produce oxygen through photosynthesis and use nutrients that may otherwise be used by phytoplankton, which helps to minimize nuisance algal blooms.

Under certain conditions, a few species may become a problem and require control measures. 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 (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*) can also upset the delicate balance of a lake ecosystem by out competing native plants and reducing species diversity. These species will be discussed further in depth in the Aquatic Invasive Species section. 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 Management and Protection

Important Note:
Even though some of these techniques are not applicable to Lawrence Lake, it is still important for lake users to have a basic understanding of all the techniques so they can better understand why particular methods are or are not applicable in their lake. The techniques applicable to Lawrence Lake are discussed in Summary and Conclusions section and the Implementation Plan found near the end of this document.

Many times an aquatic plant management plan is aimed at only controlling nuisance plant growth that has limited the recreational use of the lake, usually navigation, fishing, and swimming. It is important to remember the vital benefits that native aquatic plants provide to lake users and the lake ecosystem, as described above. Therefore, all aquatic plant management plans also need to address the enhancement and protection of the aquatic plant community. Below are general descriptions of the many techniques that can be utilized to control and enhance aquatic plants. Each alternative has benefits and limitations that are explained in its description. Please note that only legal and commonly used methods are included. For instance, the herbivorous grass carp (*Ctenopharyngodon idella*) is illegal in Wisconsin and rotovation, a process by which the lake bottom is tilled, is not a commonly accepted practice. Unfortunately, there are no "silver bullets" that can completely cure all aquatic plant problems, which makes planning a crucial step in any aquatic plant management activity. Many of the plant management and protection techniques commonly used in Wisconsin are described below.

Permits

The signing of the 2001-2003 State Budget by Gov. McCallum enacted many aquatic plant management regulations. The rules for the regulations have been set forth by the WDNR as NR 107 and 109. A major change includes that all forms of aquatic plant management, even those that did not require a permit in the past, require a permit now, including manual and mechanical removal. Manual cutting and raking are exempt from the permit requirement if the area of plant removal is no more than 30 feet wide and any piers, boatlifts, swim rafts, and other recreational and water use devices are located within that 30 feet. This action can be conducted up to 150 feet from shore. Please note that a permit is needed in all instances if wild rice is to be removed. Furthermore, installation of aquatic plants, even natives, requires approval from the WDNR.

Permits are required for chemical and mechanical manipulation of native and non-native plant communities. Large-scale protocols have been established for chemical treatment projects covering >10 acres or areas greater than 10% of the lake littoral zone and more than 150 feet from shore. Different protocols are to be followed for whole-lake scale treatments (≥160 acres or ≥50% of the lake littoral area). Additionally, it is important to note that local permits and U.S. Army Corps of Engineers regulations may also apply. For more information on permit requirements, please contact the WDNR Regional Water Management Specialist or Aquatic Plant Management and Protection Specialist.

Manual Removal (Hand-Harvesting & DASH)

Manual removal methods include hand-pulling, raking, and hand-cutting (Photograph 3.4-2). Hand-pulling involves the manual removal of whole plants, including roots, from the area of concern and disposing them out of the waterbody. Raking entails the removal of partial and whole plants from the lake by dragging a rake with a rope tied to it through plant beds. Specially designed rakes are available from commercial sources or an asphalt rake can be used. Hand-cutting differs from the other two manual methods because the entire plant is not removed, rather the plants are cut similar to mowing a lawn; however, Wisconsin law states that all plant fragments must be removed.

Photograph 3.4-2. Example of aquatic plants that have been removed manually.

Manual removal or hand-harvesting of aquatic invasive species has gained favor in recent years as an alternative to herbicide control programs. Professional hand-harvesting firms can be contracted for these efforts and can either use basic snorkeling or scuba divers, whereas others might employ the use of a Diver Assisted Suction Harvest (DASH) which involves divers removing plants and feeding them into a suctioned hose for delivery to the deck of the harvesting vessel. The DASH methodology is considered a form of mechanical harvesting and thus requires a WDNR approved permit. DASH is thought to be more efficient in removing target plants than divers alone and is believed to limit fragmentation during the harvesting process.

Cost

Contracting aquatic invasive species removal by third-party firm can cost approximately $1,500 per day for traditional hand-harvesting methods whereas the costs can be closer to $2,500 when DASH technology is used. Additional disposal, travel, and permitting fees may also apply.

Advantages	*Disadvantages*
• Very cost effective for clearing areas around docks, piers, and swimming areas. • Relatively environmentally safe if treatment is conducted after June 15th. • Allows for selective removal of undesirable plant species. • Provides immediate relief in localized area. • Plant biomass is removed from waterbody.	• Labor intensive. • Impractical for larger areas or dense plant beds. • Subsequent treatments may be needed as plants recolonize and/or continue to grow. • Uprooting of plants stirs bottom sediments making it difficult to conduct action. • May disturb benthic organisms and fish-spawning areas. • Risk of spreading invasive species if fragments are not removed.

Bottom Screens

Bottom screens are very much like landscaping fabric used to block weed growth in flowerbeds. The gas-permeable screen is placed over the plant bed and anchored to the lake bottom by staking or weights. Only gas-permeable screen can be used or large pockets of gas will form under the mat as the result of plant decomposition. This could lead to portions of the screen becoming detached from the lake bottom, creating a navigational hazard. Normally the screens are removed and cleaned at the end of the growing season and then placed back in the lake the following spring. If they are not removed, sediments may build up on them and allow for plant colonization on top of the screen. Please note that depending on the size of the screen a Wisconsin Department of Natural Resources permit may be required.

Cost

Material costs range between $.20 and $1.25 per square-foot. Installation cost can vary largely, but may roughly cost $750 to have 1,000 square feet of bottom screen installed. Maintenance costs can also vary, but an estimate for a waterfront lot is about $120 each year.

Advantages	*Disadvantages*
• Immediate and sustainable control. • Long-term costs are low. • Excellent for small areas and around obstructions. • Materials are reusable. • Prevents fragmentation and subsequent spread of plants to other areas.	• Installation may be difficult over dense plant beds and in deep water. • Not species specific. • Disrupts benthic fauna. • May be navigational hazard in shallow water. • Initial costs are high. • Labor intensive due to the seasonal removal and reinstallation requirements. • Does not remove plant biomass from lake. • Not practical in large-scale situations.

Water Level Drawdown

The primary manner of plant control through water level drawdown is the exposure of sediments and plant roots/tubers to desiccation and either heating or freezing depending on the timing of the treatment. Winter drawdowns are more common in temperate climates like that of Wisconsin and usually occur in reservoirs because of the ease of water removal through the outlet structure. An important fact to remember when considering the use of this technique is that only certain species are controlled and that some species may even be enhanced. Furthermore, the process will likely need to be repeated every two or three years to keep target species in check.

Cost

The cost of this alternative is highly variable. If an outlet structure exists, the cost of lowering the water level would be minimal; however, if there is not an outlet, the cost of pumping water to the desirable level could be very expensive. If a hydro-electric facility is operating on the system, the costs associated with loss of production during the drawdown also need to be considered, as they are likely cost prohibitive to conducting the management action.

Advantages	*Disadvantages*
• Inexpensive if outlet structure exists. • May control populations of certain species, like Eurasian watermilfoil for a few years. • Allows some loose sediment to consolidate, increasing water depth. • May enhance growth of desirable emergent species. • Other work, like dock and pier repair may be completed more easily and at a lower cost while water levels are down.	• May be cost prohibitive if pumping is required to lower water levels. • Has the potential to upset the lake ecosystem and have significant effects on fish and other aquatic wildlife. • Adjacent wetlands may be altered due to lower water levels. • Disrupts recreational, hydroelectric, irrigation and water supply uses. • May enhance the spread of certain undesirable species, like common reed and reed canary grass. • Permitting process may require an environmental assessment that may take months to prepare. • Non-selective.

Mechanical Harvesting


Photograph 3.4-3. Mechanical harvester.

Aquatic plant harvesting is frequently used in Wisconsin and involves the cutting and removal of plants much like mowing and bagging a lawn. Harvesters are produced in many sizes that can cut to depths ranging from 3 to 6 feet with cutting widths of 4 to 10 feet. Plant harvesting speeds vary with the size of the harvester, density and types of plants, and the distance to the off-loading area. Equipment requirements do not end with the harvester. In addition to the harvester, a shore-conveyor would be required to transfer plant material from the harvester to a dump truck for transport to a landfill or compost site. Furthermore, if off-loading sites are limited and/or the lake is large, a transport barge may be needed to move the harvested plants from the harvester to the shore in order to cut back on the time that the harvester spends traveling to the shore conveyor. Some lake organizations contract to have nuisance plants harvested, while others choose to purchase their own equipment. If the latter route is chosen, it is especially important for the lake group to be very organized and realize that there is a great deal of work and expense involved with the purchase, operation, maintenance, and storage of an aquatic plant harvester. In either case, planning is very important to minimize environmental effects and maximize benefits.

Cost

Equipment costs vary with the size and features of the harvester, but in general, standard harvesters range between $45,000 and $100,000. Larger harvesters or stainless steel models may cost as much as $200,000. Shore conveyors cost approximately $20,000 and trailers range from $7,000 to $20,000. Storage, maintenance, insurance, and operator salaries vary greatly.

Advantages	***Disadvantages***
• Immediate results. • Plant biomass and associated nutrients are removed from the lake. • Select areas can be treated, leaving sensitive areas intact. • Plants are not completely removed and can still provide some habitat benefits. • Opening of cruise lanes can increase predator pressure and reduce stunted fish populations. • Removal of plant biomass can improve the oxygen balance in the littoral zone. • Harvested plant materials produce excellent compost.	• Initial costs and maintenance are high if the lake organization intends to own and operate the equipment. • Multiple treatments are likely required. • Many small fish, amphibians and invertebrates may be harvested along with plants. • There is little or no reduction in plant density with harvesting. • Invasive and exotic species may spread because of plant fragmentation associated with harvester operation. • Bottom sediments may be re-suspended leading to increased turbidity and water column nutrient levels.

Herbicide Treatment

Photograph 3.4-4. Liquid herbicide application. Photo credit: Amy Kay, Clarke.

The use of herbicides to control aquatic plants and algae is a technique that is widely used by lake managers. Traditionally, herbicides were used to control nuisance levels of aquatic plants and algae that interfere with navigation and recreation. While this practice still takes place in many parts of Wisconsin, the use of herbicides to control aquatic invasive species is becoming more prevalent. Resource managers employ strategic management techniques towards aquatic invasive species, with the objective of reducing the target plant's population over time; and an overarching goal of attaining long-term ecological restoration. For submergent vegetation, this largely consists of implementing control strategies early in the growing season; either as spatially-targeted, small-scale spot treatments or low-dose, large-scale (whole lake) treatments. Treatments occurring roughly each year before June 1 and/or when water temperatures are below 60°F can be less impactful to many native plants, which have not emerged yet at this time of year. Emergent species are targeted with foliar applications at strategic times of the year when the target plant is more likely to absorb the herbicide.

While there are approximately 300 herbicides registered for terrestrial use in the United States, only 13 active ingredients can be applied into or near aquatic systems. All aquatic herbicides must be applied in accordance with the product's US Environmental Protection Agency (EPA) approved label. There are numerous formulations and brands of aquatic herbicides and an extensive list can be found in Appendix F of (Gettys, 2009).

Applying herbicides in the aquatic environment requires special considerations compared with terrestrial applications. WDNR administrative code states that a permit is required if, "you are standing in socks and they get wet." In these situations, the herbicide application needs to be completed by an applicator licensed with the Wisconsin Department of Agriculture, Trade and Consumer Protection. All herbicide applications conducted under the ordinary high-water mark require herbicides specifically labeled by the United States Environmental Protection Agency

Aquatic herbicides can be classified in many ways. Organization of this section follows Netherland (2009) in which mode of action (i.e., how the herbicide works) and application techniques (i.e., foliar or submersed treatment) group the aquatic herbicides. The table below provides a general list of commonly used aquatic herbicides in Wisconsin and is synthesized from (Netherland, 2009).

The arguably clearest division amongst aquatic herbicides is their general mode of action and fall into two basic categories:

1. Contact herbicides act by causing extensive cellular damage, but usually do not affect the areas that were not in contact with the chemical. This allows them to work much faster, but in some plants does not result in a sustained effect because the root crowns, roots, or rhizomes are not killed.
2. Systemic herbicides act slower than contact herbicides, being transported throughout the entire plant and disrupting biochemical pathways which often result in complete mortality.

Table 3.4-1. Common herbicides used for aquatic plant management.

General Mode of Action		Compound	Specific Mode of Action	Most Common Target Species in Wisconsin
Contact		Copper	plant cell toxicant	Algae, including macro-algae (i.e. muskgrasses & stoneworts)
		Endothall	Inhibits respiration & protein synthesis	Submersed species, largely for curly-leaf pondweed; invasive watermilfoil control when mixed with auxin herbicides
		Diquat	Inhibits photosynthesis & destroys cell membranes	Nusiance species including duckweeds, targeted AIS control when exposure times are low
		Flumioxazin	Inhibits photosynthesis & destroys cell membranes	Nusiance species, targeted AIS control when exposure times are low
Systemic	Auxin Mimics	2,4-D	auxin mimic, plant growth regulator	Submersed species, largely for invasive watermilfoil
		Triclopyr	auxin mimic, plant growth regulator	Submersed species, largely for invasive watermilfoil
		Florpyrauxifen -benzyl	arylpicolinate auxin mimic, growth regulator, different binding afinity than 2,4-D or triclopyr	Submersed species, largely for invasive watermilfoil
	In Water Use Only	Fluridone	Inhibits plant specific enzyme, new growth bleached	Submersed species, largely for invasive watermilfoil
	Enzyme Specific (ALS)	Penoxsulam	Inhibits plant-specific enzyme (ALS), new growth stunted	Emergent species with potential for submergent and floating-leaf species
		Imazamox	Inhibits plant-specific enzyme (ALS), new growth stunted	New to WI, potential for submergent and floating-leaf species
	Enzyme Specific (foliar use only)	Glyphosate	Inhibits plant-specific enzyme (ALS)	Emergent species, including purple loosestrife
		Imazapyr	Inhibits plant-specific enzyme (EPSP)	Hardy emergent species, including common reed

Both types are commonly used throughout Wisconsin with varying degrees of success. The use of herbicides is potentially hazardous to both the applicator and the environment, so all lake organizations should seek consultation and/or services from professional applicators with training and experience in aquatic herbicide use.

Herbicides that target submersed plant species are directly applied to the water, either as a liquid or an encapsulated granular formulation. Factors such as water depth, water flow, treatment area size, and plant density work to reduce herbicide concentration within aquatic systems. Understanding concentration and exposure times are important considerations for aquatic herbicides. Successful control of the target plant is achieved when it is exposed to a lethal concentration of the herbicide for a specific duration of time. Much information has been gathered in recent years, largely as a result of an ongoing cooperative research project between the Wisconsin Department of Natural Resources, US Army Corps of Engineers Research and Development Center, and private consultants (including Onterra). This research couples quantitative aquatic plant monitoring with field-collected herbicide concentration data to evaluate efficacy and selectivity of control strategies implemented on a subset of Wisconsin lakes and flowages. Based on their preliminary findings, lake managers have adopted two main treatment strategies: 1) whole-lake treatments, and 2) spot treatments.

Spot treatments are a type of control strategy where the herbicide is applied to a specific area (treatment site) such that when it dilutes from that area, its concentrations are insufficient to cause significant affects outside of that area. Spot treatments typically rely on a short exposure time (often hours) to cause mortality and therefore are applied at a much higher herbicide concentration than whole-lake treatments. This has been the strategy historically used on most Wisconsin systems.

Whole-lake treatments are those where the herbicide is applied to specific sites, but when the herbicide reaches equilibrium within the entire volume of water (entire lake, lake basin, or within the epilimnion of the lake or lake basin); it is at a concentration that is sufficient to cause mortality to the target plant within that entire lake or basin. The application rate of a whole-lake treatment is dictated by the volume of water in which the herbicide will reach equilibrium. Because exposure time is so much longer, target herbicide levels for whole-lake treatments are significantly less than for spot treatments.

Cost

Herbicide application charges vary greatly between $400 and $1,500 per acre depending on the chemical used, who applies it, permitting procedures, and the size/depth of the treatment area.

Advantages	*Disadvantages*
• Herbicides are easily applied in restricted areas, like around docks and boatlifts. • Herbicides can target large areas all at once. • If certain chemicals are applied at the correct dosages and at the right time of year, they can selectively control certain invasive species, such as Eurasian watermilfoil.	• All herbicide use carries some degree of human health and ecological risk due to toxicity. • Fast-acting herbicides may cause fish kills due to rapid plant decomposition if not applied correctly. • Many people adamantly object to the use of herbicides in the aquatic environment; therefore, all stakeholders should be included in the decision to use them.

• Some herbicides can be used effectively in spot treatments. • Most herbicides are designed to target plant physiology and in general, have low toxicological effects on non-plant organisms (e.g., mammals, insects)	• Many aquatic herbicides are nonselective. • Some herbicides have a combination of use restrictions that must be followed after their application. • Overuse of same herbicide may lead to plant resistance to that herbicide.

Biological Controls

There are many insects, fish and pathogens within the United States that are used as biological controls for aquatic macrophytes. For instance, the herbivorous grass carp has been used for years in many states to control aquatic plants with some success and some failures. However, it is illegal to possess grass carp within Wisconsin because their use can create problems worse than the plants that they were used to control. Other states have also used insects to battle invasive plants, such as water hyacinth weevils (*Neochetina spp.*) and hydrilla stem weevil (*Bagous spp.*) to control water hyacinth (*Eichhornia crassipes*) and hydrilla (*Hydrilla verticillata)*, respectively.

However, Wisconsin, along with many other states, is currently experiencing the expansion of lakes infested with Eurasian watermilfoil and as a result has supported the experimentation and use of the milfoil weevil (*Euhrychiopsis lecontei*) within its lakes. The milfoil weevil is a native weevil that has shown promise in reducing Eurasian watermilfoil stands in Wisconsin, Washington, Vermont, and other states. Research is currently being conducted to discover the best situations for the use of the insect in battling Eurasian watermilfoil. Currently the milfoil weevil is not a WDNR grant-eligible method of controlling Eurasian watermilfoil.

Cost

Stocking with adult weevils costs about $1.20/weevil and they are usually stocked in lots of 1000 or more.

Advantages	***Disadvantages***
• Milfoil weevils occur naturally in Wisconsin. • Likely environmentally safe and little risk of unintended consequences.	• Stocking and monitoring costs are high. • This is an unproven and experimental treatment. • There is a chance that a large amount of money could be spent with little or no change in Eurasian watermilfoil density.

Wisconsin has approved the use of two species of leaf-eating beetles (*Galerucella calmariensis* and *G. pusilla*) to battle purple loosestrife. These beetles were imported from Europe and used as a biological control method for purple loosestrife. Many cooperators, such as county conservation departments or local UW-Extension locations, currently support large beetle rearing operations. Beetles are reared on live purple loosestrife plants growing in kiddy pools surrounded by insect netting. Beetles are collected with aspirators and then released onto the target wild population. For more information on beetle rearing, contact your local UW-Extension location.

In some instances, beetles may be collected from known locations (cella insectaries) or purchased through private sellers. Although no permits are required to purchase or release beetles within Wisconsin, application/authorization and release forms are required by the WDNR for tracking and monitoring purposes.

Cost

The cost of beetle release is very inexpensive, and in many cases is free.

Advantages	*Disadvantages*
• Extremely inexpensive control method. • Once released, considerably less effort than other control methods is required. • Augmenting populations may lead to long-term control.	• Although considered "safe," reservations about introducing one non-native species to control another exist. • Long range studies have not been completed on this technique.

Analysis of Current Aquatic Plant Data

Aquatic plants are an important element in every healthy lake. Changes in lake ecosystems are often first seen in the lake's plant community. Whether these changes are positive, such as variable water levels or negative, such as increased shoreland development or the introduction of an exotic species, the plant community will respond. Plant communities respond in a variety of ways. For example, there may be a loss of one or more species. Certain life forms, such as emergent or floating-leaf communities, may disappear from specific areas of the lake. A shift in plant dominance between species may also occur. With periodic monitoring and proper analysis, these changes are relatively easy to detect and provide very useful information for management decisions.

As described in more detail in the methods section, multiple aquatic plant surveys were completed on Lawrence Lake; the first looked strictly for the exotic plant, curly-leaf pondweed, while the others that followed assessed both native and non-native species. Combined, these surveys produce a great deal of information about the aquatic vegetation of the lake. These data are analyzed and presented in numerous ways; each is discussed in more detail below.

Primer on Data Analysis & 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 in Lawrence Lake. 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. 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 Lawrence

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 Lawrence Lake to be compared to other lakes within the region and state.

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

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 were 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 value from Lawrence Lake is compared to data collected by Onterra and the WDNR Science Services on 85 lakes within the North Central Hardwood Forests ecoregion and on 392 lakes throughout Wisconsin.

Community Mapping

A key component of any aquatic plant community assessment is the delineation of the emergent and floating-leaf aquatic plant communities within each lake as these plants are often underrepresented during the point-intercept survey. This survey creates a snapshot of these important communities within each lake as they existed during the survey and is valuable in the development of the management plan and in comparisons with future surveys. Examples of emergent plants include cattails, rushes, sedges, grasses, bur-reeds, and arrowheads, while examples of floating-leaf species include the water lilies. The emergent and floating-leaf aquatic plant communities in Lawrence Lake were mapped using a Trimble Global Positioning System (GPS) with sub-meter accuracy.

Exotic Plants

Because of their tendency to upset the natural balance of an aquatic ecosystem, exotic species are paid particular attention to during the aquatic plant surveys. Two exotics, curly-leaf pondweed and Eurasian watermilfoil are the primary targets of this extra attention.

Eurasian watermilfoil is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties (Figure 3.4-1). Eurasian watermilfoil is unique in that its primary mode of propagation is not by seed. It actually spreads by shoot fragmentation, which has supported its transport between lakes via boats and other equipment. In addition to its propagation method, Eurasian watermilfoil has two other competitive advantages over native aquatic plants, 1) it starts growing very early in the spring when water temperatures are too cold for most native plants to grow, and 2) once its stems reach the water surface, it does not stop growing like most native plants, instead it continues to grow along the surface creating a canopy that blocks light from reaching native plants. Eurasian watermilfoil can create dense stands and dominate submergent communities, reducing important natural habitat for fish and other wildlife, and impeding recreational activities such as swimming, fishing, and boating.

Curly-leaf pondweed is a European exotic first discovered in Wisconsin in the early 1900's that has an unconventional lifecycle giving it a competitive advantage over our native plants. Curly – leaf pondweed begins growing almost immediately after ice-out and by mid-June is at peak biomass. While it is growing, each plant produces many turions (asexual reproductive shoots) along its stem. By mid-July most of the plants have senesced, or died-back, leaving the turions in the sediment. The turions lie dormant until fall when they germinate to produce winter foliage, which thrives under the winter snow and ice. It remains in this state until spring foliage is produced in early May, giving the plant a significant jump on native vegetation. Like Eurasian watermilfoil, curly-leaf pondweed can become so abundant that it hampers recreational activities within the lake. Furthermore, its mid-summer die back can cause algal blooms spurred from the nutrients released during the plant's decomposition.

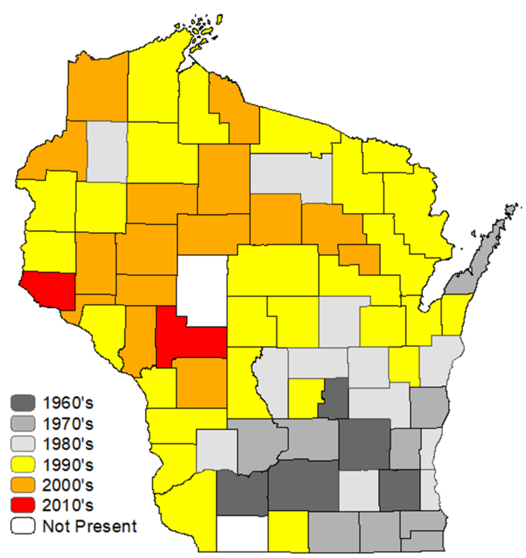


Figure 3.4-1. Spread of Eurasian watermilfoil within WI counties. WDNR Data 2021, mapped by Onterra.

Because of its odd life-cycle, a special survey is conducted early in the growing season to inventory and map curly-leaf pondweed occurrence within the lake. Although Eurasian watermilfoil starts to grow earlier than our native plants, it is at peak biomass during most of the summer, so it is inventoried during the comprehensive aquatic plant survey completed in mid to late summer. Aquatic invasive species mapping methodology is discussed in Section 6.0, Methods.

Aron & Associates completed a 2004 aquatic plant survey as a part of developing the Lawrence Lake Aquatic Plant Management Plan. The survey methodology used twenty transects throughout the lake to identify aquatic plant species and abundance. During this survey, 25 aquatic plant species were identified. Dominant plants were noted as muskgrasses, coontail, flat-stem pondweed, and common waterweed. While this data provides the earliest reference for what species existed in the lake at that time, it is unable to be used as a comparison to the most recent point-intercept survey (2022) due to the differing survey methodologies.

Lawrence Lake Aquatic Plant Survey Results

Included as a part of this lake management planning project were several surveys with a purpose of assessing the aquatic plant population in Lawrence Lake. These field surveys, completed in 2022, included an Early Season AIS Survey, a whole-lake point-intercept survey, an EWM peak biomass survey, and a community mapping survey. A total of 40 species of plants have been located in Lawrence Lake during these 2022 aquatic plant surveys of which four are considered non-native species: Eurasian watermilfoil, curly-leaf pondweed, Chinese silvergrass, and watercress (Table 3.4-2). Because the non-native plants found in Lawrence Lake have the ability to negatively impact lake ecology, recreation, and aesthetics, the populations of these plants are discussed in greater detail within the subsequent *Non-Native Aquatic Plants in Lawrence Lake* section.

Lakes in Wisconsin vary in their morphometry, water chemistry, water clarity, substrate composition, management, and recreational use, all factors which influence aquatic plant community composition. Like terrestrial plants, different aquatic plant species are adapted to grow in certain substrate types; some species are only found growing in soft substrates, others only in sandy/rocky areas, and some can be found growing in either. The combination of both soft sediments and areas of harder substrates creates different habitat types for aquatic plants, and generally leads to a higher number of aquatic plant species within the lake.

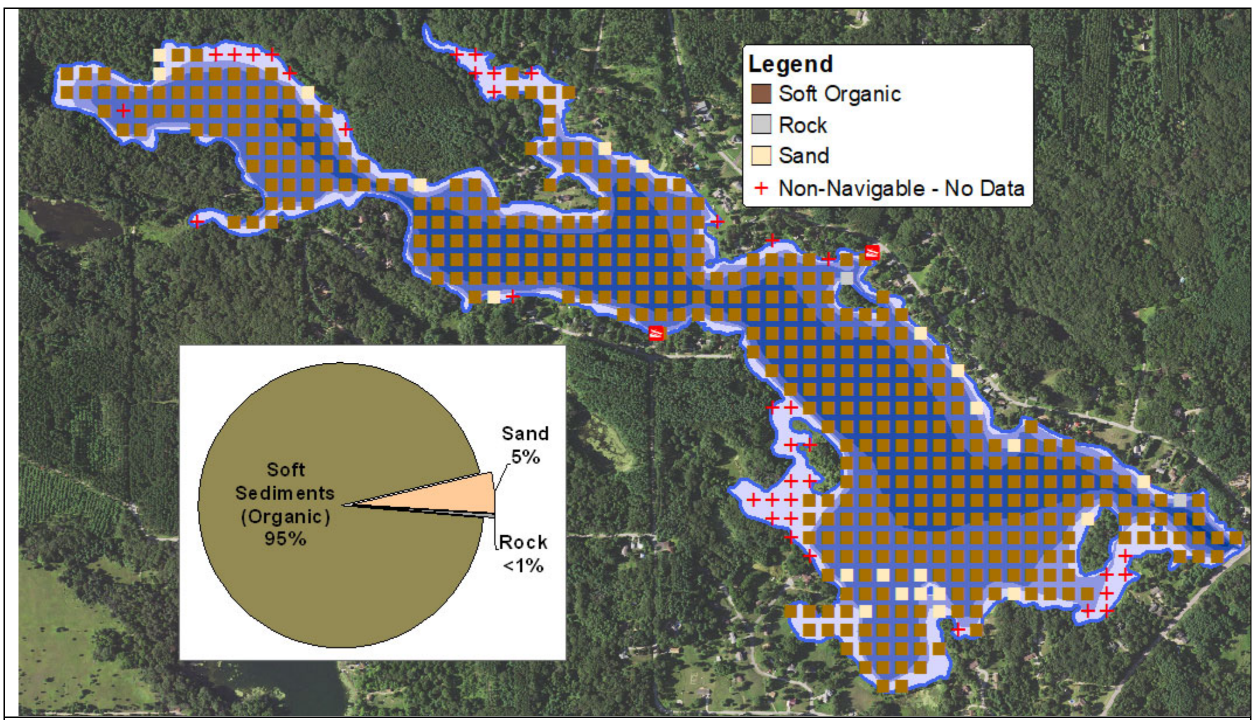


Figure 3.4-2. Lawrence Lake proportion of substrate types within littoral areas. Created using data from 2022 aquatic plant point-intercept survey.

During the 2022 point-intercept survey, information regarding substrate type was collected at locations sampled with a pole-mounted rake (less than 15 feet). These data indicate that 95% of the point-intercept locations contained soft organic sediments, 5% contained sand, and <1% contained rock (Figure 3.4-2). The soft organic sediment throughout the majority of Lawrence Lake is very conducive for supporting lush aquatic plant growth.

Table 3.4-2. Aquatic plant species located in Lawrence Lake during the 2022 surveys.

Growth Form	Scientific Name	Common Name	WI State Status	Coefficient of Conservatism	2022 (Onterra)
Emergent	*Carex comosa*	Bristly sedge	Native	5	I
	Eleocharis erythropoda	Bald spikerush	Native	3	I
	Iris versicolor	Northern blue flag	Native	5	I
	Juncus effusus	Soft rush	Native	4	I
	Miscanthus spp.	Silvergrass	Non-Native - Invasive	N/A	I
	Nasturtium officinale	Watercress	Non-Native - Invasive	N/A	I
	Sagittaria latifolia	Common arrowhead	Native	3	I
	Schoenoplectus acutus	Hardstem bulrush	Native	5	I
	Schoenoplectus tabernaemontani	Softstem bulrush	Native	4	X
	Scirpus cyperinus	Wool grass	Native	4	I
	Typha latifolia	Broad-leaved cattail	Native	1	I
FL	*Nuphar variegata*	Spatterdock	Native	6	I
	Nymphaea odorata	White water lily	Native	6	X
	Persicaria amphibia	Water smartweed	Native	5	I
Submergent	*Ceratophyllum demersum*	Coontail	Native	3	X
	Chara spp.	Muskgrasses	Native	7	X
	Elodea canadensis	Common waterweed	Native	3	X
	Heteranthera dubia	Water stargrass	Native	6	X
	Myriophyllum sibiricum	Northern watermilfoil	Native	7	X
	Myriophyllum spicatum	Eurasian watermilfoil	Non-Native - Invasive	N/A	X
	Najas flexilis	Slender naiad	Native	6	X
	Najas guadalupensis	Southern naiad	Native	7	X
	Potamogeton crispus	Curly-leaf pondweed	Non-Native - Invasive	N/A	X
	Potamogeton foliosus	Leafy pondweed	Native	6	X
	Potamogeton friesii	Fries' pondweed	Native	8	X
	Potamogeton illinoensis	Illinois pondweed	Native	6	X
	Potamogeton natans	Floating-leaf pondweed	Native	5	I
	Potamogeton obtusifolius	Blunt-leaved pondweed	Native	9	X
	Potamogeton praelongus	White-stem pondweed	Native	8	I
	Potamogeton pusillus	Small pondweed	Native	7	X
	Potamogeton richardsonii	Clasping-leaf pondweed	Native	5	X
	Potamogeton zosteriformis	Flat-stem pondweed	Native	6	X
	Ranunculus aquatilis	White water crowfoot	Native	8	X
	Stuckenia pectinata	Sago pondweed	Native	3	X
	Utricularia vulgaris	Common bladderwort	Native	7	X
	Vallisneria americana	Wild celery	Native	6	X
	Zannichellia palustris	Horned pondweed	Native	7	X
FF	*Lemna minor*	Lesser duckweed	Native	5	X
	Lemna trisulca	Forked duckweed	Native	6	X
	Spirodela polyrhiza	Greater duckweed	Native	5	X

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

Approximately 96% of the point-intercept sampling locations contained aquatic vegetation. Aquatic plants were found to be growing out to the maximum depth of the lake (15 feet), meaning that the entire lake is considered to be within the littoral zone. Aquatic plant rake fullness data collected in 2022 indicates that 29% of the 474 littoral sampling locations contained vegetation with a total rake fullness rating (TRF) of 1, 24% had a TRF rating of 2, and 43% had a TRF rating of 3 showing overall aquatic plant biomass in Lawrence Lake is very high (Figure 3.4-3).

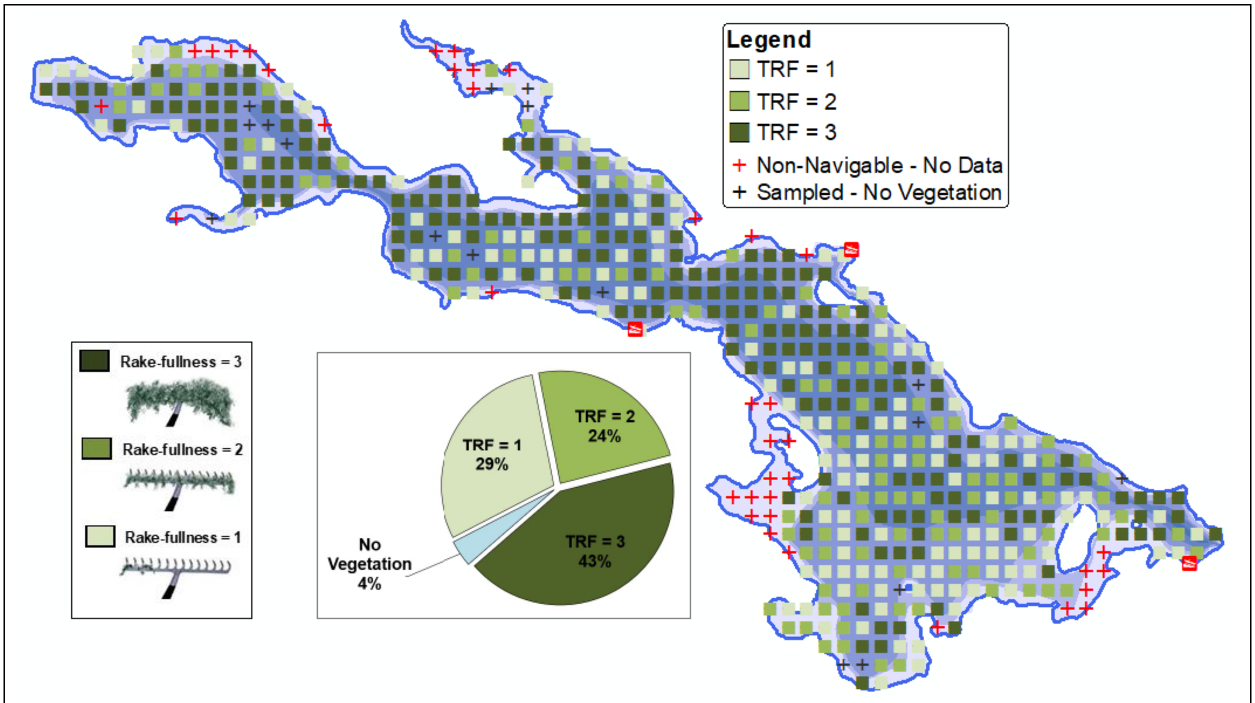


Figure 3.4-3. Lawrence Lake total rake fullness ratings from the 2022 survey.

A whole-lake point-intercept survey is used to quantify the abundance of individual species within the lake. Of the 40 aquatic plant species located in Lawrence Lake in 2022, 26 were encountered directly on the rake during the whole-lake point-intercept survey (Figure 3.4-4). The remaining 14 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 relatively rare within the plant community.

Of the 26 species directly sampled with the rake during the point-intercept survey, muskgrasses (*Chara* spp.), northern watermilfoil (*Myriophyllum sibiricum*), Fries' pondweed (*Potamogeton friesii*), and coontail (*Ceratophyllum demersum*) were the four most-frequently encountered species in 2022 (Photograph 3.4-5). Muskgrasses, or species of the genus *Chara* spp., are actually a form of macro algae, not an actual aquatic macrophyte. They are grey to green colored and grow in large clumps in shallow to deep water. When growing in hard, mineral rich water, muskgrasses sometimes become coated with lime, giving them a rough, "gritty" feel. They are easily identified by their strong skunk-like or garlic odor. As well as providing a food source for waterfowl, muskgrass often serves as a sanctuary for small fish and other aquatic organisms. In 2022, muskgrasses were found at 60.8% of the point-intercept locations and also growing at various depths ranging from 1 to 15 feet (Figure 3.4-4).

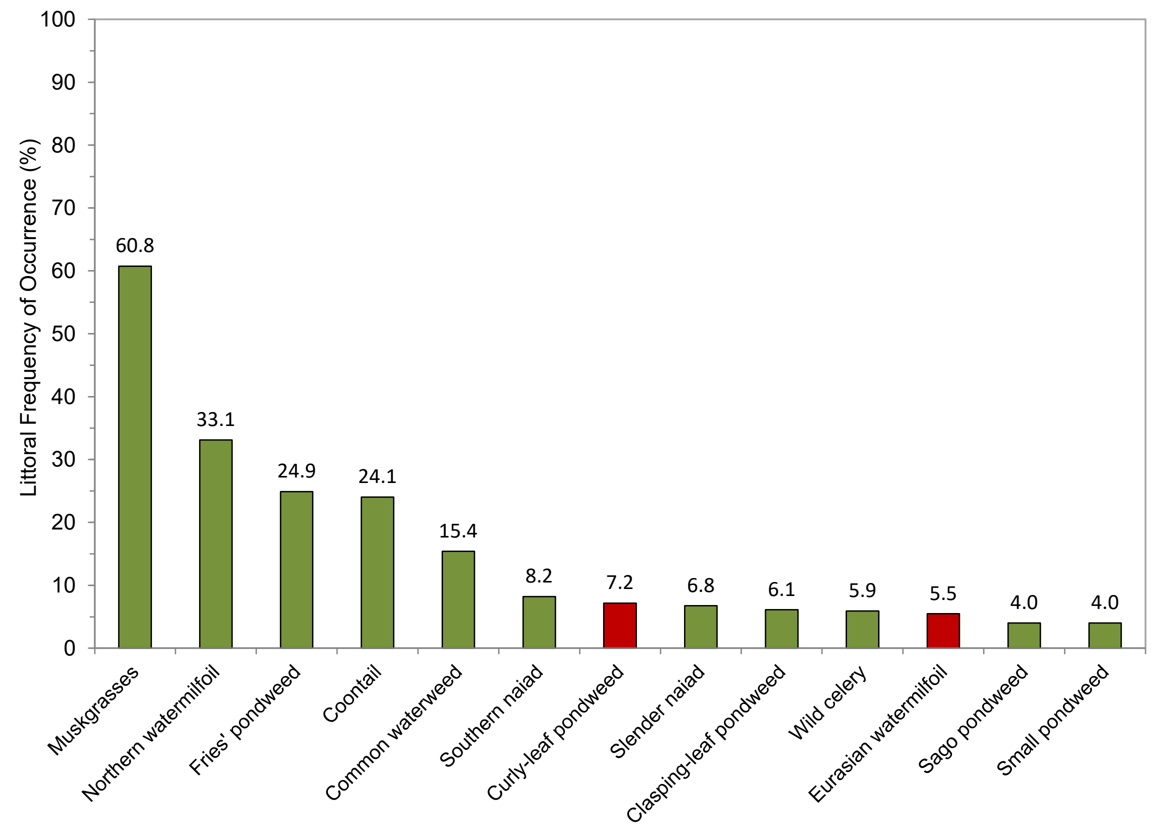
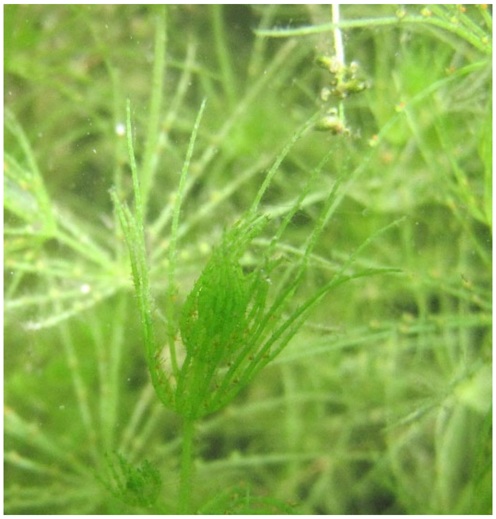


Figure 3.4-4. Lawrence Lake aquatic plant littoral frequency of occurrence. Created using data from 2022 surveys.

Northern watermilfoil, arguably the most common milfoil species in Wisconsin lakes, is frequently found growing in soft sediments and higher water clarity (Photograph 3.4-5). Northern watermilfoil can be falsely identified as Eurasian watermilfoil, especially since it is known to take on the reddish appearance of Eurasian watermilfoil as the plant reacts to sun exposure as the growing season progresses. The feathery foliage of northern watermilfoil traps filamentous algae and detritus, providing valuable invertebrate habitat. Because northern watermilfoil prefers high water clarity, its populations are declining state-wide as lakes are becoming more eutrophic. In 2022 northern watermilfoil was found at 33.1% of the point-intercept locations and also growing at various depths ranging from 1 to 14 feet (Figure 3.4-4). Relative to all other plant species within Lawrence Lake, muskgrasses and northern watermilfoil, the two most common plants, make up 42% of the aquatic plant population together.

A common species in calcareous waters, Fries' pondweed is one of Wisconsin's several narrow-leaved pondweed species (Photograph 3.4-5). Within Lawrence Lake, it was found within a range of depths from 1-14 feet, and was one of only three native species observed growing at the maximum depth where plants were found (along with coontail and muskgrasses). Fries' pondweed plays a large role in aquatic ecosystems by providing structural habitat and sources of food to invertebrates, fish, and other wildlife. Often growing in deeper water, this species supplies oxygen to the deeper, colder layer of water that is sealed off from atmospheric oxygen during the summer in thermally stratified lakes. In 2022, Fries' pondweed was found at 24.9% of the point-intercept locations (Figure 3.4-4).

Muskgrasses (*Charra* spp.)	Northern watermilfoil (*Myriophyllum sibiricum*)	Fries' pondweed (*Potamogeton fresii*)
		

Photograph 3.4-5. The three most common native aquatic plants found in Lawrence Lake in 2022. Photo credit: Onterra.

Coontail has whorls of leaves which fork into two to three segments, and provides ample surface area for the growth of periphyton and habitat for invertebrates. Unlike most of the submersed plants found in Wisconsin, coontail does not produce true roots and is often found growing entangled amongst other aquatic plants or matted at the surface. Because it lacks true roots, coontail derives most of its nutrients directly from the water (Gross, 2003). This ability in combination with a tolerance for low-light conditions allows coontail to become more abundant in eutrophic waterbodies with higher nutrients and low water clarity. Coontail has the capacity to form dense beds that can float and mat on the water's surface. In 2022, coontail was found at 23.8% of the point-intercept locations and also growing at various depths ranging from 1 to 15 feet.

As explained above in the Primer on Data Analysis and Data Interpretation Section, the littoral frequency of occurrence analysis allows for an understanding of how often each of the plants is located during the point-intercept survey. Because each sampling location may contain numerous plant species, relative frequency of occurrence is one tool to evaluate how often each plant species is found in relation to all other species found (composition of population). For instance, while muskgrasses were found at 61% of the sampling locations in Lawrence Lake, its relative frequency of occurrence is 27%. Explained another way, if 100 plants were randomly sampled from Lawrence Lake, 27 of them would be muskgrasses. Looking at relative frequency of occurrence (Figure 3.4-5), five species comprise approximately 70% of the plant community in Lawrence Lake.

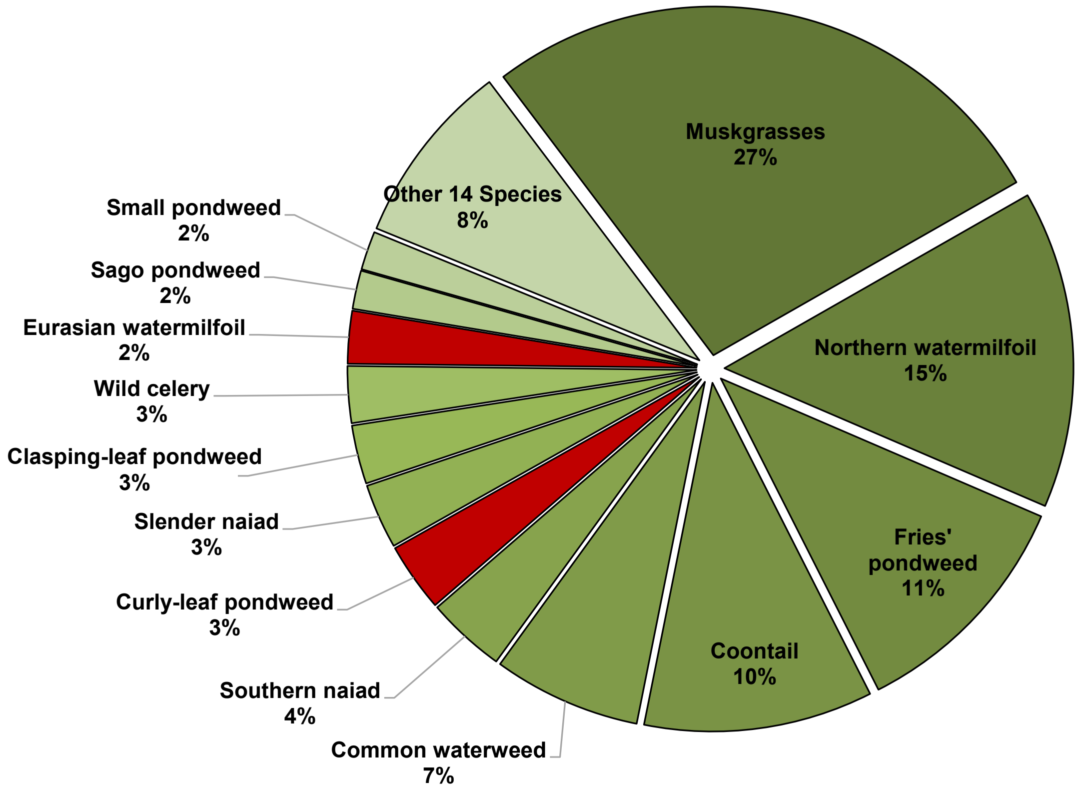


Figure 3.4-5. Lawrence Lake aquatic plant relative frequency of occurrence. Created using data from 2022 survey.

As discussed previously, 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. For example, while 40 native aquatic plant species were located in Lawrence Lake during the 2022 surveys, only 26 were encountered on the rake during the point-intercept survey with two of those being non-native species. Figure 3.4-6 shows that the native species richness for Lawrence Lake is above the NCHF Ecoregion and Wisconsin State medians.

The species that are present in Lawrence Lake are indicative of good quality conditions. Data collected from the aquatic plant surveys show that the average conservatism value (6.0) is above the North Central Hardwood Forests Ecoregion and slightly below the Wisconsin State median (Figure 3.4-6), indicating that the some of the plant species found in Lawrence Lake are considered sensitive to environmental disturbance and their presence signifies excellent environmental conditions.

Combining Lawrence Lake's aquatic plant species richness and average conservatism values to produce its Floristic Quality Index (FQI) results in a value of 29.2 (equation shown below); which is above the median values for the ecoregion and state (Figure 3.4-6), and further illustrating the quality of Lawrence Lake's plant community.

$$FQI = \text{Average Coefficient of Conservatism } (6.0) * \sqrt{\text{Number of Native Species } (24)}$$
$$FQI = 29.2$$

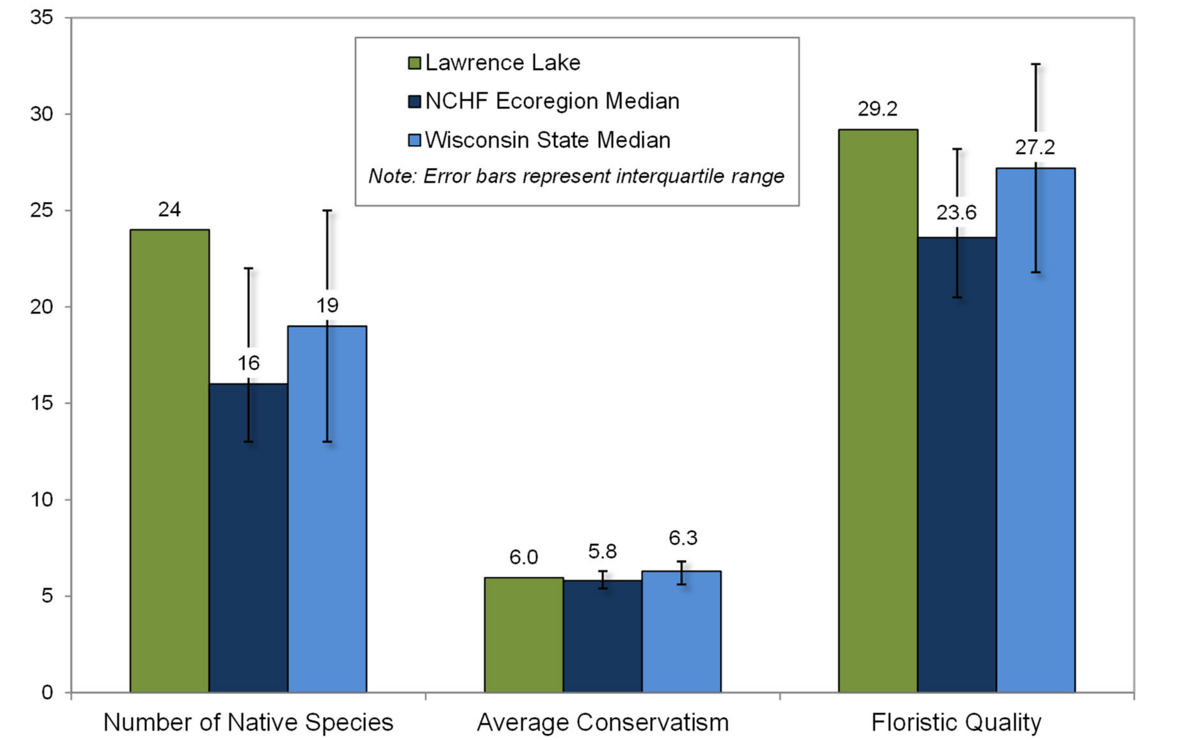


Figure 3.4-6. Lawrence Lake Floristic Quality Assessment. Created using data from the 2022 survey. Analysis following (Nichols, 1999) where NCHF = North Central Hardwood Forests Ecoregion.

Because Lawrence Lake contains a high number of native aquatic plant species, one may assume their aquatic plant communities have high species diversity. However, as discussed earlier, species diversity is also influenced by how evenly the plant species are distributed within the community.

The aquatic plant community in Lawrence Lake was found to be highly diverse, with a Simpson's diversity value of 0.87 (Figure 3.4-7). This value ranks above state and ecoregion medians. Lakes with diverse aquatic plant communities have higher resilience to environmental disturbances and greater resistance to invasion by non-native plants. A plant community with a mosaic of species with differing morphological attributes provides zooplankton, macroinvertebrates, fish and other wildlife with diverse structural habitat and various sources of food.

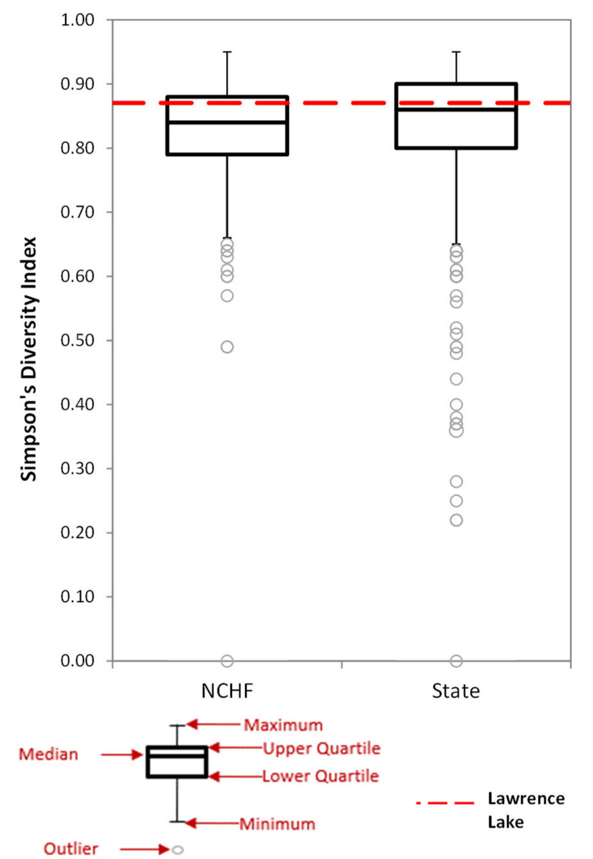


Figure 3.4-7. Lawrence Lake species diversity index. Created using data from 2022 aquatic plant surveys. Ecoregion data provided by WDNR Science Services.

The quality of Lawrence Lake's plant community is also indicated by the high incidence of emergent and floating-leaf plant communities that occur in near-shore areas around the lake. The 2022 community map indicates that approximately 37.7 acres (17.4%) of the 217 acre-lake contain these types of plant communities (Figure 3.4-8 and Map 8). Fifteen different floating-leaf and emergent species were located on Lawrence Lake, providing valuable structural habitat for invertebrates, fish, and other wildlife. These communities also stabilize lake substrate and shoreland areas by dampening wave action from wind and watercraft.

Because the community map represents a 'snapshot' of the important emergent and floating-leaf plant communities, a replication of this survey in the future will provide a valuable understanding of the dynamics of these communities within Lawrence Lake. This is important because these communities are often negatively affected by recreational use and shoreland development. One study found a 66% reduction in vegetation coverage on developed shorelands when compared to the undeveloped shorelands in Minnesota lakes (Radomski & Goeman, 2001). Furthermore, they also found a significant reduction in abundance and size of northern pike (*Esox lucius*), bluegill (*Lepomis macrochirus*), and pumpkinseed (*Lepomis gibbosus*) associated with these developed shorelands.

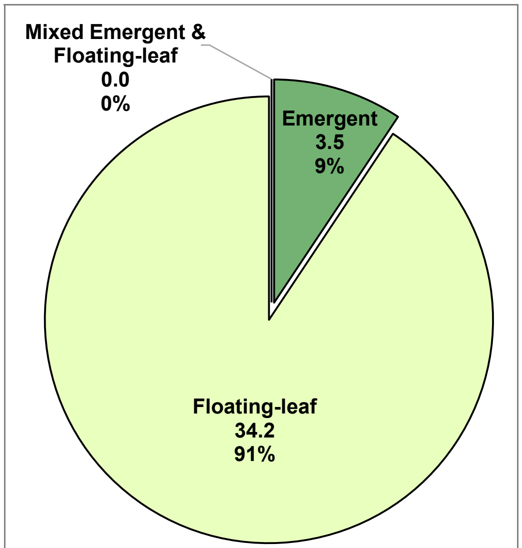


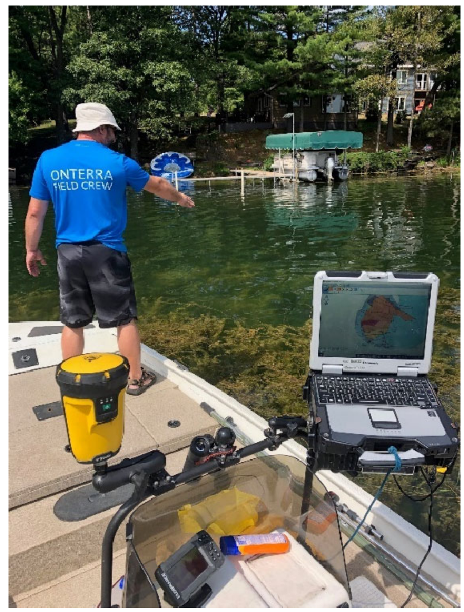
Figure 3.4-8. Lawrence Lake acres of plant community types. Created from the 2022 community mapping survey.

Non-Native Aquatic Plants in Lawrence Lake

It is important to note that two types of surveys are discussed in the subsequent materials: 1) whole lake point-intercept surveys and 2) AIS mapping survey.

The point-intercept survey provides a standardized way to gain quantitative information about a lake's aquatic plant population through visiting predetermined locations and using a rake sampler to identify all the plants at each location. The point-intercept survey can be applied at various scales. Most commonly, the point-intercept survey is applied at the whole-lake scale to provide a lake-wide assessment of the overall plant community.

While the point-intercept survey is a valuable tool to understand the overall plant population of a lake, it does not offer a full account (census) of where a particular species exists in the lake. During the AIS mapping survey, the entire littoral area of the lake is surveyed through visual observations from the boat (Photograph 3.4-7). Field crews supplemented the visual survey by deploying a submersible camera along with periodically doing rake tows. The AIS population is mapped using sub-meter GPS technology by using either 1) point-based or 2) area-based methodologies. Large colonies >40 feet in diameter are mapped using polygons (areas) and are qualitatively attributed a density rating based upon a five-tiered scale from *highly scattered* to *surface matting*. Point-based techniques were applied to AIS locations that were considered as *small plant colonies* (<40 feet in diameter), *clumps of plants*, or *single or few plants*.



Photograph 3.4-7. AIS mapping survey. Photo credit Onterra.

Overall, each survey has its strengths and weaknesses, which is why both are utilized in different ways as part of this project.

Eurasian watermilfoil (*Myriophyllum spicatum*)

Because of its potential to upset the natural balance of an aquatic ecosystem, non-native species are paid particular attention to during the aquatic plant surveys. The non-native plant that is of primary concern in Lawrence Lake is Eurasian watermilfoil (EWM, Photograph 3.4-6). Eurasian watermilfoil is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties. Eurasian watermilfoil was officially verified and documented within Lawrence Lake in 2005, but was known in the lake since at least 2001 when chemical treatments took place and was likely present in the lake for years prior. The EWM population is considered to be established within the lake.


Photograph 3.4-6. Eurasian watermilfoil on a Wisconsin lake. Photo credit Onterra.

Eurasian watermilfoil is unique in that its primary mode of propagation is not by seed. It actually spreads by shoot fragmentation, which has supported its transport between lakes via boats and other equipment. In addition to its propagation method, EWM has two other competitive advantages over native aquatic plants: 1) it starts growing very early in the spring when water temperatures are too cold for most native plants to grow, and 2) once its stems reach the water surface, it sometimes does not stop growing like most native plants and instead continues to grow along the surface creating a canopy that blocks light from reaching native plants.

Eurasian watermilfoil can create dense stands and dominate submergent communities, reducing important natural habitat for fish and other wildlife, and impeding recreational activities such as swimming, fishing, and boating. However, in some lakes, EWM appears to integrate itself within the community without becoming a nuisance or having a measurable impact to the ecological function of the lake.

EWM Research: WDNR Long-Term EWM Trends Monitoring

Starting in 2005, WDNR Science Services began conducting annual point-intercept aquatic plant surveys on a set of lakes to understand how EWM populations vary over time. This was in response to commonly held beliefs of the time that once EWM becomes established in a lake, its population would continue to increase over time.

Like other aquatic plants, EWM populations are dynamic and annual changes in EWM frequency of occurrence have been documented in many lakes, including those that are not being actively managed for EWM control (no herbicide treatment or hand-harvesting program). The data are clearest for unmanaged lakes in the Northern Lakes and Forests Ecoregion (NLF) and the North Central Hardwood Forests Ecoregion (NCHF) (Figure 3.4-9).

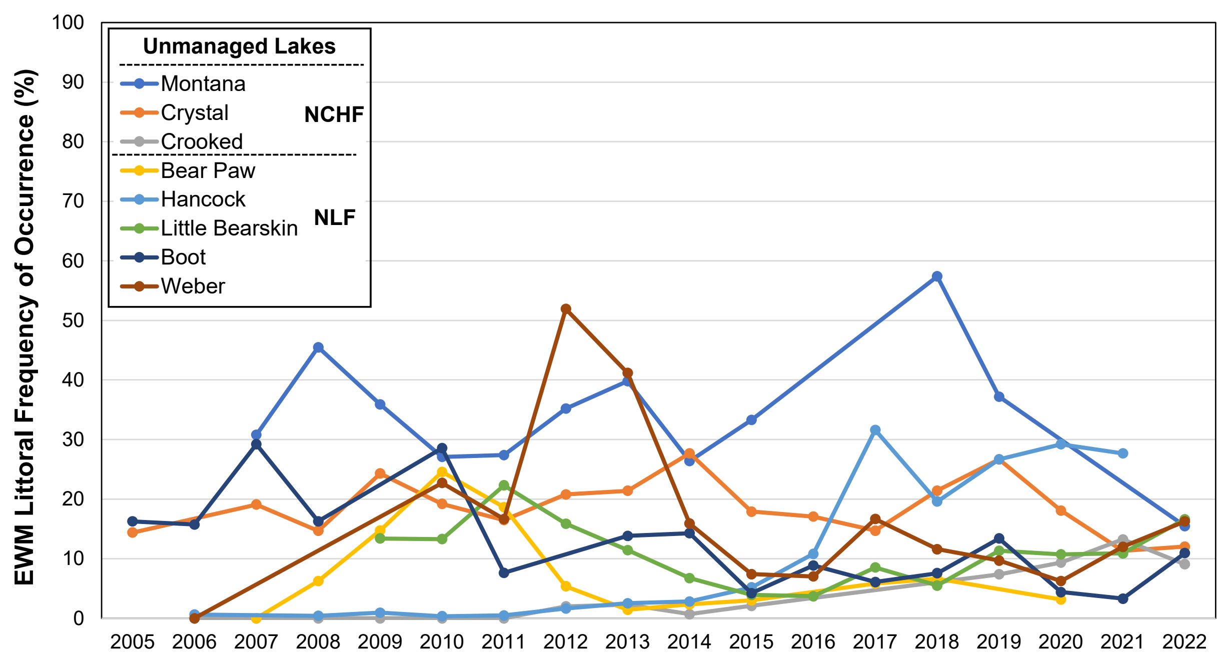


Figure 3.4-9. Littoral frequency of occurrence of EWM in the NLF and NCHF Ecoregions without management. Data provided by and used with permission from WDNR.

The results of the study clearly indicate that EWM populations in unmanaged lakes can fluctuate greatly between years (Figure 3.4-9). Following initial infestation, EWM expansion was rapid on some lakes, but overall was variable and unpredictable (Nault, 2016). On some lakes, the EWM populations reached a relatively stable equilibrium whereas other lakes had more moderate year-to-year variation. Regional climatic factors also seem to be a driver in EWM populations, as many EWM populations declined in 2015 even though the lakes were at vastly different points in time following initial detection within the lake. 2019 also experienced record rainfall which may have had an impact on the EWM population indirectly through a decrease in water clarity.

EWM population of Lawrence Lake

The 2022 point-intercept survey found EWM had a littoral frequency of occurrence of 5.5% and also that EWM is located throughout all areas of Lawrence Lake, including in deeper water to 13 feet. Lawrence Lake's high water clarity allows for EWM (and native plants) to grow and colonize to deeper depths.

As a part of this project, EWM was initially mapped during the Early-Season AIS Survey in May 2022 to get a first look at the distribution of this species (Figure 3.4-10 and Map 9). EWM continues to grow throughout the summer months and therefore, a Late-Season EWM Mapping Survey was completed in early-October when EWM is typically at or near its peak-biomass for the growing season in this region of the state. EWM was found throughout much of the littoral areas of Lawrence Lake with approximately 56.8 acres of contiguous EWM colonies mapped in the October 2022 Late-Season mapping survey (Figure 3.4-10 and Map 10). Approximately 41.7 acres were comprised of *highly scattered* and *scattered* EWM, 15.1 acres were comprised of *dominant* or *highly dominant* EWM colonies.

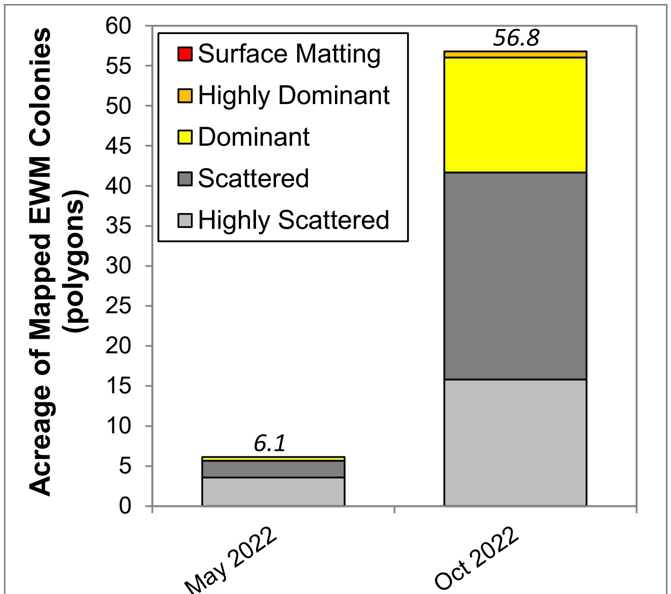


Figure 3.4-10. Acreage of colonized EWM in Lawrence Lake in 2022. Created using data from Onterra AIS mapping surveys.

Future AIS Management Philosophy

During the Planning Committee meetings held as part of this project, the aquatic plant community of Lawrence Lake was discussed in detail. Multiple surveys were completed on the lake during 2022 to document the presence and abundance of both native and non-native aquatic plants. The results of the surveys overwhelmingly indicate that Lawarence Lake does not have a problem with aquatic invasive plants, but instead, and issue with nuisance levels of aquatic plants and those nuisance plants consist mostly of native species with some AIS as well.

While Eurasian watermilfoil is not currently a primary issue in Lawrence Lake, in an effort to increase the overall understanding of the committee and the district as a whole, three broad Eurasian watermilfoil management goals were discussed including a generic potential action plan to help reach each of the goals (Figure 3.4-11). Conversation regarding risk assessment of the various management actions were also discussed. The Planning Committee also reviewed these management perspectives in the context of perceived riparian stakeholder support, which is discussed in the subsequent sub-section.

1. **No Coordinated Active Management**
   (Let Nature Take its Course)
   - Focus on education of manual removal methods for property owners
   - Lake organization does not oppose contracted efforts, but does not organize or pay for them
2. **Minimize navigation and recreation impediment**
   (Nuisance Control)
   - Hand-harvesting alone is not likely able to accomplish this goal and herbicides or a mechanical harvester may be required
3. **Reduce EWM Population on a lake-wide level**
   (Lake-Wide Population Management)
   - Would likely rely on herbicide treatment strategies (risk assessment)
   - Will not eradicate EWM
   - Set triggers (thresholds) of implementation and tolerance

Figure 3.4-11. Potential EWM Management Perspectives

1. Let Nature Take its Course: On some lakes, invasive plant populations plateau or reduce without active management. Some lake groups decide to periodically monitor the EWM population, either through an EWM mapping survey or a whole-lake point-intercept survey, but may not coordinate active management (e.g., hand-harvesting or herbicide treatments). Individual riparians could choose to hand-remove the EWM within their recreational footprint, but the lake group would not assist financially or by securing permits if necessary. In most instances, the lake group may select an EWM population threshold or trigger where they would revisit their management goal if the population reached that level.

2. Nuisance Control: The concept of ecosystem services is that the natural world provides a multitude of services to humans, such as the production of food and water (provisioning), control of climate and disease (regulating), nutrient cycles and pollination (supporting), and spiritual and recreational benefits (cultural). Some lake groups acknowledge that the most pressing issues with their AIS population is the reduced recreation, navigation, and aesthetics compared to before the AIS became established in their lake. Particularly on lakes with large EWM populations that may be impractical or unpopular to target on a lake-wide basis, the lake group would coordinate (secure permits and financially support the effort) a strategy to improve the navigability within the lake. This is typically accomplished by targeting EWM populations in high-use parts of the through mechanical harvesting or spot herbicide treatments and allowing other areas of low use to remain unmanaged.

3. Lake-Wide Population Management: Some believe that there is an intrinsic responsibility to correct for changes in the environment that are caused by humans. For lakes with EWM populations, that may mean to manage the EWM population at a reduced level with the perceived goal to allow the lake to function as it had prior to EWM establishment. Due to the inevitable collateral impacts from most forms of EWM management, lake managers and natural resource regulators question whether that is an achievable goal.

For newly introduced EWM populations, the entire population may be targeted through hand-harvesting or herbicide spot treatments. Herbicide spot treatments, particularly historical treatments with 2,4-D, generally lead to short term EWM population reductions with reductions largely being limited to a season or two. This type of strategy can be analogous to the "whack-a-mole" arcade game; where areas are targeted, rebound, and then are targeted again on an every-other year basis. As new areas emerge and get factored into the strategy, it becomes harder to manage all the areas. Typically, if management is withheld at this stage, the EWM will rebound to its full capacity within a year. The repeated need for exposing the same areas of the system to herbicides as is required when engaged in an annual spot treatment program has gone out of favor with some lake managers due to concerns over the non-target impacts that can accompany this type of strategy. In recent years, lake managers have sought actions that achieve multi-year EWM population suppression, such as whole-lake treatments or spot treatments with chemistries theorized to require shorter exposure times. The EWM population reductions are more commensurate with the financial costs and risks of the treatment.

To gain multi-year EWM suppression, future spot herbicide treatments would likely need to consider herbicides (diquat, florpyrauxifen-benzyl, etc.) or herbicide combinations (2,4-D/endothall, diquat/endothall, etc.) thought to be more effective under short exposure situations than with traditional weak-acid auxin herbicides (e.g., 2,4-D, triclopyr). At the time of this writing, florpyrauxifen-benzyl (ProcellaCOR™), a combination of 2,4-D/endothall (Chinook®), and a combination of diquat/endothall (Aquastrike ™) are examples of herbicides with reported short exposure time requirements.

ProcellaCOR™ is currently the region's most popular spot-treatment strategy. Onterra's experience monitoring many ProcellaCOR™ treatments within the state since 2019, EWM control has been high in most cases with almost no EWM being located during the summer post treatment. Within these treatments, native plant impacts have been minimal outside of some sensitive dicot species such as northern watermilfoil. Specific to Lawrence Lake, northern watermilfoil and coontail are native aquatic plant species present that would exhibit sensitivity to this herbicide based on previous field cases studied by Onterra. While these plants have been found to be susceptible, ProcellaCOR™ is a comparatively more selective herbicide when compared to others such as 2,4-D which have shown greater native plant impacts.

Herbicide Resistance

While understood in terrestrial herbicide applications for years, tolerance evolution is an emerging topic amongst aquatic herbicide applicators, lake management planners, regulators, and researchers. Herbicide resistance is when a population of a given species develops reduced susceptibility to an herbicide over time, such that an herbicide use pattern that once was effective no longer produces the same level of effect. This occurs in a population when some of the targeted plants have an innate tolerance to the herbicide and some do not. Following an herbicide treatment, the more tolerant strains will rebound whereas the more sensitive strains will be controlled. Thus, the plants that re-populate the lake will be those that are more tolerant to that herbicide resulting in a more tolerant population over time.

If genetic variation in the target population exists, particularly the presence of hybrid watermilfoils, repetitive treatments with the same herbicide may cause a shift towards increased herbicide tolerance in the population. Rotating herbicide use-patterns can help avoid population-level herbicide tolerance evolution from occurring.

Stakeholder Survey Responses to Eurasian Watermilfoil Management

As discussed in Section 2.0, the stakeholder survey asks many questions pertaining to perception of the lake and how it may have changed over the years. The return rate of the 2022 survey was 38%. Because the response rate was below 60%, the survey results can only be understood in the context of the population that responded to the survey instead of the entire population offered to participate in the survey.

Respondents were asked if they believed EWM was present in or immediately around Lawrence Lake (Question 24). Of the 60 respondents who answered this question, fifty-eight percent of those respondents indicated that EWM is present in Lawrence Lake. In an effort to understand Lawrence Lake respondent's perceptions on herbicide use, the 2022 stakeholder survey asked to gauge support for previous and future Eurasian watermilfoil herbicide management on Lawrence Lake. The majority of respondents (71%) either *moderately* or *completely support* past use of aquatic herbicides to manage EWM (Figure 3.4-12).

Question 26: What is your level of support or opposition for the past use of aquatic herbicides to treat EWM in previous years?

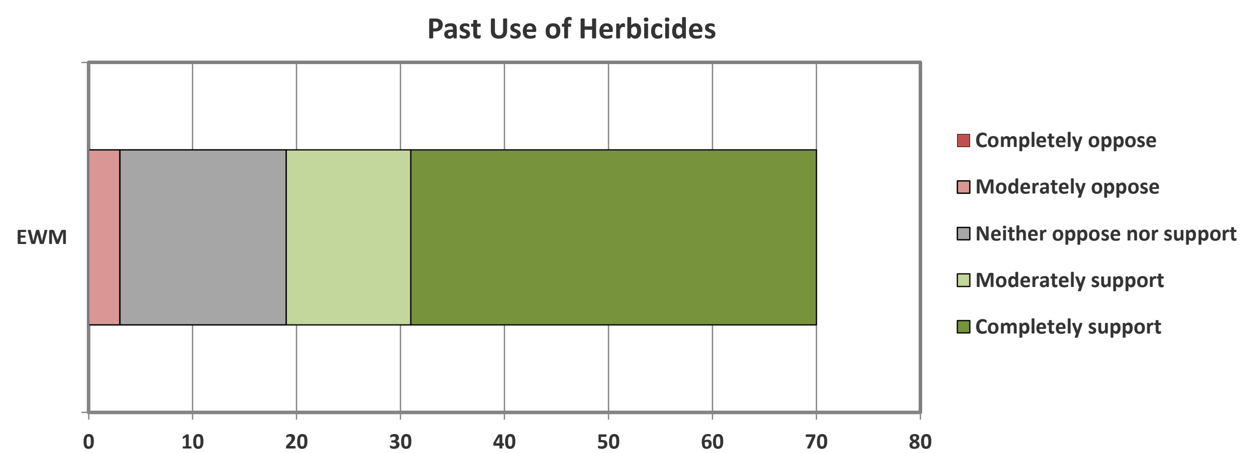


Figure 3.4-12. Select survey responses from the Lawrence Lake stakeholder survey. Additional questions and response charts may be found in Appendix B.

In 2022, Lawrence Lake respondents were asked about their level of support or opposition for the future use of aquatic herbicide to manage EWM. Again, the majority of respondents (77%) indicated *moderately* or *completely support* for future herbicide treatments (Figure 3.4-13). The respondents who selected *moderately oppose* indicated their reasons for opposing herbicide were *potential impacts to native aquatic plant species, future impacts are unknown, potential impacts to native (non-plant) species (fish, insects, etc.),* and *potential impacts to human health.*

Question 27: What is your level of support or opposition for future aquatic herbicide use to target EWM in Lawrence Lake?

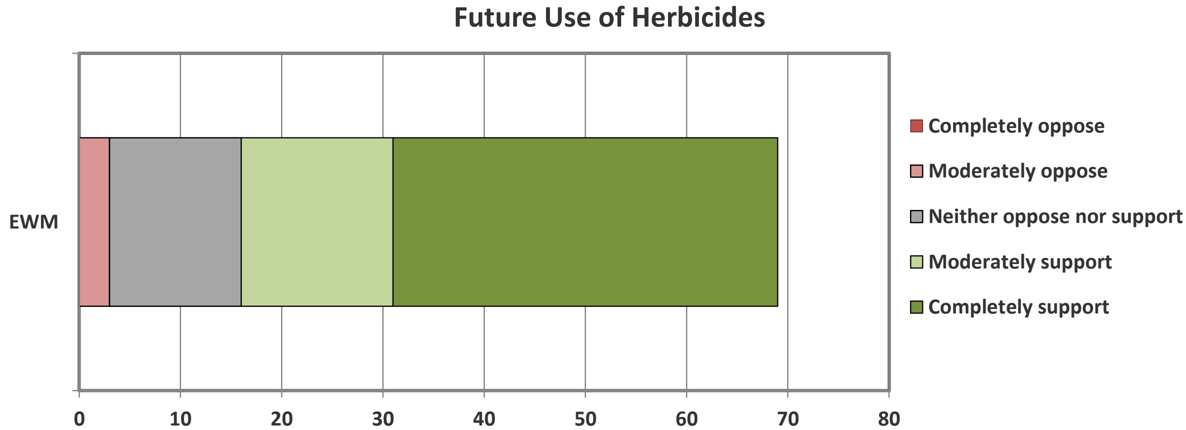


Figure 3.4-13. Select survey responses from the Lawrence Lake stakeholder survey. Additional questions and response charts may be found in Appendix B.

Curly-leaf Pondweed (*Potamogeton crispus*)

Curly-leaf pondweed (CLP; Photograph 3.4-8) was first documented in Lawrence Lake in 1994. Curly-leaf pondweed's primary method of propagation is through the production of numerous asexual reproductive structures called turions. Once mature, these turions break free from the parent plant and may float for some time before settling and overwintering on the lake bottom. Once favorable growing conditions return (i.e., spring), new plants emerge and grow from these turions. Many of the turions produced by CLP begin to sprout in the fall and overwinter as small plants under the ice. Immediately following ice-out, these plants grow rapidly giving them a competitive advantage over native vegetation. Curly-leaf pondweed typically reaches its peak biomass by May to early-June, and following the production of turions, most of the CLP will naturally senesce (die back) by mid-July.

Photograph 3.4-8. Curly-leaf pondweed plants. Locations of CLP in Lawrence Lake can be found on Map 11. Photo credit Onterra.

If the CLP population is large enough, the natural senescence and the resulting decaying of plant material can release sufficient nutrients into the water to cause mid-summer algal blooms. In some lakes, CLP can reach growth levels which interfere with navigation and recreational activities. However, in other lakes, CLP appears to integrate itself into the plant community and does not grow to levels which inhibit recreation or have apparent negative impacts to the lake's ecology. Because CLP naturally senesces in early summer, surveys are completed early in the growing season in an effort to capture the full extent of the population.

An Early-Season AIS Survey on Lawrence Lake was completed on May 31, 2022 to capture the full extent of the lake's CLP population. The 2022 survey found that the CLP population in

Lawrence Lake was found throughout the lake with localized *dominant* density colonies (Map 11). The population was comprised of approximately 9.8 acres of CLP, 1.6 acres of which were delineated as *dominant* or greater density. Isolated locations of *small plant colonies*, *clumps of plants*, and *single plants* were also found throughout the lake.

Curly-leaf Pondweed Management

The theoretical goal of CLP population management is to kill the plants each year before they are able to produce and deposit new turions. Not all of the turions produced each year sprout new plants the following year; many lie dormant in the sediment to sprout in subsequent years. This results in the creation of a sediment turion bank or reserve. Normally, a control strategy for an established CLP population includes multiple years of herbicide application of the same area to deplete the existing turion bank within the sediment. An example of this type of strategy would be through the annual application of the endothall for five or more consecutive years targeting the same areas of the lake. In instances where a large turion base may have already built up because of a long-term presence in the system, lake managers and regulators question whether the repetitive annual herbicide strategies may be imparting more strain on the environment than the existence of the invasive species.

Research conducted by (Skogerboe et al. 2008) at the US Army Corps of Engineers Research and Development Center found that management strategies that fails to kill the entire CLP plant (including rhizomes and root crowns) does not prevent new turion formation. The research found that stressed CLP plants actually produced more turions, and when above-ground biomass has been removed, the plants produced turions in the sediment along the rhizomes (stick turions). This means that sub-lethal herbicide treatments could actually increase the population over time.

Because CLP has been present in Lawrence Lake for nearly 30 years, the population is considered established within the lake. It is possible that the CLP population may not expand its footprint beyond what has already been observed in the lake in recent years. It should be expected that the CLP population will be variable from year to year in Lawrence Lake as environmental variables such as snow depth, ice cover, and water temperatures, may or may not be favorable for turion germination in any given year. Future CLP management may consider the use of mechanical harvesting in locally dense areas of CLP as a means of relief from nuisance conditions in early-summer. It is important to note that CLP naturally senesces in early-summer meaning that this species does not contribute to nuisance plant growth conditions that may be occurring on the lake from approximately mid-July through the remainder of the growing season.

Stakeholder Survey Responses to Curly-leaf Pondweed Management

As discussed in Section 2.0, the stakeholder survey asks many questions pertaining to perception of the lake and how it may have changed over the years. The return rate of the 2022 survey was 38%. Because the response rate was below 60%, the survey results can only be understood in the context of the population that responded to the survey instead of the entire population offered to participate in the survey.

Respondents were asked if they believed CLP was present in or immediately around Lawrence Lake (Question 24). Of the 60 respondents who answered this question, fifty percent of those respondents indicated that CLP is present in Lawrence Lake. In an effort to understand Lawrence Lake respondents' perceptions on herbicide use, the 2022 stakeholder survey asked to gauge support for previous and future curly-leaf pondweed herbicide management on Lawrence Lake. The majority of respondents (70%) either *moderately* or *completely support* past use of aquatic herbicides to manage CLP (Figure 3.4-14).

Question 26: What is your level of support or opposition for the past use of aquatic herbicides to treat CLP in previous years?

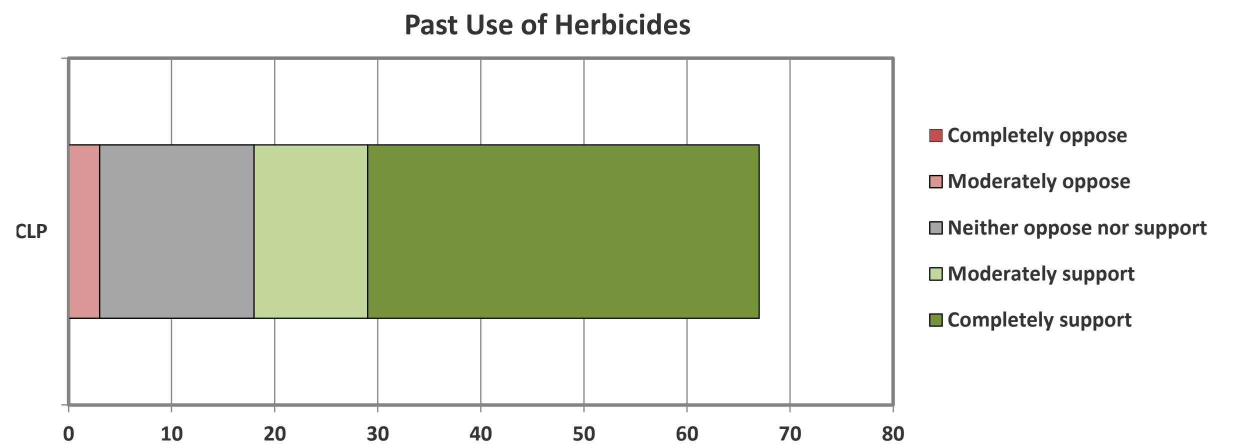


Figure 3.4-14. Select survey responses from the Lawrence Lake stakeholder survey. Additional questions and response charts may be found in Appendix B.

In 2022, Lawrence Lake respondents were asked about their level of support or opposition for the future use of aquatic herbicide to manage CLP. Again, the majority of respondents (70%) indicated *moderately* or *completely support* for future herbicide treatments (Figure 3.4-15). The stakeholders who selected *moderately oppose* indicated their reasons for opposing herbicide were *potential impacts to native aquatic plant species, future impacts are unknown, potential impacts to native (non-plant) species (fish, insects, etc.),* and *potential impacts to human health.*

Question 26: What is your level of support or opposition for future aquatic herbicide use to target EWM in Lawrence Lake?

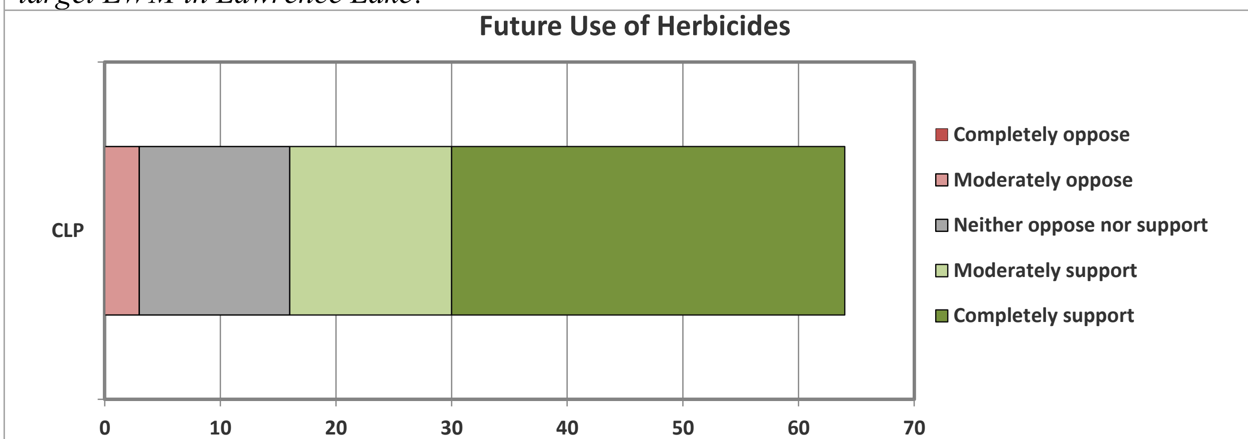


Figure 3.4-15. Select survey responses from the Lawrence Lake stakeholder survey. Additional questions and response charts may be found in Appendix B.

Aquatic Plant Management History

Aquatic plant management history over the past 15+ years has largely been through annual herbicide treatments along shorelines that have many riparian properties. A variety of herbicides have been used over the course of time including 2,4-D, diquat, endothall, copper, and flumioxazin (Table 3.4-3). Some of these chemicals are used to target CLP or EWM specifically, while others are less selective and have been used to target excessive growth of native plants.

Table 3.4-3. Aquatic plant management history in Lawrence Lake from 2008-2022. Records from WDNR.

year	chemicals used	amount used (units)	treated acreage
2008	2,4-D	10 gal	5.5
	Copper	5.5 gal	
	diquat	5.5 gal	
	endothall	5.5 gal	
2009	endothall	6.25 gal	2.7
	Copper	1 gal	
2010	permit issued - no treatment record		24
2011	endothall	2.5 gal	1.3
	2-4D	25 gal	5.6
	endothall	40 lbs	
2012	permit issued - no treatment record		7
2013	2,4-D	340 lbs	1.49
	2,4-D	32.5 gal	2.84
	endothall	125 lbs	2.88
2014	2,4-D	640 lbs	2.46
2015	2,4-D	4.75 gal	0.43
	2,4-D	33.75 gal	3.13
	2,4-D	1.75 gal	0.43
	2,4-D	3.75 gal	0.33
	endothall	2.5 gal	
2016	permit issued - no treatment record		9
2017	diquat	2.38 gal	1.19
	Copper	2.85 gal	
2018	2,4-D	162.89 gal	11.32
	diquat	2.38 gal	1.19
	Copper	3.57 gal	
2019	endothall	23.18 gal	4.3
2020	endothall + diquat	80 gal	8
	diquat	2 gal	1.6
	Copper	3.5 gal	
2021	Flumioxazin	17.4 lbs	2.9
2022	Flumioxazin	17.4 lbs	2.9

Silvergrass (*Miscanthus* spp.)

Silvergrass is a large, robust perennial grass that can grow from 5 – 10 feet in height (Photograph 3.4-9). Native to China, Japan, and Korea, this species is sold commercially in the United States for ornamental use and has since escaped into Wisconsin's wetland areas forming large monotypic colonies and displacing valuable native wetland species. Onterra mapped two silvergrass locations during the community mapping survey on August 2, 2022. The results of the survey indicate silvergrass is not widespread in shoreland areas around Lawrence Lake (Map 8).

Photograph 3.4-9. Silvergrass along the shoreline of Lawrence Lake. Other locations in Lawrence Lake can be found on Map 8. Photo credit Onterra.

Watercress (*Nasturtium officinale*)

Watercress is a semi-aquatic perennial herb with white flowers (Photograph 3.4-10). This plant is native to Eurasia, this species was sold commercially in the United States for ornamental use and has since escaped into Wisconsin's wetland areas. The watercress found around the lake was in flower at the time of the survey making for easy identification. Onterra mapped five watercress locations during the community mapping survey on August 2, 2022. The results of the survey indicate that watercress is not widespread in shoreland areas around Lawrence Lake (Map 8).

Photograph 3.4-10. Watercress in a shallow area on Lawrence Lake. Photo credit: Onterra.

3.5 Aquatic Invasive Species in Lawrence Lake

As is discussed in section 2.0 Stakeholder Participation, the lake stakeholders were asked about aquatic invasive species (AIS) and their presence in Lawrence Lake within the anonymous stakeholder survey. Onterra and the WDNR have confirmed that there are four AIS present (Table 3.5-1).

Table 3.5-1. AIS present within Lawrence Lake.

Type	Common name	Scientific name	Location within the report
Plants	Eurasian watermilfoil	*Myriophyllum spicatum*	Section 3.4 – Aquatic Plants
	Curly-leaf Pondweed	*Potamogeton crispus*	Section 3.4 – Aquatic Plants
	Silvergrass	*Miscanthus* spp.	Section 3.4 – Aquatic Plants
	Watercress	*Nasturtium officinale*	Section 3.4 – Aquatic Plants
Invertebrates	Banded mystery snail	*Viviparus georgianus*	Section 3.5 – Aquatic Animals
	Chinese mystery snail	*Cipangopaludina chinensis*	Section 3.5 – Aquatic Animals

Figure 3.5-2 displays the aquatic invasive species that Lawrence Lake stakeholder survey respondents believe are in Lawrence Lake. Only the species known to be present in Lawrence Lake are discussed below or within their respective locations listed in Table 3.5-1. While it is important to recognize which species stakeholders believe to present within their lake, it is more important to share information on the species present and possible management options. More information on these invasive species or any other AIS can be found at the following links:

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

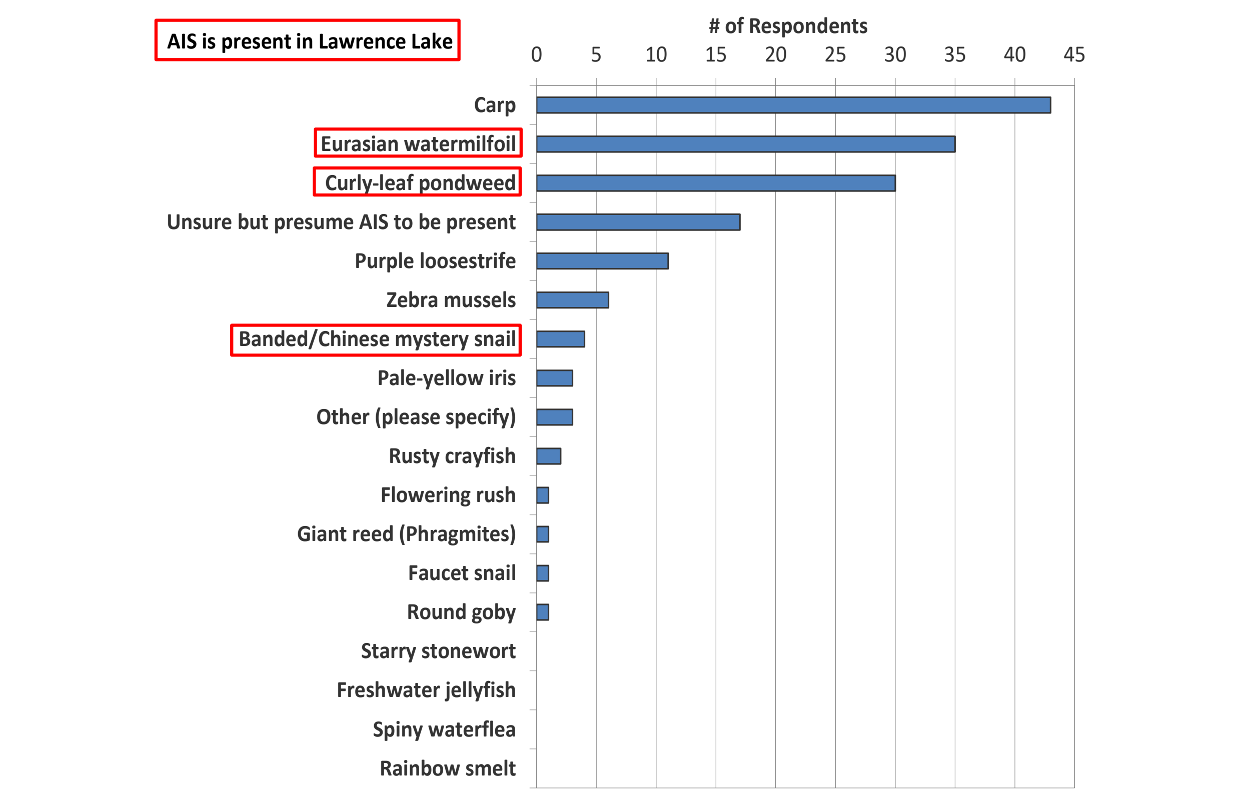


Figure 3.5-1. Stakeholder survey response Question #20. Which aquatic invasive species do you believe are in Lawrence Lake?

Aquatic Animals

Mystery snails

There are two types of mystery snails found within Wisconsin waters, the Chinese mystery snail (*Cipangopaludina chinensis*) and the banded mystery snail (*Viviparus georgianus*) (Figure 3.5-2). Both snails can be identified by their large size, thick hard shell and hard operculum (a trap door that covers the snail's soft body). These traits also make them less edible to native predators. These species thrive in eutrophic waters with very little flow. They are bottom-dwellers eating diatoms, algae and organic and inorganic bottom materials. One study conducted in northern Wisconsin lakes found that the Chinese mystery snail did not have strong negative effects on native snail populations (Solomon, Olden, P.T.J, Dillion Jr., & Vander Zander, 2010). However, researchers did detect negative impacts to native snail communities when both Chinese mystery snails and the rusty crayfish were present (Johnson, Olden, Solomon, & Vander Zanden, 2009).

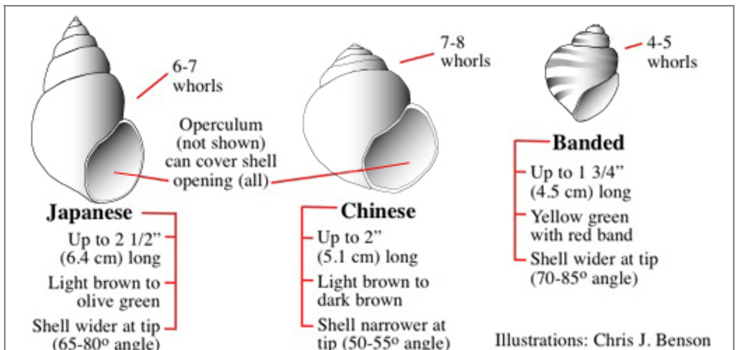


Figure 3.5-2. Identification of non-native mystery snails. Courtesy of Minnesota Sea Grant: (http://www.seagrant.umn.edu/ais/mysterysnail).

3.6 Fisheries Data Integration

Fishery management is an important aspect in the comprehensive management of a lake ecosystem; therefore, a brief summary of available data is included here as a reference. The following section is not intended to be a comprehensive plan for the lake's fishery, as those aspects are currently being conducted by the fisheries biologists overseeing Lawrence Lake. The goal of this section is to provide an overview of some of the data that exists. Although current fish data were not collected as a part of this project, the following information was compiled based upon data available from the Wisconsin Department of Natural Resources (WDNR) and personal communications with DNR Fisheries Biologist Adam Nickel (WDNR 2023).

Lawrence Lake Fishery

Energy Flow of a Fishery

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

A concept called energy flow describes how the biomass of piscivores is determined within a lake. Because algae and plant matter are generally small in energy content, it takes an incredible amount of this food type to support a sufficient biomass of zooplankton and insects. In turn, it takes a large biomass of zooplankton and insects to support planktivorous fish species. And finally, there must be a large planktivorous fish community to support a modest piscivorous fish community. Studies have shown that in natural ecosystems, it is largely the amount of primary productivity (algae and plant matter) that drives the rest of the producers and consumers in the aquatic food chain. This relationship is illustrated in Figure 3.6-1.

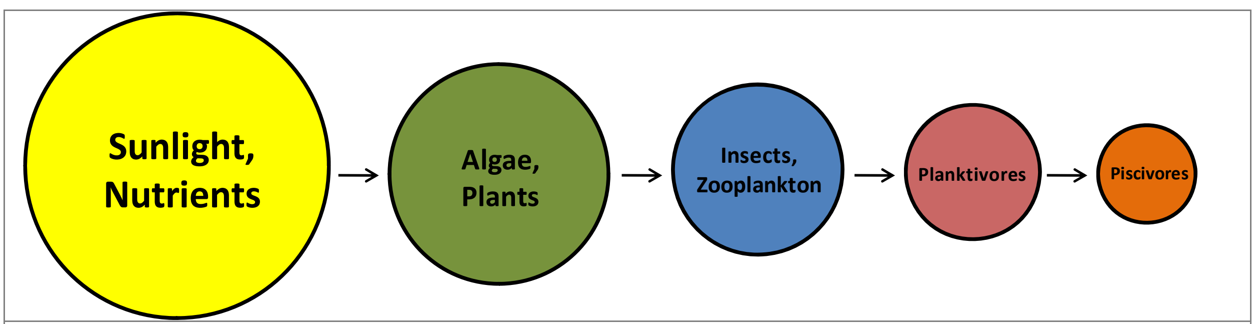


Figure 3.6-1. Aquatic food chain. Adapted from (Carpenter, Kitchell, & Hodgson, 1985)

As discussed in the Water Quality section, Lawrence Lake is a eutrophic system, meaning it has high nutrient content and thus relatively high primary productivity. Simply put, this means Lawrence Lake should be able to support sizable populations of predatory fish (piscivores) because the supporting food chain is relatively robust. Table 3.6-1 shows the popular game fish present in the system.

Table 3.6-1. Gamefish present in Lawrence Lake with corresponding biological information (Becker, 1983).

Black Crappie (*Pomoxis nigromaculatus*)	7	May - June	Near *Chara* or other vegetation, over sand or fine gravel	Fish, cladocera, insect larvae, other invertebrates
Bluegill (*Lepomis macrochirus*)	11	Late May - Early August	Shallow water with sand or gravel bottom	Fish, crayfish, aquatic insects and other invertebrates
Green Sunfish (Lepomis cyanellus)	7	Late May - Early August	Shelter with rocks, logs, and clumps of vegetation, 4 - 35 cm	Zooplankton, insects, young green sunfish and other small fish
Largemouth Bass (*Micropterus salmoides*)	13	Late April - Early July	Shallow, quiet bays with emergent vegetation	Fish, amphipods, algae, crayfish and other invertebrates
Northern Pike (Esox lucius)	25	Late March - Early April	Shallow, flooded marshes with emergent vegetation with fine leaves	Fish including other pike, crayfish, small mammals, water fowl, frogs
Pumpkinseed (*Lepomis gibbosus*)	12	Early May - August	Shallow warm bays 0.3 - 0.8 m, with sand or gravel bottom	Crustaceans, rotifers, mollusks, flatworms, insect larvae (terrestrial and aquatic)
Walleye (*Sander vitreus*)	18	Mid April - Early May	Rocky, wavewashed shallows, inlet streams on gravel bottoms	Fish, fly and other insect larvae, crayfish
Yellow Bullhead (*Ameiurus natalis*)	7	May - July	Heavy weeded banks, beneath logs or tree roots	Crustaceans, insect larvae, small fish, some algae
Yellow Perch (*Perca flavescens*)	13	April - Early May	Sheltered areas, emergent and submergent veg	Small fish, aquatic invertebrates

Survey Methods

In order to keep the fishery of a lake healthy and stable, fisheries biologists must assess the current fish populations and trends. To begin this process, the correct sampling technique(s) must be selected to efficiently capture the desired fish species. A commonly used passive trap is a fyke net (Photograph 3.6-1). Fish swimming towards this net along the shore or bottom will encounter the lead of the net, be diverted into the trap and through a series of funnels which direct the fish further into the net. Once reaching the end, the fisheries technicians can open the net, record biological characteristics, mark (usually with a fin clip), and then release the captured fish.

The other commonly used sampling method is electrofishing (Photograph 3.6-1). This is done, often at night, by using a specialized boat fit with a generator and two electrodes installed on the front touching the water. Once a fish comes in contact with the electrical current produced, the fish involuntarily swims toward the electrodes. When the fish is in the vicinity of the electrodes, they become stunned making them easier to net and place into a livewell to recover. Contrary to what some may believe, electrofishing does not kill the fish and after being placed in the livewell fish generally recover within minutes. As with a fyke net survey, biological characteristics are recorded and any fish that has a mark (considered a recapture from the earlier fyke net survey) are also documented before the fish is released.

The mark-recapture data collected between these two surveys is placed into a statistical model to calculate the population estimate of a fish species. Fisheries biologists can then use this data to make recommendations and informed decisions on managing the future of the fishery.

Photograph 3.6-1. Fyke net positioned in the littoral zone of a Wisconsin Lake (left) and an electroshocking boat (right).

Fish Stocking

Photograph 3.6-2. Walleye fingerling.

To assist in meeting fisheries management goals, the WDNR may permit the stocking of fingerling or adult fish in a waterbody that were raised in permitted hatcheries (Photograph 3.6-2). Stocking a lake may be done to assist the population of a species due to a lack of natural reproduction in the system, or to otherwise enhance angling opportunities. Lawrence Lake has received extensive and repeated stocking efforts of multiple species over the last 20 years. Northern pike were stocked multiple times since 1972, however no stocking events have taken place since 1997 (Table 3.6-3). A total of 7,847 fingerling pike were stocked, as well as 625,000 fry. Both black crappie and yellow perch have been stocked in recent years as well. A total of 31,875 black crappie fingerlings and 44,275 yellow perch fingerlings have been stocked since 2008 (Table 3.6-4). In addition to gamefish and panfish, several stocking events of fathead minnows have occurred since 2010.

Table 3.6-2. Stocking data available for walleye in Lawrence Lake (1976-2020).

Year	Species	Age Class	# Fish Stocked	Avg Fish Length (in)
2020	WALLEYE	LARGE FINGERLING	2,000	6.0
2019	WALLEYE	LARGE FINGERLING	3,000	6.0
2018	WALLEYE	SMALL FINGERLING	4,500	6.0
2017	WALLEYE	LARGE FINGERLING	4,000	6.0
2016	WALLEYE	SMALL FINGERLING	4,000	6.0
2015	WALLEYE	SMALL FINGERLING	4,000	6.0
2014	WALLEYE	SMALL FINGERLING	4,000	6.0
2013	WALLEYE	SMALL FINGERLING	3,500	6.0
2012	WALLEYE	SMALL FINGERLING	4,000	6.0
2010	WALLEYE	SMALL FINGERLING	4,000	6.0
2009	WALLEYE	SMALL FINGERLING	3,800	6.0
2008	WALLEYE	LARGE FINGERLING	3,600	6.5
2000	WALLEYE	LARGE FINGERLING	400	9.0
1994	WALLEYE	FINGERLING	3,500	7.0
1993	WALLEYE	FINGERLING	2,467	9.0
1976	WALLEYE	FINGERLING	1,400	7.0

Table 3.6-3. Stocking data available for northern pike in Lawrence Lake (1972-1997).

Year	Species	Age Class	# Fish Stocked	Avg Fish Length (in)
1997	NORTHERN PIKE	LARGE FINGERLING	442	8.0
1996	NORTHERN PIKE	FINGERLING	884	8.8
1995	NORTHERN PIKE	FINGERLING	442	8.2
1992	NORTHERN PIKE	FINGERLING	442	8.0
1991	NORTHERN PIKE	FINGERLING	1,155	8.0
1991	NORTHERN PIKE	FRY	500,000	0.6
1985	NORTHERN PIKE	FINGERLING	1,000	8.0
1978	NORTHERN PIKE	YEARLING	600	
1976	NORTHERN PIKE	FINGERLING	300	13.0
1975	NORTHERN PIKE	YEARLING	1,282	
1974	NORTHERN PIKE	YEARLING	600	15.0
1973	NORTHERN PIKE	FRY	125,000	
1972	NORTHERN PIKE	YEARLING	700	13.0

Table 3.6-4. Stocking data available for panfish in Lawrence Lake (2008-2020).

Year	Species	Age Class	# Fish Stocked	Avg Fish Length
2020	YELLOW PERCH	YEARLING	1,775	6.0
2020	YELLOW PERCH	SMALL FINGERLING	2,000	4.0
2019	YELLOW PERCH	SMALL FINGERLING	3,000	4.0
2018	BLACK CRAPPIE	SMALL FINGERLING	4,000	4.0
2018	YELLOW PERCH	SMALL FINGERLING	5,000	4.0
2017	BLACK CRAPPIE	SMALL FINGERLING	3,000	4.0
2017	YELLOW PERCH	SMALL FINGERLING	4,000	4.0
2016	YELLOW PERCH	SMALL FINGERLING	4,500	4.0
2015	BLACK CRAPPIE	SMALL FINGERLING	4,000	4.0
2015	YELLOW PERCH	SMALL FINGERLING	4,000	4.0
2014	BLACK CRAPPIE	SMALL FINGERLING	4,000	4.0
2014	YELLOW PERCH	SMALL FINGERLING	4,000	4.0
2013	BLACK CRAPPIE	SMALL FINGERLING	6,000	4.0
2012	BLACK CRAPPIE	SMALL FINGERLING	6,000	4.0
2010	BLACK CRAPPIE	SMALL FINGERLING	3,900	4.0
2010	YELLOW PERCH	SMALL FINGERLING	6,000	4.0
2009	BLACK CRAPPIE	SMALL FINGERLING	975	4.0
2009	YELLOW PERCH	SMALL FINGERLING	4,000	4.0
2008	YELLOW PERCH	SMALL FINGERLING	6,000	4.0

Fishing Activity

Based on data collected from the stakeholder survey (Appendix B), fishing (open-water) was the most important reason for owning property on or near Lawrence Lake (Question #8). Almost 87% of respondents have fished Lawrence Lake in the last three years (Question 9). Figure 3.6-2 displays the fish that Lawrence Lake stakeholders enjoy catching the most, with bluegill/sunfish, being the most popular. Approximately 71% of these same respondents believed that the quality of fishing on the lake was either good or excellent (Figure 3.6-3). Approximately 65% of stakeholders believe the quality of the fishery has either remained the same or has gotten better to some degree since they started fishing the lake (Figure 3.6-4).

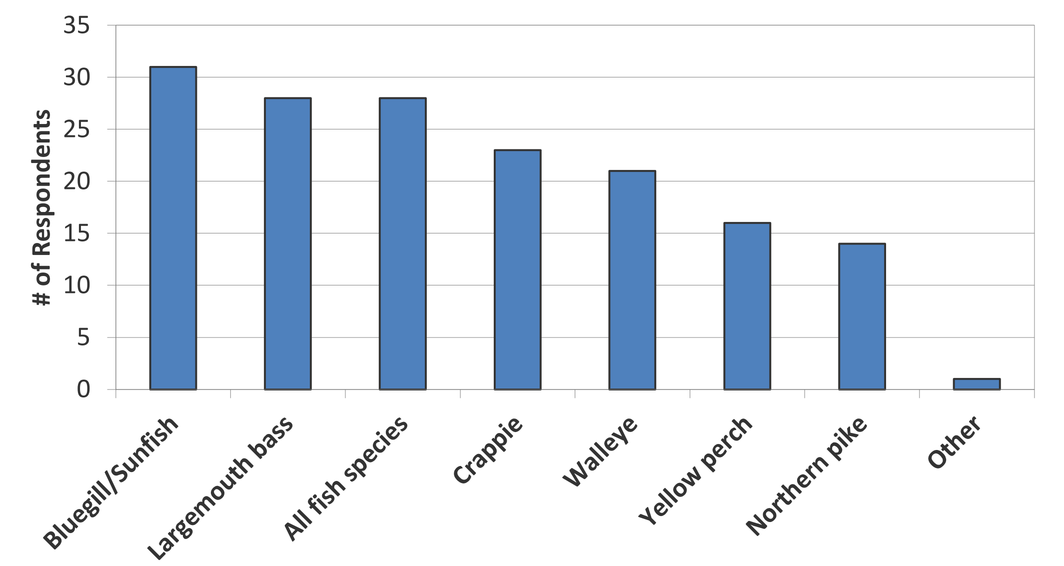


Figure 3.6-2. Stakeholder survey response Question #10. What species of fish do you like to catch on Lawrence Lake?

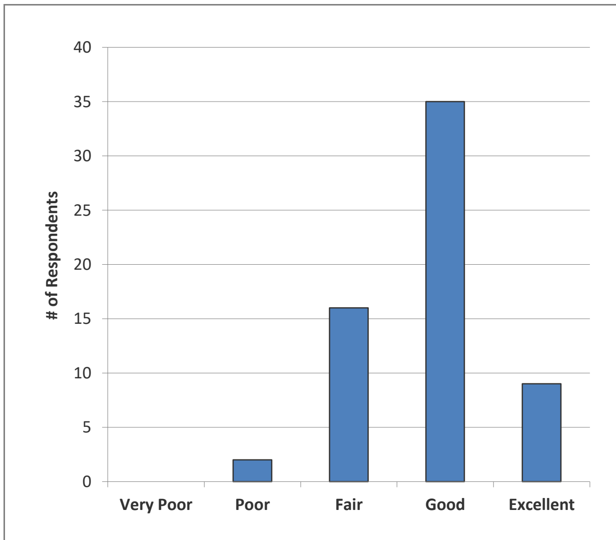


Figure 3.6-3. Stakeholder survey response Question #12. How would you describe the current quality of fishing on Lawrence Lake?

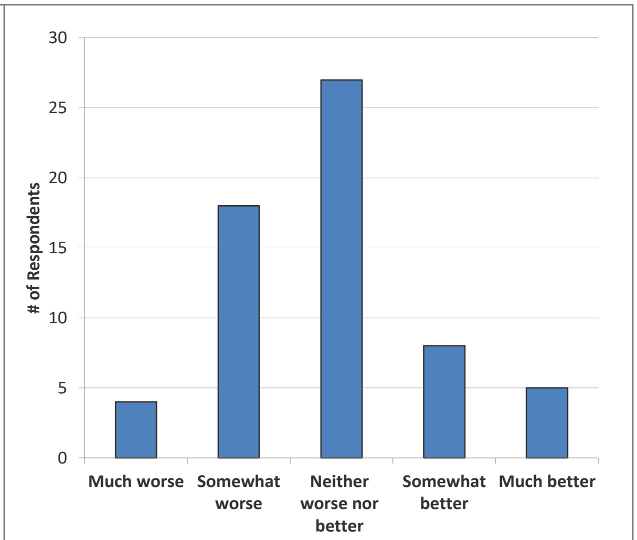


Figure 3.6-4. Stakeholder survey response Question #13. How has the quality of fishing changed on Lawrence Lake since you started fishing the lake?

Gamefish

The gamefish present on Lawrence Lake represent different population dynamics depending on the species. The results for the stakeholder survey show landowners prefer to catch walleye on Lawrence Lake (Figure 3.6-2). An electrofishing survey targeting largemouth bass and bluegill was conducted in spring of 2023, which covered 5 miles of shoreline and focused on capturing largemouth bass and bluegill. An official report of this survey should be available in 2024.

Largemouth bass are considered common in Lawrence Lake. Largemouth bass are the gamefish that stakeholders prefer to pursue the most. During the 2023 bass and panfish survey, 779 largemouth bass were captured. This equaled a catch rate of 155 bass/mile and put Lawrence in 95^{th} percentile when compared to similar lakes in the state. The size structure of the bass captured was specifically highlighted, with over 25% of the fish captured larger than 14inches (communications, WDNR biologist Adam Nickel).

Northern pike are considered common in Lawrence Lake. While not specifically targeted, 33 pike were captured in the 2023 survey. Several stocking events of northern pike occurred in 1970's, 1980's, and 1990's, however no stocking of pike has occurred in recent years. Results from the stakeholder survey show that northern pike are the third-most targeted gamefish species in Lawrence Lake (communications, WDNR biologist Adam Nickel).

Walleyes are a valued sportfish in Wisconsin and are present in Lawrence Lake. Walleyes have been stocked in Lawrence Lake on a regular basis since 2008, with 12 stocking events occurring in the last 15 years. A total of 44,400 walleye fingerlings have been stocked during this timeframe (Table 3.6-2). According to the stakeholder survey, walleye are a popular gamefish species that Lawrence Lake anglers pursue. While not specifically targeted, a total of eight walleyes were captured in the 2023 survey (communications, WDNR biologist Adam Nickel)

Panfish

Bluegills are the most common species of panfish in Lawrence Lake and are the species most pursued by Lawrence Lake anglers. During the 2023 survey, a total of 513 bluegills were captured. This also puts the Lawrence Lake bluegill population in the 95^{th} percentile for catch rate when compared to similar lakes in the state. Trophy-sized fish were also present, with a 10.2 inch bluegill being the largest recorded during the survey (communications, WDNR biologist Adam Nickel).

Yellow perch and **black crappie** are other commonly found panfish species in Lawrence Lake. The methods of the electrofishing survey are not the best for targeting both of these species, however any perch or crappie encountered were recorded. In total, 17 yellow perch and 12 black crappies were captured in the 2023 survey (communications, WDNR biologist Adam Nickel).

Lawrence Lake Fish Habitat

Substrate Composition

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

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

According to the point-intercept survey conducted by Onterra in 2022, 95% of the substrate sampled in the littoral zone of Lawrence Lake were soft, organic sediments and the remaining 5% was a sandy substrate.

Woody Habitat

As discussed in the Shoreland Condition Section, the presence of coarse woody habitat is important for many stages of a fish's life cycle, including nesting or spawning, escaping predation as a juvenile, and hunting insects or smaller fish as an adult. Unfortunately, as development has increased on Wisconsin lake shorelines in the past century, this beneficial habitat has often been the first to be removed from the natural shoreland zone. Leaving these shoreland zones barren of coarse woody habitat can lead to decreased abundances and slower growth rates in fish (Sass, 2009). A 2022 survey documented 107 pieces of coarse woody along the shores of Lawrence Lake, resulting in a ratio of approximately 16 pieces per mile of shoreline. Fisheries biologists do not suggest a specific number of fish sticks for a lake but rather highly encourage their installation wherever possible. To learn how Lawrence Lake's coarse woody habitat is compared to other lakes in its region please refer to section 3.3.

Fish Habitat Structures

Some fisheries managers may look to incorporate fish habitat structures on the lakebed or littoral areas extending to shore for the purpose of improving fish habitats and spawning areas. These projects are typically conducted on lakes lacking significant coarse woody habitat in the shoreland zone. The "Fish sticks" program, outlined in the WDNR best practices manual, adds trees to the shoreland zone restoring fish habitat to critical near shore areas. Typically, every site has 3 – 5 trees which are partially or fully submerged in the water and anchored to shore (Photograph 3.6-3). The WDNR recommends placement of the fish sticks during the winter on ice when possible to prevent adverse impacts on fish spawning or egg incubation periods. The program requires a WDNR permit and can be funded through many different sources including the WDNR, County Land & Water Conservation Departments or partner contributions.

Photograph 3.6-3. Examples of fish sticks (left) and half-log habitat structures. (Photos by WDNR)

Fish cribs are a type of fish habitat structure placed on the lakebed. These structures are more commonly utilized when there is not a suitable shoreline location for fish sticks. Installing fish cribs may also be cheaper than fish sticks; however some concern exists that fish cribs can concentrate fish, which in turn leads to increased predation and angler pressure. Having multiple locations of fish cribs can help mitigate that issue.

Half-logs are another form of fish spawning habitat placed on the bottom of the lakebed (Photograph 3.6-3). Smallmouth bass specifically have shown an affinity for overhead cover when creating spawning nests, which half-logs provide (Wills, Bremigan, & Haynes, 2004). If the waterbody is exempt from a permit or a permit has been received, information related to the construction, placement and maintenance of half-log structures are available online.

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

Placement of a fish habitat structure in a lake may be exempt from needing a permit if the project meets certain conditions outlined by the WDNR's checklists available online:

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

If a project does not meet all of the conditions listed on the checklist, a permit application may be sent in to the WDNR and an exemption requested.

If interested, the Lawrence Lake Protection & Rehabilitation District may work with the local WDNR fisheries biologist to determine if the installation of fish habitat structures should be considered in aiding fisheries management goals for Lawrence Lake.

Fishing Regulations

Regulations for Lawrence Lake fish species as of March 2023 are displayed in Table 3.6-4.

For specific fishing regulations on all fish species, anglers should visit the WDNR website (*www.http://dnr.wi.gov/topic/fishing/regulations/hookline.html)* or visit their local bait and tackle shop to receive a free fishing pamphlet that contains this information.

Table 3.6-4. WDNR fishing regulations for Lawrence Lake (as of March 2023).

Species	Daily bag limit	Length Restrictions	Season
Panfish (bluegill, pumpkinseed, sunfish, crappie and yellow perch)	25	None	Open All Year
Largemouth bass and smallmouth bass	5	14"	May 7, 2022 to March 5, 2023
Smallmouth bass	5	14"	May 7, 2022 to March 5, 2023
Largemouth bass	5	14"	May 7, 2022 to March 5, 2023
Northern pike	5	26"	May 7, 2022 to March 5, 2023
Walleye, sauger, and hybrids	5	15"	May 7, 2022 to March 5, 2023
Bullheads	Unlimited	None	Open All Year
Cisco and whitefish	10	None	Open All Year

Mercury Contamination and Fish Consumption Advisories

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

General fish consumption guidelines for Wisconsin inland waterways are presented in Figure 3.6-8. There is an elevated risk for children as they are in a stage of life where cognitive development is rapidly occurring. As mercury and PCB both locate to and impact the brain, there are greater restrictions on women who may have children or are nursing children, and also for children under 15.

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

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

Figure 3.6-8. Wisconsin statewide safe fish consumption guidelines. Graphic displays consumption guidance for most Wisconsin waterways. Figure adapted from WDNR website graphic (http://dnr.wi.gov/topic/fishing/consumption/)

Fishery Management & Conclusions

Lawrence Lake provides a diverse fishery with multiple species of fish for anglers to pursue. Intensive stocking efforts in recent years have helped bolster the walleye and panfish populations. Overall, Lawrence Lake stakeholders seem pleased with the state of the fishery. Largemouth bass populations in Lawrence Lake are some of the best in the area both in terms of catch rate and size structure. Similarly, bluegill populations and size structure also ranked highly when compared to similar systems across the state. While not specifically targeted, popular fish species such as black crappie, walleye, and yellow perch were all encountered throughout the survey.

4.0 SUMMARY AND CONCLUSIONS

The design of this project was intended to fulfill four objectives;

1) Collect baseline data to increase the general understanding of the Lawrence Lake ecosystem.
2) Collect detailed information regarding invasive plant species within the lake, with the primary emphasis being on Eurasian watermilfoil and curly-leaf pondweed.
3) Create a better understanding of the lake's historical surveys and studies, especially those regarding lake sediments and dredging.
4) Collect sociological information from Lawrence Lake stakeholders regarding their use of the lake and their thoughts pertaining to the past and current condition of the lake and its management.

The four objectives were fulfilled during the project and have led to a good understanding of the Lawrence Lake ecosystem, the folks that care about the lake, and what needs to be completed to protect and enhance it.

Overall, the studies that were completed on Lawrence Lake indicate that it is healthy in terms of its watershed, water quality, and aquatic plant community. Lawrence Lake is an impounded river and not a natural lake, therefore; it cannot be managed as a natural lake. There are certain aspects of an impoundment, like the size of its watershed, that create specific management challenges. The condition of the ecosystem and realistic management actions are summarized below. For a full understanding of Lawrence Lake, the sections above should be reviewed and used as a reference. For a full understanding of the steps the Lawrence Lake Protection and Rehabilitation District will be taking to protect and enhance the lake while increasing its capacity to do so, the implementation plan in the next section should be read.

Like all impoundments, Lawrence Lake has a large watershed compared to the size of the lake. The full watershed of Lawrence Lake spans over 13,700 acres; however, due to the abundance of seepage lakes in the watershed, the acreage around those lakes is considered *isolated* from Lawrence Lake. In other words, each seepage lake's watershed would not drain to Lawrence Lake unless the lake, plus its watershed, overtopped with water which could then make its way to Lawrance Lake. When those isolated watersheds are not included in the area draining to Lawrence Lake, the lake's *direct* watershed is approximately 3,778 acres. This is still a large watershed and when compared to the surface acreage of the lake, reveals a watershed-to-lake area ratio of 16:1, which is moderately high. This means that 16 acres of land drains to every acre of Lawrence Lake. The larger the surface area draining to a lake, the greater the opportunity for the runoff to gather pollutants, like nutrients. Fortunately, nearly 70% of Lawrence Lake's watershed is comprised of forests and wetlands. These two land cover types release the least amount of phosphorus during runoff events. Further, row crop agriculture, which exports the highest amount of phosphorus, makes up only about 10% of the watershed; and the areas where it does exist are relatively far from the lake. Finally, a large amount of the water draining to the lake originates from groundwater seeps feeding headwater streams. This provides large volumes of relatively clean water to dilute runoff from other sources in the watershed.

Lawrence Lake's shorelands are in relatively good condition with the majority of it supporting nearly full canopy cover and intact shrub and herbaceous layers. Ninety-five percent of the shoreline contains very little impervious surface and less than 40% of the area includes unacceptable levels of manicured lawn. The lake does not contain a great deal of coarse woody habitat, which is an important fish habitat. This includes the undeveloped shorelines of the lake as well. However, much of the undeveloped shoreline is wetland, which does not support abundant tree growth.

Unfortunately, very little water quality data exists for Lawrence Lake. However, the recent and historical data that are available indicate that for the most part, the lake's water quality is very good compared to other lakes in the ecoregion and the state. Compared to the water quality of other millponds in the Central Sands Region, Lawrence Lake's water quality is excellent. This is the case because of the morphology and condition of the watershed and that of the immediate shoreline. While opportunities definitely exist for improvements to the Lawrence Lake shoreline, for example, rain gardens, native plantings, reduced impervious surface, and coarse wood habitat. Ultimately, these improvements would do more in terms of habitat improvement compared to improving the lake's already very good water quality.

The Lawrence Lake plan includes monitoring of lake water quality through the Wisconsin Citizens Lake Monitoring Network. In fact, actions to reenroll in the program were initiated following the second planning meeting.

Four aquatic plant surveys were completed on Lawrence Lake during the 2022 growing season. The surveys measured the makeup and abundance of the aquatic plant community through a point-intercept survey, which collects quantitative data, and three mapping surveys aimed at particular species of aquatic plants, like curly-leaf pondweed and Eurasian watermilfoil, and types of aquatic plants, like emergent and floating-leaf species. Overall, the surveys indicated that the floristic quality and the species diversity of the system are comparable or slightly better than other waterbodies in the ecoregion and state. Further, while AIS plants exist in the lake, they are far outnumbered by native species.

Ultimately, Lawrence Lake does not have an AIS issue, but it does have a nuisance aquatic plant issue primarily made up of native plant species and some non-native species. This is somewhat of a difficult concept for some district members to accept, but the fact is that curly-leaf pondweed and Eurasian watermilfoil together make up less than 5% of the plant population in the lake, while native species like northern watermilfoil, muskgrasses, Fries'pondweed, and coontail make up 15%, 27%, 11%, and 10%, respectively. This is important because an aquatic plant management strategy aimed at controlling AIS in Lawerence Lake will not relieve the legitimate impacts by nuisance plants on recreation within the lake. The implementation plan in the next section includes the use of herbicides to create 15-foot-wide navigation lanes in select areas of Lawrence Lake. The maximum area that would be treated as a part of this action is less than four acres. The plan also includes periodic monitoring of aquatic plants.

A spring 2023 electrofishing survey completed on Lawrence Lake found exceptional catch rates for largemouth bass and bluegill in Lawrence Lake compared to other lakes of the same type and other lakes of the state in general. These results are another indicator of the good ecological health of Lawrence Lake.

Sediment buildup, especially in Inlet Bay, is a large concern among district members. Studies completed by Liesch Environmental Services in fall 2007 (Liesch 2008) documented depth of soft sediment ranging as deep as 6.2 feet in the upper portion of the bay. Average depth of soft sediment was just over 3 feet. Limited chemical analysis showed low organic content of the sediment, which means that for the most part, the sediment in the bay is not the result of incomplete decomposition of biomass, which is the case in many impoundments. In Inlet Bay where the samples were collected, the sediment is largely mineral; however, it is not the result of sediment or ‘dirt’ that originated on land in the watershed making its way to the lake; it is likely the result of dissolved minerals that are brought to the lake by Lawrence Creek. As the creek water enters the lake, its chemical characteristics change, for example the pH decreases, and as a result some of the mineral content precipitates (solidifies) and over time, builds up on the lake bottom as flocculent sediments.

Two legitimate methods exist for reducing sediments in lakes: dredging and drawdown. Dredging is the physical removal of the sediment from the lake through mechanical means. The sediments must then be properly disposed of on land. The use of drawdown can reduce sediments in two ways: transport out of the area via channelization, and through compaction and consolidation, which is the decomposition of sediment organic matter and drying of sediments that permanently compact the sediment into a reduced volume. The use of aeration and pellets is not a legitimate method for removing sediments although it is touted as such by many snake oil sales companies.

Utilizing drawdown on Lawrence Lake is currently limited to a partial drawdown due to mechanical issues with the dam’s sluice gate which prevent it from opening more than 5 inches. As described above, much of the sediment in Inlet Bay is mineral, so very little consolidation would result from decomposition of organic sediments. The Inlet Bay sediments are quite flocculent, so there would likely be high channelization in the area; however, as a part of only a partial drawdown, as opposed to a full drawdown, as discussed below, those sediments may only be displaced in an area closer to the dam, which is undesirable by district members.

A full winter drawdown or a drawdown that would extend into the summer months, would likely expose many shallow areas around the lake to aeration, leading to excellent consolidation and compaction. It would also impact many of the plants that hamper navigation on the lake. Further, a portion of the mineral sediments in Inlet Bay would likely be flushed from the lake as a result of channelization and head cutting. Realistic concerns regarding negative impacts on the lake’s excellent pan and bass fishery would need to be addressed if this action is to be considered. Drawdowns also upset other ecological aspects in a lake as well, such as a temporary increase in some woody emergent species near shorelines, movement of coarse woody debris, and dewatering of adjacent wetlands. Ultimately a public meeting would be required as a part of the permitting process where the risks and benefits of a drawdown on Lawrence Lake would be discussed in an open forum.

The Liesch report also included the cost of three dredging scenarios utilizing different disposal methods with each considering the removal of just over 21,000 cu.yd. of sediment from Inlet Bay. Of the three scenarios, the use of geotextile bags to temporarily store the dredge spoils as it dried was the most feasible. An updated estimate for the removal of 21,000 cu.yd. using current costs is slightly over $700,000.

5.0 IMPLEMENTATION PLAN

The Implementation Plan presented below was created through the collaborative efforts of the Lawrence Lake Protection & Rehabilitation District Planning Committee and ecologist/planners from Onterra. It represents the path the Lawrence Lake Protection & Rehabilitation District will follow in order to meet their lake 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 Lawrence Lake stakeholders as portrayed by the members of the Planning Committee, the returned stakeholder surveys, and numerous communications between Planning Committee members and the lake stakeholders. The Implementation Plan is a living document in that it will be under constant review and adjustment depending on the condition of the lake, the availability of funds, level of volunteer involvement, and the needs of the stakeholders.

Management Goal 1: Continue Informing District Members about Lawrence Lake, Lake Management, and District Business

Management Action:	Continue to maintain and update District Website
Timeframe:	Continued action.
Facilitator:	District Board of Commissioners
Potential Grant:	Wisconsin Surface Water Education Grant
Description:	In 2023, the LLPRD overhauled their website (https://lawrencelakeprdistrict.com/). Currently, the website includes information about the district, its mission, and district leadership. It also includes photos and recent newsletters. Current news and upcoming meetings, are highlighted and past meeting minutes are also available. The district will continue to enhance and update this website with current information, including the posting of the Lawrence Lake Comprehensive Management Plan when finalized.
Action Steps:	See description above.

Management Action:	Utilize social media and email to provide timely and relevant information to LLPRD members.
Timeframe:	2024
Facilitator:	District Board of Commissioners
Potential Grant:	Wisconsin Surface Water Education Grant
Description:	Electronic media is the quickest and most efficient method to distribute information to large groups of people desiring that information. To facilitate this, the LLPRD will continue to build their district-wide email database and create a moderated district Facebook page. Both of these

media types will be utilized to pass along timely information, such as urgent notices, direct readers to new or updated information on the district website, and announce district meetings.

It will be at the discretion of the district leadership if the Facebook page will be an opened or closed group, who will be allowed to post, and if an Instagram account will also be created and linked to the page.

Action Steps: See description above.

Management Action: Continue to publish electronic newsletter, *Larry Lake Newsletter*.

Timeframe: Continued action.

Facilitator: District Board of Commissioners

Description: In 2021, the LLPRD began distributing an electronic newsletter via email. To date, the district has published three *Larry Lake Newsletters* to its membership; each with general district information, interesting stories about Lawrence Lake and the Lawrence Lake area, and meeting announcements/reports. The district will work to continue publishing the newsletter via email and the district's website. Articles will be solicited from district membership, local officials, WDNR staff, local outdoor sports clubs, and local businesses. The UW-Extension Lakes Program also has many informative articles that can be published with proper citation (https://www3.uwsp.edu/cnr-ap/UWEXLakes/Pages/resources/newsletter/default.aspx).

Example Educational Topics:

- Nitrates in groundwater
- Water quality monitoring updates
- Dam operation and maintenance
- Boating safety and ordinances
- Catch and release fishing
- Littering (particularly on ice)
- Noise, air, and light pollution
- Shoreland restoration and protection
- Septic system maintenance
- Fishing Rules
- Specific topics brought forth in other management actions

Action Steps:

1. Recruit district member as newsletter editor.
2. Determine realistic publication frequency, such as quarterly.
3. Create format and list of reoccurring articles (e.g. *From Chairperson*, *District Calendar*, *Lawrence Lake Ecology*, *Updates from Marquette County Lakes Association*, etc.)
4. Build a small reserve of articles before publishing.
5. Build subscribership.

<u>Management Action:</u>	Participate in annual Wisconsin Lakes & Rivers Convention.
Timeframe:	Annually
Facilitator:	District Board of Commissioners
Description:	Wisconsin is unique in that there is a long-standing partnership between a governmental body, a citizen-based lake lobbying and protection association, and the state's primary educational outreach program. That unique group is the Wisconsin Lakes Partnership and its three members, the Wisconsin Dept. of Natural Resources, Wisconsin Lakes, and the UW-Extension Lakes Program, facilitate many lake-related events within the state. The primary event is the Wisconsin Lakes & Rivers Convention held each spring in Stevens Point. This is the largest citizen-based lakes conference in the nation and is specifically suited to the needs of lake associations and districts. It is an exceptional opportunity for lake group members to learn about lake management and monitoring; network with other lake groups, agency staff, and lake management contractors; and learn how to effectively operate a lake association/district. The LLPRD will sponsor the attendance of 3-5 district members annually at the convention. Following the attendance of the convention, the members will report specifics to the board of commissioners regarding topics that may be applicable to the management of Lawrence Lake and operations of the district. The attendees will also create a summary in the form of a newsletter article and if appropriate, update the district membership at the annual meeting. Information about the convention can be found at: https://wisconsinwaterweek.org/.
Action Steps:	See description above.

Management Goal 2: Maintain Navigation and Other Recreational Opportunities on Lawrence Lake

Management Action: Utilize herbicide applications responsibly to maintain navigation lanes and fishing access areas on Lawrence Lake.

Timeframe: 2024

Facilitator: District Board of Commissioners

Description: Several areas in Lawrence Lake support nuisance levels of aquatic plants that hamper watercraft navigation, passive water sports, and angling. Data collected during 2022 indicate that these areas are not dominated by exotic plant species, but rather native species, such as muskgrasses, northern watermilfoil, Fries' pondweed, coontail, and common waterweed. Herbicide treatments have been used on Lawrence Lake regularly since 2008 (Table 3.4-3). Early-on, the treatments were aimed at controlling Eurasian watermilfoil and to a lesser extent, curly-leaf pondweed. Around 2017, the focus of the treatments were less on exotic control and more on providing navigational access.

The studies completed as a part of this project documented that Lawrence Lake does not have an AIS problem, but instead, a nuisance native issue in some areas. Navigation lane treatments completed in the past several years with flumioxazin have proven to be effective at providing access to open water areas by riparians and those accessing the lake via its north public access.

During the second planning meeting, mechanical harvesting was discussed at length, including potential costs and logistics. The level of control needed in Lawrence Lake is relatively small in acreage and is not needed each year in all areas; therefore, mechanical harvesting is not feasible at this time. This is the case because contract harvesters not only charge a per-acre or per-hour fee, but they also include a mobilization fee and often a cancelation fee. In the end, the overall cost, and the understanding that some areas would not need attention every year, made mechanical harvesting an unrealistic option at this time.

Winter water level drawdown was also considered during the second planning meeting; however, unsurety of the current dam function according to the dam tender (see last action in this goal) and long-term impact on the plants that need control, led to the conclusion that for plant control, a drawdown was not appropriate at this time. Further, a partial drawdown was considered; however, there is legitimate concern that this action would only displace sediment from Inlet Bay to an area closer to the dam instead of removing it from the lake.

When the Lawrence Lake aquatic plant management plan is updated, both mechanical harvesting and winter drawdown will be reassessed based upon the aquatic plant data collected at that time. If the plant population changes and herbicide use for navigation lane maintenance is no longer feasible, both techniques will be seriously reconsidered.

Map 12 displays the 15-foot-wide navigation lanes the district will consider to maintain with herbicide applications beginning in 2024. The total area is approximately 3.8 acres, and the lanes are placed to provide access to open water by riparian property owners and users of the lake's two public boat landings. Each year the LLPRD will assess these areas to determine if treatment is needed. Currently, the plan anticipates a single treatment, likely with flumioxazin, during late-June or early-July. The district will consult each year with the contracted applicator regarding timing and herbicide selection. The applicator will be responsible for obtaining the proper permit from the WDNR.

Action Steps: See description above.

Management Action: Consider providing educational information of mechanical dredging to impacted district members and educational information on a lake drawdown to the district membership.

Timeframe: 2024/2025

Facilitator: District Board of Commissioners

Potential Grant: Wisconsin Surface Water Planning Grant

Description: Much of Inlet Bay is under a foot deep and/or contains high density of aquatic plants. Much of the bay is unnavigable due to these conditions. In 2008, the LLPRD contracted with Liesch Engineering to complete a simple sediment depth study and scope estimated costs for removal of sediments from the bay via several methods. One of the methods discussed in the report was the use of hydraulic dredging to several geotextile tubes at a large to be determined storage site next to the lake. Once the sediment within the tubes is dewatered, the sediments would be land spread. The estimated cost to remove 21,441 cubic yards of sediment via hydraulic dredging, dewatering in geotextile tubes, land spreading the spoils, and restoring the dewatering site was approximately $595,560. Updating only the hydraulic dredging costs from the 2008 estimate of $10/cu.ft. to the current cost of $15-$20/cu.ft. increased the cost between $702,765 and $809,970.

The board will identify what individual property owners or groups of property owners may do related to dredging in front of their property(ies). The LLPRD will provide any references or contacts related dredging that it becomes aware of during the course of its operation, attendance at conferences or from discussions with governmental bodies (e.g., WDNR).

The above information will be communicated via Lake District Board meetings and/or the website as deemed appropriate.

During the second planning meeting, the possibility of removing sediments from Inlet Bay via a temporary drawdown was discussed. Two methods were presented to the committee, a partial drawdown of the lake to expose the Inlet Bay to channelization and consolidation, and a larger water level reduction, during the winter, to expose much of the lake's shallow areas to consolidation and a longer length of the original stream channel to channelization. Both options brought about much concern for the lake's fishery, the impact, or lack thereof, on aquatic plants, and impacts to downstream water bodies due to sediment transport from the lake. There was also much concern that a drawdown would only move sediments from Inlet Bay to other parts of the lake. As of Fall 2023, the Lawrence Lake dam tender has confirmed that the sluice gate can only be raised approximately five inches before the mechanism freezes. Therefore, in its current state, the Lawrence dam would only allow an approximate 3-foot drawdown to be implemented. As stated above, this would likely only displace sediments from the Inlet Bay to an area closer to the dam, which is not a desirable outcome of a drawdown.

Action Steps: See description above.

Management Action: Determine if the Lawrence Dam is fully operational.

Timeframe: 2024

Facilitator: District Board of Commissioners

Description: During the planning process, it was disclosed that the sluice gate on the Lawrence Dam may not be fully functional and able to be completely opened. Further, there is concern that potential obstructions exist near the sluice gate that may prevent the gate from being closed once it is opened. The mission of the LLPRD is written as: "It is the Mission of the Lawrence Lake Protection and Rehabilitation District to ensure the safety and soundness of the Lawrence Lake dam while maintaining and enhancing the quality of Lawrence Lake and to act as an advocate for the interests of all District Members." In order to fulfill its mission, the LLPRD will have the sluice gate inspected, including the potential upstream obstructions. These investigations would be completed with the assistance of professional dam engineers.

Action Steps: See description above.

Management Goal 3: Maintain Consistent Environmental Database for Lawrence Lake

Management Action: Monitor water quality through WDNR Citizens Lake Monitoring Network.

Timeframe: 2024

Facilitator: District Board of Commissioners

Potential Grant: N/A

Description: Monitoring water quality is an important aspect of every lake management planning activity. Collection of water quality data at regular intervals aids in the management of the lake by building a database that can be used for long-term trend analysis. The lack of this type of historical information hampered the water quality analysis and watershed modeling during this project. Early discovery of negative trends may lead to the reason as to why the trend is developing. Stability will be added to the program by selecting an individual from the district to coordinate the district's volunteer efforts and to recruit additional volunteers to keep the program fresh.

Mike Helminski, who collected Secchi disk transparencies on Lawrence Lake from 1995 to 2010, has reenlisted his services with the WDNR Citizen Lake Monitoring Network (CLMN) to collect transparency data again. Mike has also added the lake to the CLMN Advanced Water Quality Program, in which a volunteer collects water quality samples for processing by the Wisconsin State Laboratory of Hygiene (WSLH) once during the spring and three times during the summer months (June, July, and August). A distinct advantage of processing the samples through the WSLH is that the results are automatically loaded into the Surface Water Integrated Management System (SWIMS), the WDNR statewide database.

Currently, the WDNR is allowing lake groups to participate in the Advanced Water Quality Program for three years out of every ten years. During the years that the district cannot participate in the WDNR-funded program, the district can continue to collect water quality samples for analysis by the WSLH, by utilizing the LLPRD account number (357218) obtained as a part of this program. The samples would be shipped to the WSLH (2601 Agriculture Dr, Madison, WI 53718) with a completed Inorganic Test Form (4800-024), listing Lawrence Lakes WBIC of 167000, and Station ID of 393125.

Action Steps: See description above.

Management Action:	Conduct periodic quantitative vegetation monitoring on Lawrence Lake.
Timeframe:	Point-Intercept Survey every 5 years, Community Mapping every 10 years, AIS surveys as deemed necessary by LLPRD.
Facilitator:	District Board of Commissioners
Potential Grant:	Wisconsin Surface Water Planning Grant
Description:	As part of the ongoing AIS monitoring and vegetation management program, a whole-lake point-intercept survey will be conducted at a minimum once every 5 years. This will allow a continued understanding of the submergent aquatic plant community dynamics within Lawrence Lake and allow for periodic, lakewide surveillance of the lake for new and existing AIS. The last point-intercept survey was conducted on Lawrence Lake in 2022 as a part of this management planning project, therefore, the next anticipated point-intercept survey on the lake would be in 2027. In order to understand the dynamics of the emergent and floating-leaf aquatic plant community in Lawrence Lake, a community mapping survey would be conducted approximately every 10 years. A community mapping survey was conducted on the Lake in 2022 as a part of this management planning effort. The next community mapping survey will be completed in 2032 to coincide with the point-intercept survey that would potentially occur 5 years after the 2027 point-intercept survey discussed above. Note that the community mapping survey should be done during the same summer as a point-intercept survey, so the schedule of point-intercept surveys, as laid out above, would be the determinant of the community mapping survey. AIS surveys, including early-season surveys to primarily monitor curly-leaf pondweed, and late season surveys to monitoring Eurasian water milfoil, would be completed at the district's discretion; however, every five years, corresponding with the point-intercept surveys, would be of great benefit in updating the district's aquatic plant management plan.
Action Steps:	See description above.

Management Goal 4: Protect and Maintain Lawrence Lake Fishery

Management Action: Maintain open line of communication with Wisconsin Department of Natural Resources fisheries staff.

Timeframe: Continuation of current effort.

Facilitator: District Board of Commissioners

Description: Open water fishing was the top reason why stakeholder survey respondents owned property on or near Lawrence Lake. Developing a consistent line of communication with the local WDNR fisheries biologist (currently Scott Bunde (scott.bunde@wisconsin.gov), ensures that Lawrence Lake stakeholders will have access to the best and most current information regarding the lake's fishery and its management.

To foster this relationship, a current commissioner(s), or district member(s) under the direction of the board of commissioners, will contact Mr. Bunde via email to set up an introductory phone call or face-to-face meeting. By setting up the introductory meeting via email, Mr. Bunde will have time to compile information and prepare some initial thoughts, which lead to a more productive meeting. During that meeting, the district representative should ask if the fisheries biologist has a preferred communication method and schedule. A brief summary of the other actions under this goal should also be provided by the district representative during this meeting to alert the biologist about potential support needs.

Action Steps: See description above.

Management Action: Enhance Lawrence Lake fishery through proper stocking and coarse woody habitat additions.

Timeframe: Initiate 2024

Facilitator: District Board of Commissioners

Description: Lawrence Lake is a moderately productive system with excellent capacity and habitat diversity to produce a high-quality fishery. With this, an opportunity for education and habitat enhancement is present in order to help the ecosystem reach its maximum fishery potential. Many anglers assume that a lake's fishery can be 'forced' to its potential through stocking efforts. This is not the case in any lake as habitat availability, existing fish populations, level and make up of forage fish populations, and of course angler pressure, are critical to reaching and maintaining fishery potential. A primary objective of this action is to initiate frequent and productive communications with WDNR fisheries personnel to; 1) provide information regarding Lawrence Lake's fishery potential to district members, 2) assure that the district is doing what it can to aid local fisheries staff in performing their duties, and 3) that the WDNR staff understands the goals and concerns of the district regarding Lawrence Lake's fishery. Ultimately, this will lead to a productive and effective stocking program on Lawrence Lake.

Often, property owners will remove downed trees, stumps, etc. from a shoreland area because these items may impede watercraft navigation shore-fishing or swimming. Or, which is the case regarding some of Lawrence Lake's shoreline, prior to the lake being created, the area was a wetland that did not support large tree growth, so there is little natural CWH. However, these naturally occurring woody pieces serve as crucial habitat for a variety of aquatic organisms, particularly fish. The Shoreland Condition Section (3.3) and Fisheries Data Integration Section (3.6) discuss the benefits of coarse woody habitat in detail.

The WDNR's Healthy Lakes Initiative Grant allows partial cost coverage for coarse woody habitat improvements (referred to as "fish sticks"). This reimbursable grant program is intended for relatively straightforward and simple projects. More advanced projects that require advanced engineering design may seek alternative funding opportunities, potentially through the county.

- 75% state share grant with maximum award of $25,000; up to 10% state share for technical assistance
- Maximum of $1,000 per cluster of 3-5 trees (best practice cap)
- Implemented according to approved technical requirements (WDNR Fisheries Biologist) and complies with local shoreland zoning ordinances
- Buffer area (350 ft^2) at base of coarse woody habitat cluster must comply with local shoreland zoning or:
    - The landowner would need to commit to leaving the area un-mowed
    - The landowner would need to implement a native planting (also cost share through this grant program available)
- Coarse woody habitat improvement projects require a general permit from the WDNR
- Landowner must sign Conservation Commitment pledge to leave project in place and provide continued maintenance for 10 years

Action Steps:

1. Recruit facilitator from Planning Committee or Board of Commissioners to direct this initiative.
2. Facilitator contacts WDNR lakes coordinator and WDNR fisheries biologist to gather information on current stocking efforts, future stocking efforts and regarding initiating and conducting coarse woody habitat projects on Lawrence Lake.
3. The district will encourage property owners that have enhanced coarse woody habitat to serve as demonstration sites for future projects.
4. The district promotes a better understanding of the lake's fishery and its capacity via educational topics included in electronic and hardcopy communications with district members.

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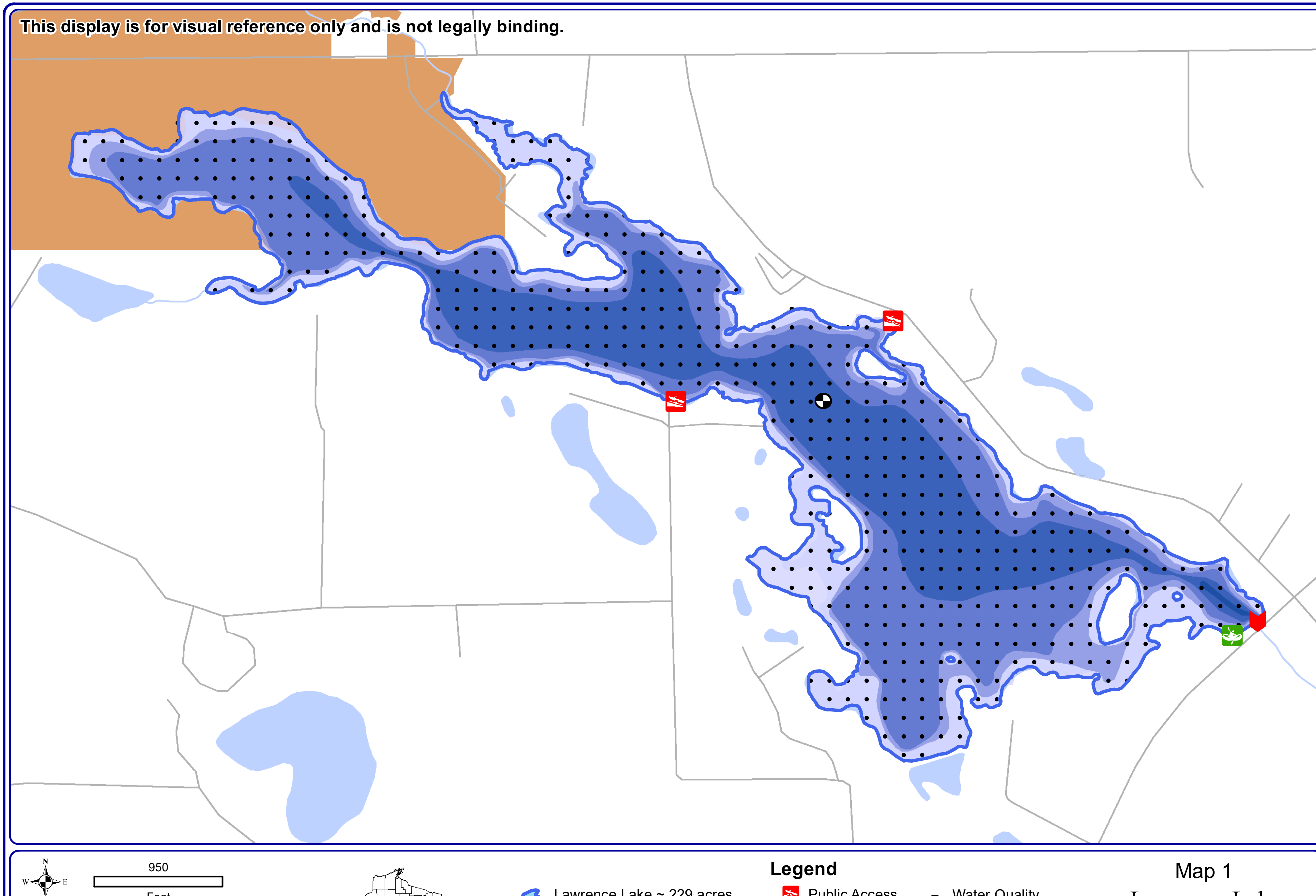

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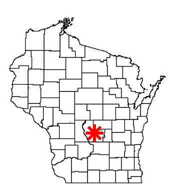
Lake Management Planning
815 Prosper Road
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

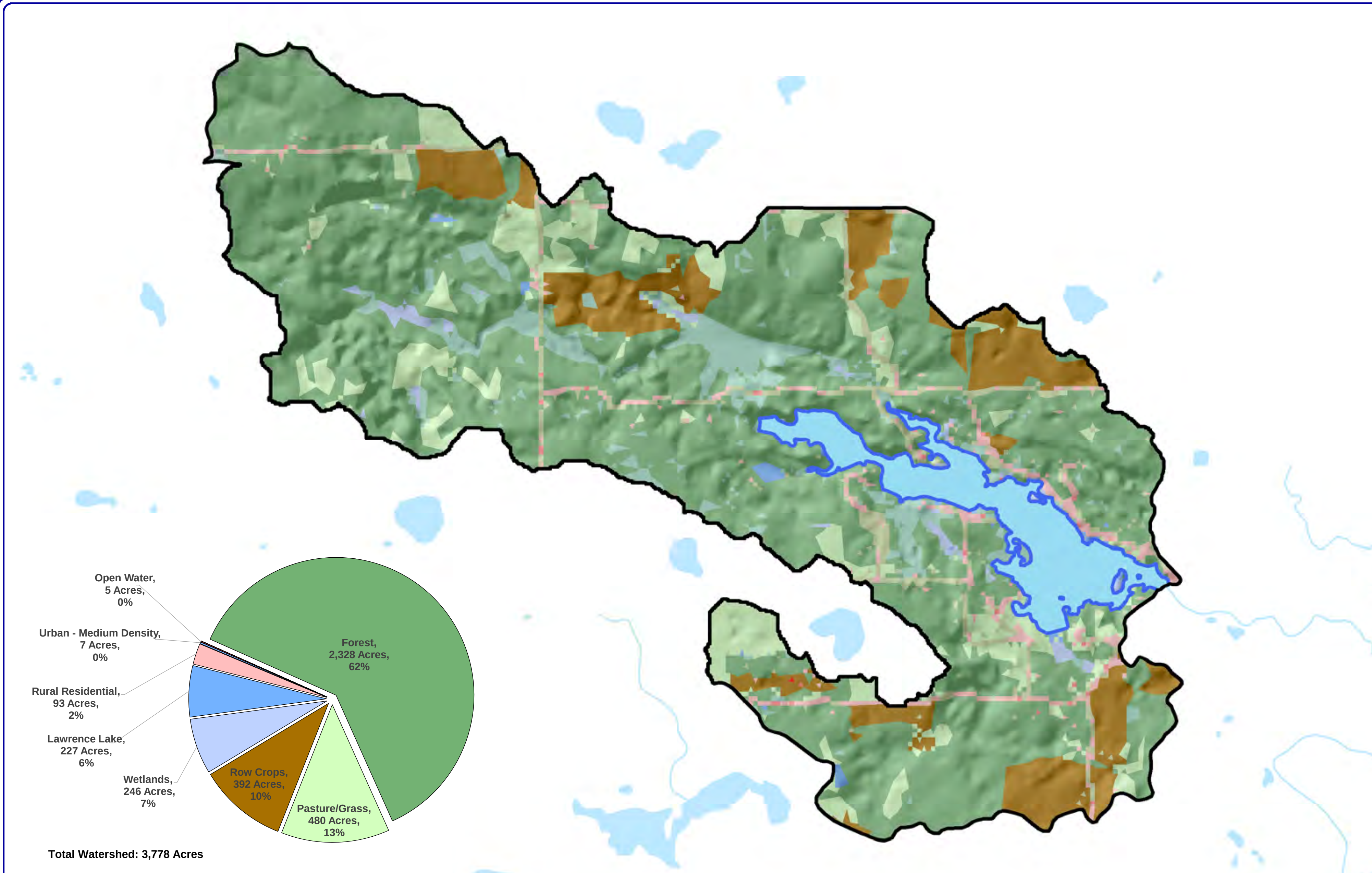
Sources:
Roads and Hydro: WDNR
Bathymetry: Onterra, 2022
Public Lands: WDNR
Map Date: March 2nd, 2023 KLW
Filename: Map1_Lawrence_Location_2022.mxd


Project Location in Wisconsin

Legend

- Lawrence Lake ~ 229 acres *Onterra Definition*
- Lawrence Lake Creek State Fish and Wildlife Area
- Point-intercept Sample Location *42-meter spacing points*
- Public Access
- Carry - In
- Dam
- Water Quality Sampling Location

Map 1
Lawrence Lake
Marquette County, Wisconsin
Project Location & Lake Boundaries



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Feet

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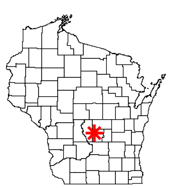
Sources:
Hydro: WDNR
Bathymetry: WDNR/Onterra
Land Cover: NLCD, 2019
Watershed Boundaries: Onterra, 2023
Map Date: March 12th, 2024 KLW

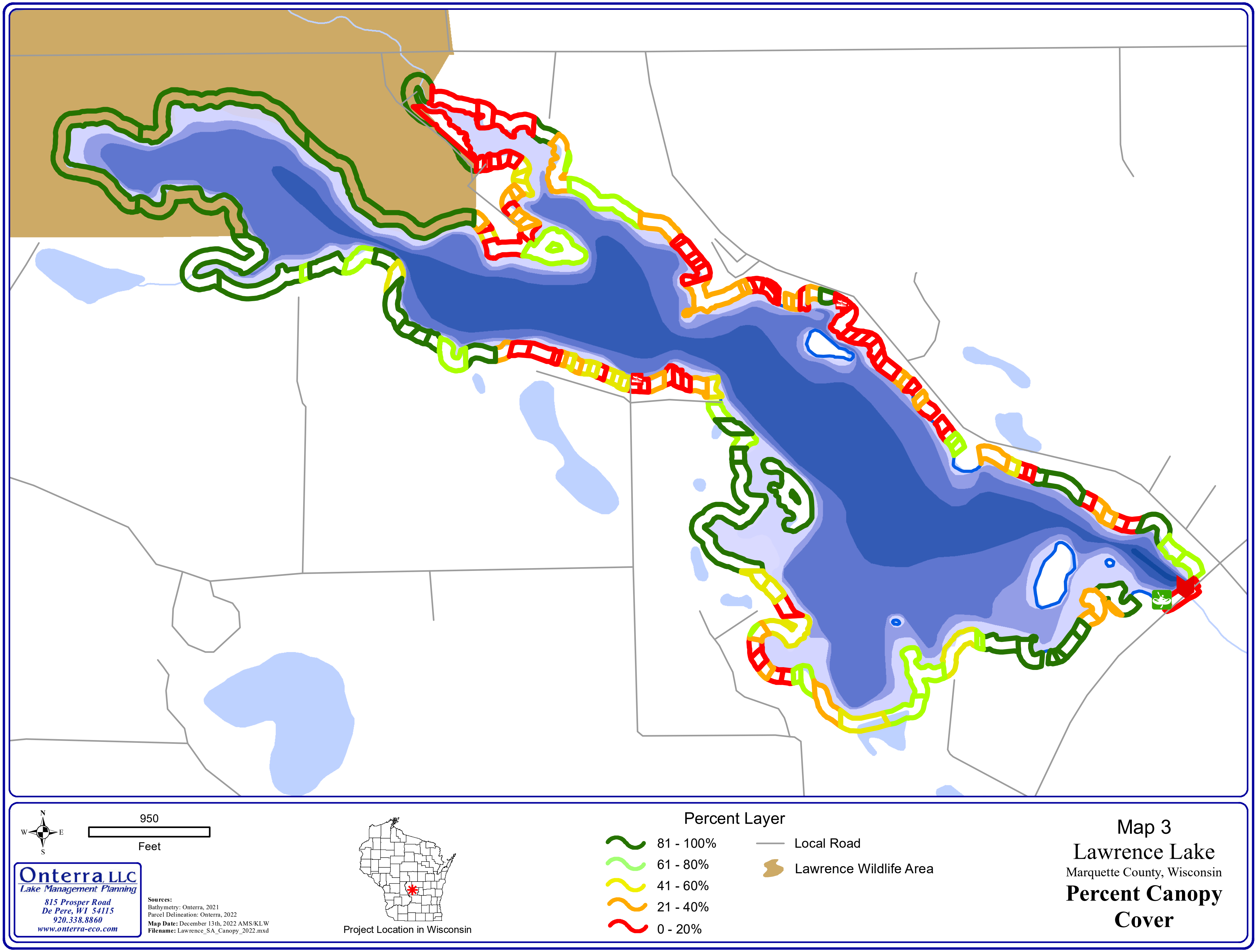


Project Location in Wisconsin

Legend

- Forest
- Forested Wetlands
- Pasture/Grass
- Open Water
- Wetland
- Row Crop Agriculture
- Rural Open Space
- Rural Residential
- Urban - High Density
- Urban - Medium Density
- Lawrence Lake Watershed Boundary

Map 2
Lawrence Lake
Marquette County, Wisconsin
Watershed Boundaries & Land Cover Types



N
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950
Feet
Onterra, LLC
Lake Management Planning
815 Prosper Road
De Pere, WI 54115
920.338.8860
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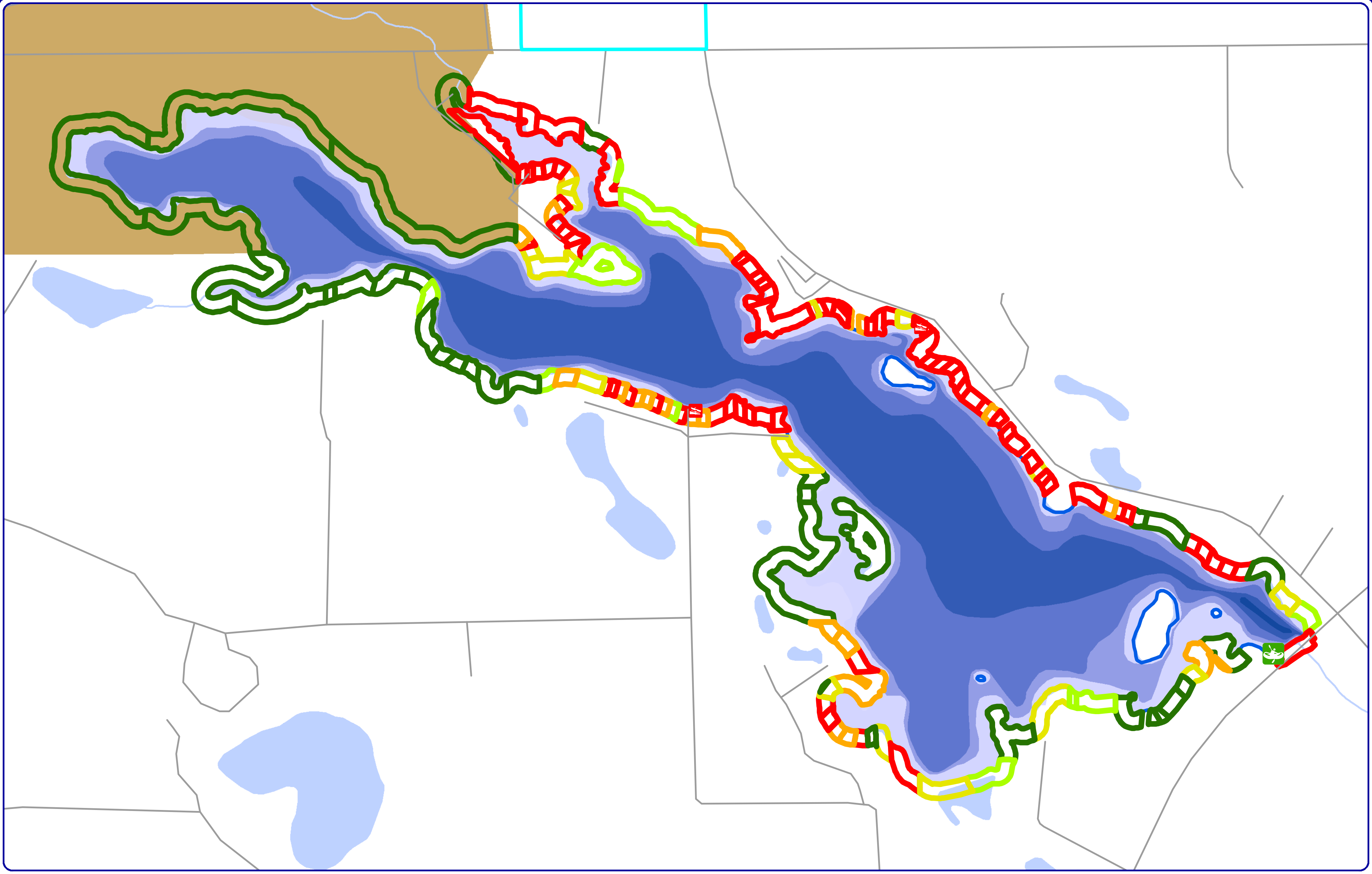
Sources:
Bathymetry: Onterra, 2021
Parcel Delineation: Onterra, 2022
Map Date: December 13th, 2022 AMS/KLW
Filename: Lawrence_SA_Canopy_2022.mxd
Project Location in Wisconsin
Percent Layer
81 - 100%
61 - 80%
41 - 60%
21 - 40%
0 - 20%
Local Road
Lawrence Wildlife Area
Map 3
Lawrence Lake
Marquette County, Wisconsin
Percent Canopy Cover



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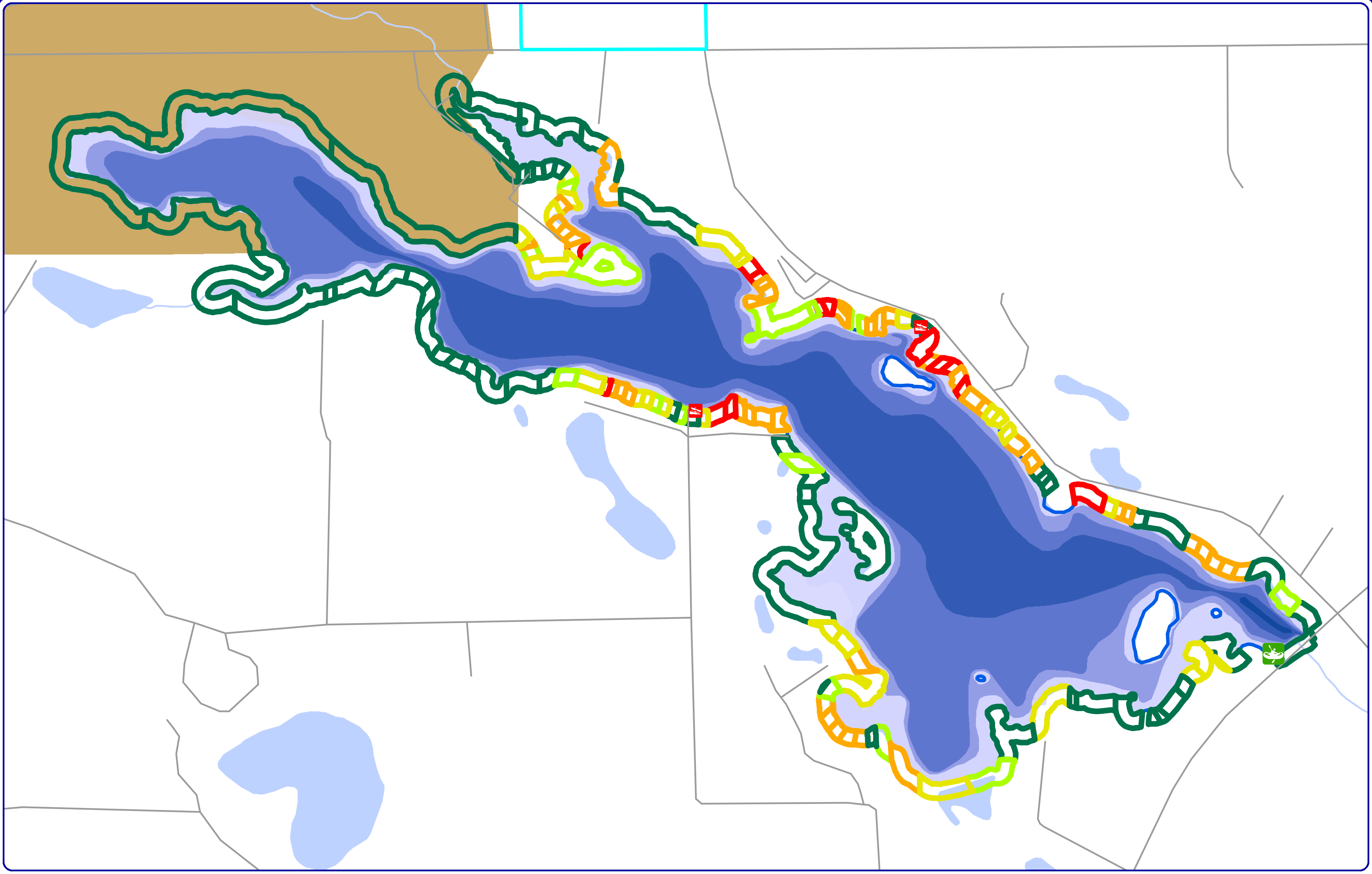
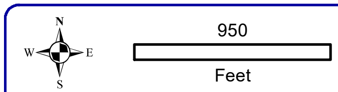
Sources:
Bathymetry: Onterra, 2021
Parcel Delineation: Onterra 2022
Map Date: December 13th, 2022 AMS/KLW
Filename: Lawrence_SA_Canopy.mxd

Map 4
Lawrence Lake
Marquette County, Wisconsin
Percent Shrub Herbaceous Cover





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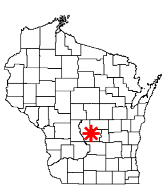
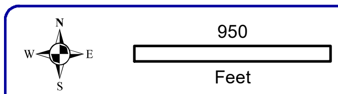
Sources:
Bathymetry: Onterra, 2021
Parcel Delineation: Onterra 2022
Map Date: December 13th, 2022 AMS/KLW
Filename: Lawrence_SA_Canopy.mxd


Project Location in Wisconsin

Percent Layer
- 81 - 100%
- 61 - 80%
- 41 - 60%
- 21 - 40%
- 0 - 20%
- Local Road
- Lawrence Wildlife Area

Map 5
Lawrence Lake
Marquette County, Wisconsin
Percent Lawn Cover



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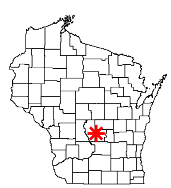
Sources:
Bathymetry: Onterra, 2021
Parcel Delineation: Onterra 2022
Map Date: December 13th, 2022 AMS/KLW
Filename: Lawrence_SA_Canopy.mxd



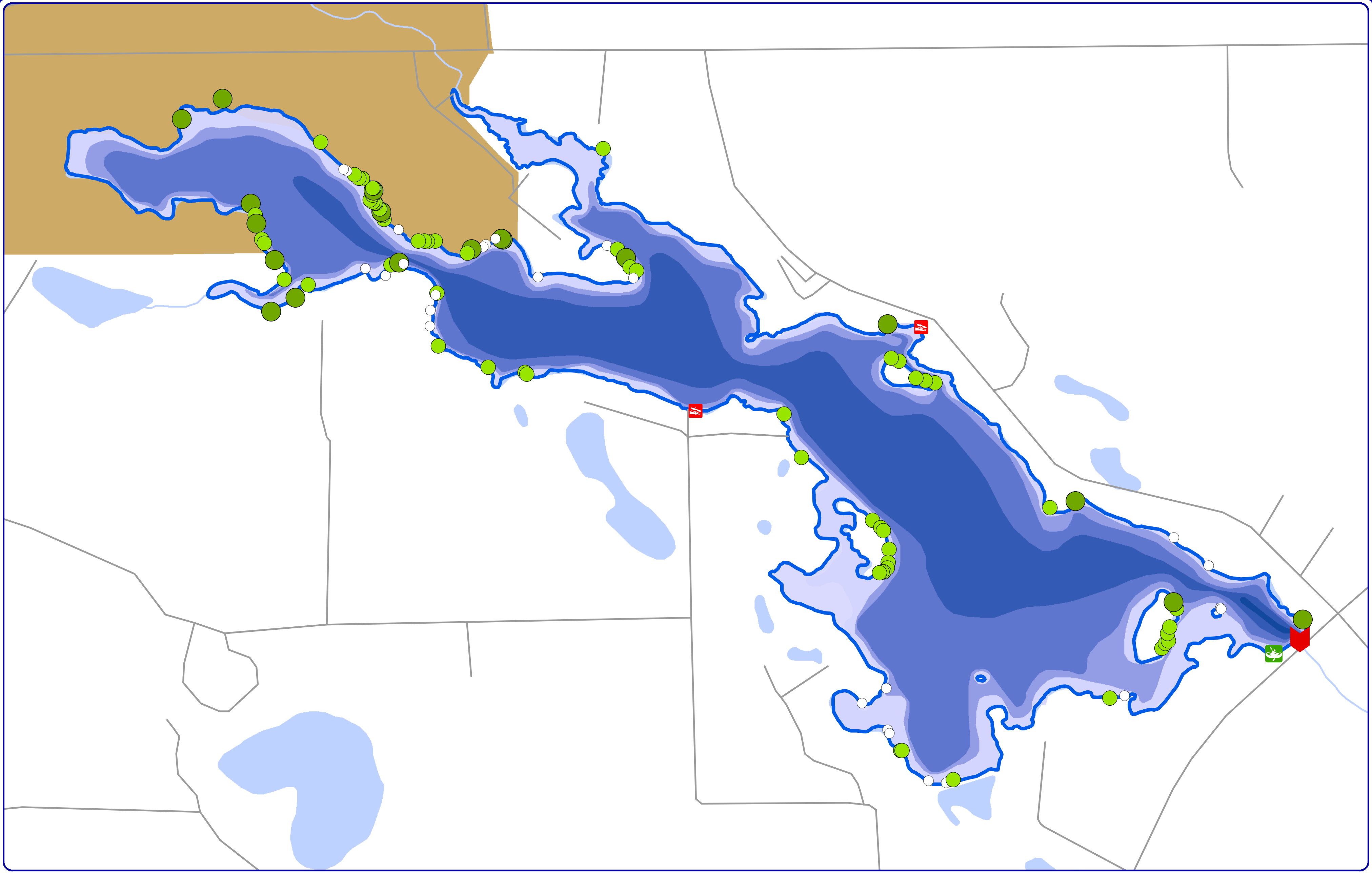
Project Location in Wisconsin

Percent Layer

- 81 - 100%
- 61 - 80%
- 41 - 60%
- 21 - 40%
- 0 - 20%
- Local Road
- Lawrence Wildlife Area

Map 6
Lawrence Lake
Marquette County, Wisconsin

Percent Impervious Surface Cover



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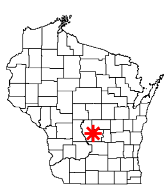
Feet



Project Location in Wisconsin

Legend

- No Branches
- Some Branches
- Full Canopy
- Local Road
- Lawrence Wildlife Area

Map 7

Lawrence Lake

Marquette County, Wisconsin

Coarse Woody Habitat Cover

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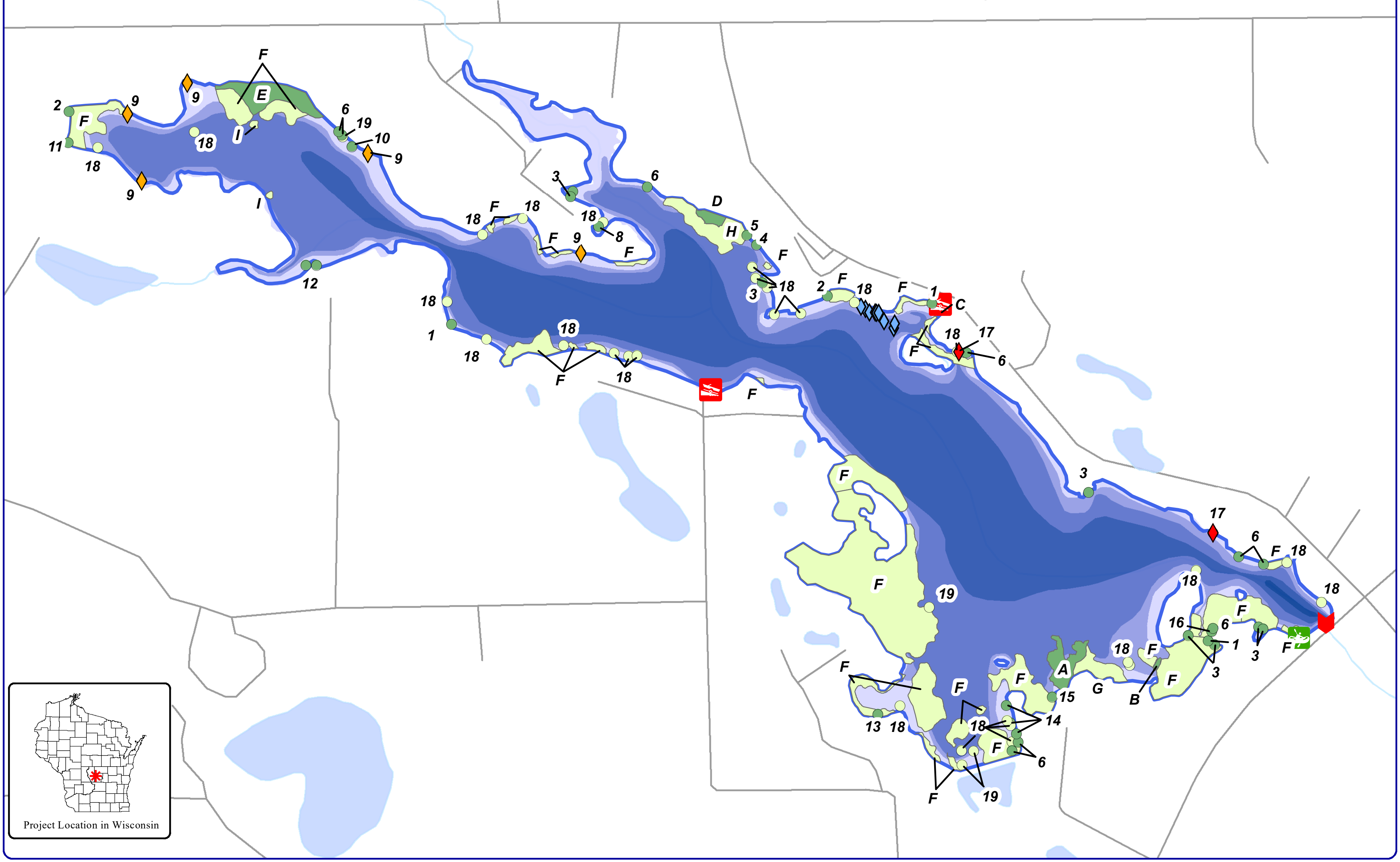
Sources:
Bathymetry: Onterra, 2021
Parcel Delineation: Onterra, 2022
Map Date: December 14th, 2022 KLW
Filename: Lawrence_CWH_2022.mxd

Note: 2022 species within lettered and numbered communities can be found in the table on the subsequent page



350
Feet

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

Sources
Hydro: WDNR
Aquatic Plants: Onterra, 2022
Orthophotography: NAIP, 2020
Map date: November 28th, 2022 KLW
Filename: Lawrence_Comm_2022.mxd

Legend

Exotic Plant Communities
- Watercress
- Silvergrass

Small Plant Communities
- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent
- Northern blue flag Iris

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

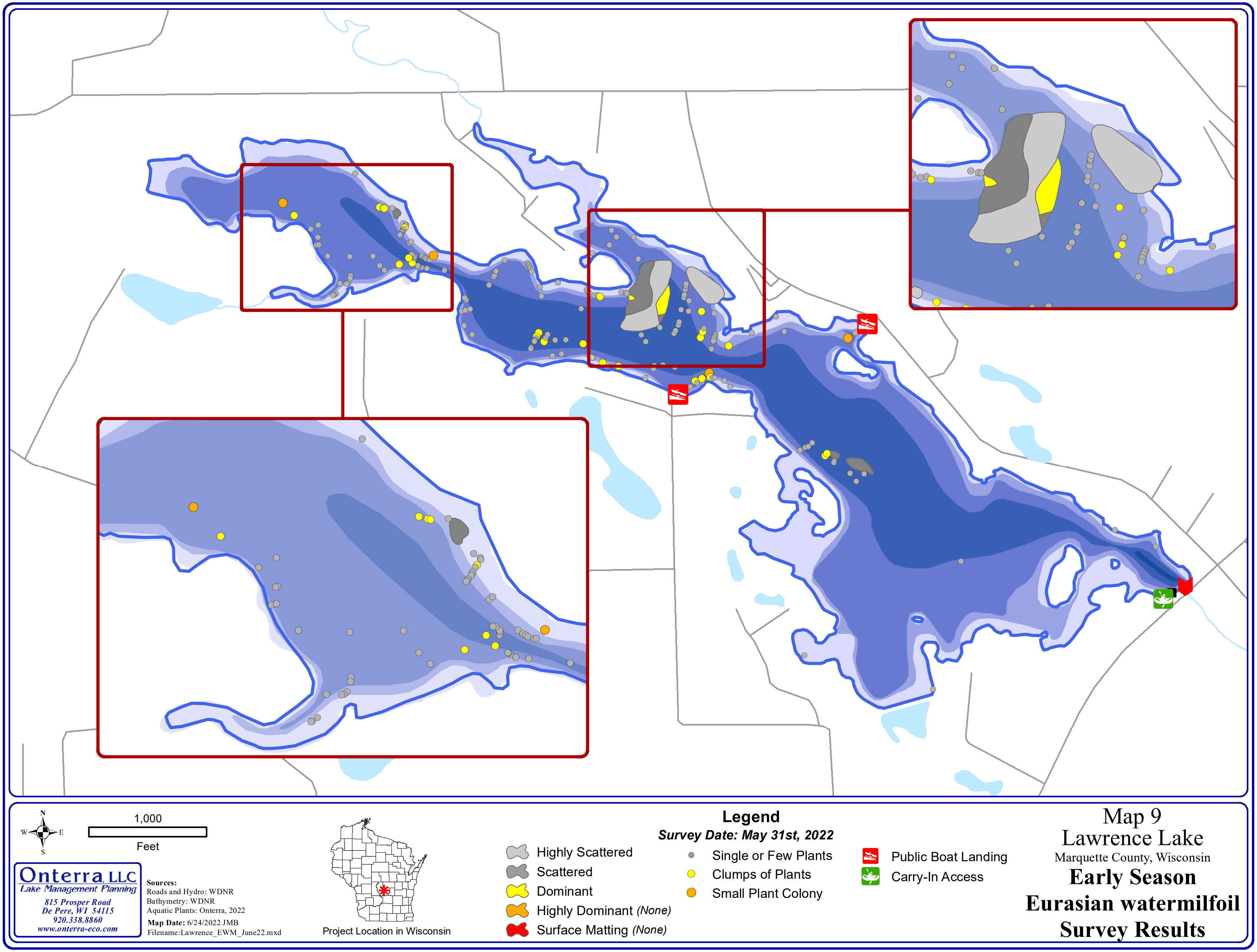
Map 8
Lawrence Lake
Marquette County, Wisconsin
Aquatic Plant Communities

Lawrence Lake 2022 Emergent & Floating-Leaf Plant Species

Corresponding Community Polygons and Points are displayed on Lawrence Lake - Map 8

Large Plant Community (Polygons)									
Emergent	**Species 1**	**Species 2**	**Species 3**	**Species 4**	**Species 5**	**Species 6**	**Species 7**	**Species 8**	**Acres**
A	Hardstem bulrush				White water lily				1.23
B	Hardstem bulrush								0.06
C	Broad-leaved cattail	Bald spikerush							0.01
D	Cattail sp.	Misc. Wetland Species			Softstem bulrush				0.31
E	Broad-leaved cattail								1.91
Floating-leaf	**Species 1**	**Species 2**	**Species 3**	**Species 4**	**Species 5**	**Species 6**	**Species 7**	**Species 8**	**Acres**
F	White water lily								31.44
G	White water lily	Floating-leaf pondweed							0.86
H	White water lily				Spatterdock				1.78
I	Spatterdock								0.11

Small Plant Community (Points)								
Emergent	**Species 1**	**Species 2**	**Species 3**	**Species 4**	**Species 5**	**Species 6**	**Species 7**	**Species 8**
1	Cattail sp.							
2	Cattail sp.	Misc. Wetland Species						
3	Broad-leaved cattail							
4	Soft rush							
5	Softstem bulrush	Cattail sp.						
6	Softstem bulrush							
7	Spikerush sp.							
8	Watercress							
9	White water lily							
10	Small spikerush							
11	Common arrowhead							
12	Common arrowhead	Softstem bulrush						
13	Bristly sedge							
14	Bristly sedge	Bald spikerush						
15	Bristly sedge	Wool-grass						
16	Amur silver grass							
Floating-leaf	**Species 1**	**Species 2**	**Species 3**	**Species 4**	**Species 5**	**Species 6**	**Species 7**	**Species 8**
17	White water lily							
18	Water smartweed							
19	Spatterdock							



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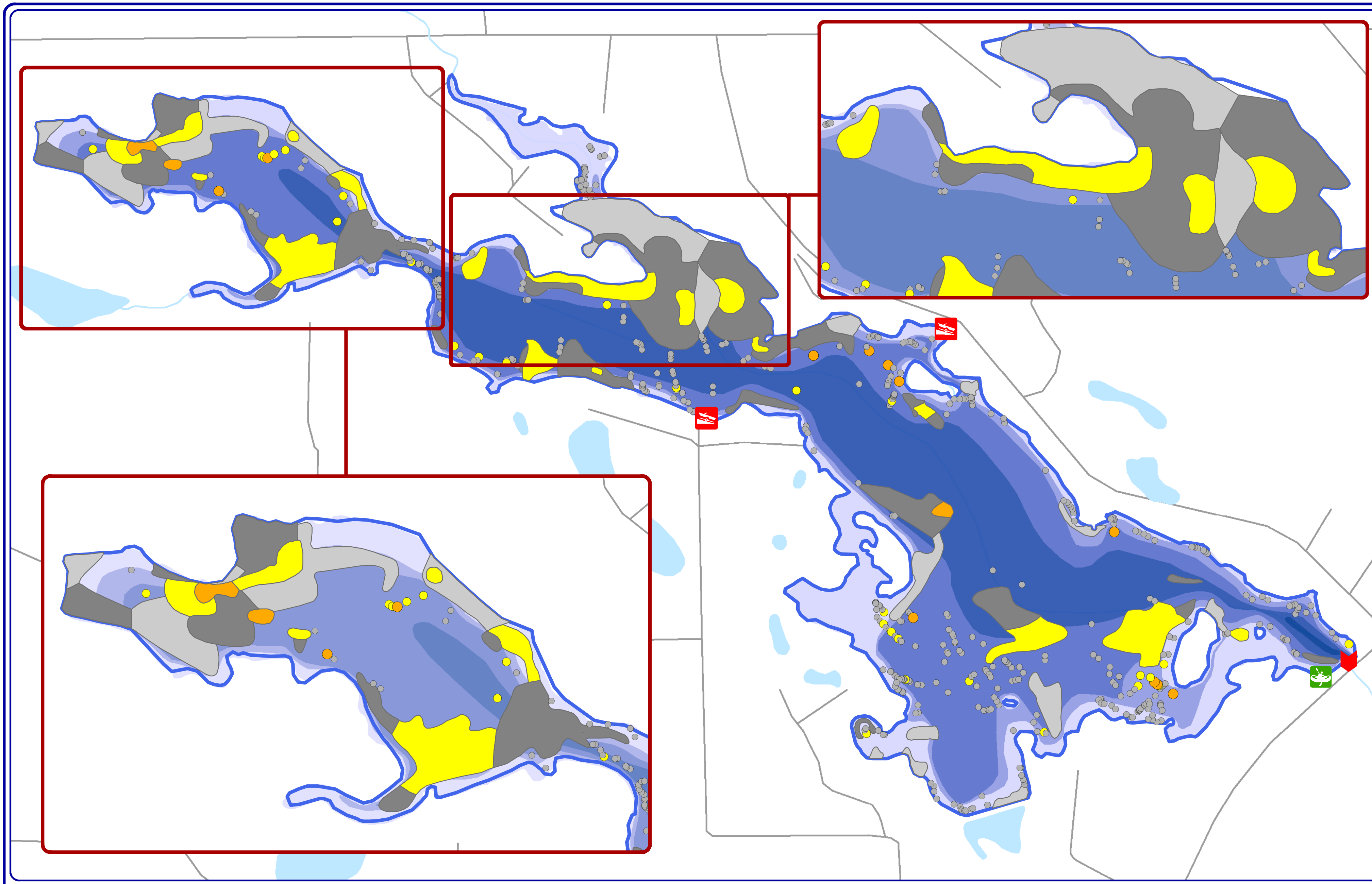
Sources:
Roads and Hydro: WDNR
Bathymetry: WDNR
Aquatic Plants: Onterra, 2022
Map Date: 6/24/2022 JMB
Filename:Lawrence_EWM_June22.mxd
Project Location in Wisconsin
Legend
Survey Date: May 31st, 2022
Highly Scattered
Scattered
Dominant
Highly Dominant (None)
Surface Matting (None)
Single or Few Plants
Clumps of Plants
Small Plant Colony
Public Boat Landing
Carry-In Access
Map 9
Lawrence Lake
Marquette County, Wisconsin
Early Season
Eurasian watermilfoil
Survey Results



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Sources:
Roads and Hydro: WDNR
Bathymetry: WDNR
Aquatic Plants: Onterra, 2022
Map Date: 10/20/2022 JMB
Filename:Lawrence_EWMPB_2022.mxd

Project Location in Wisconsin

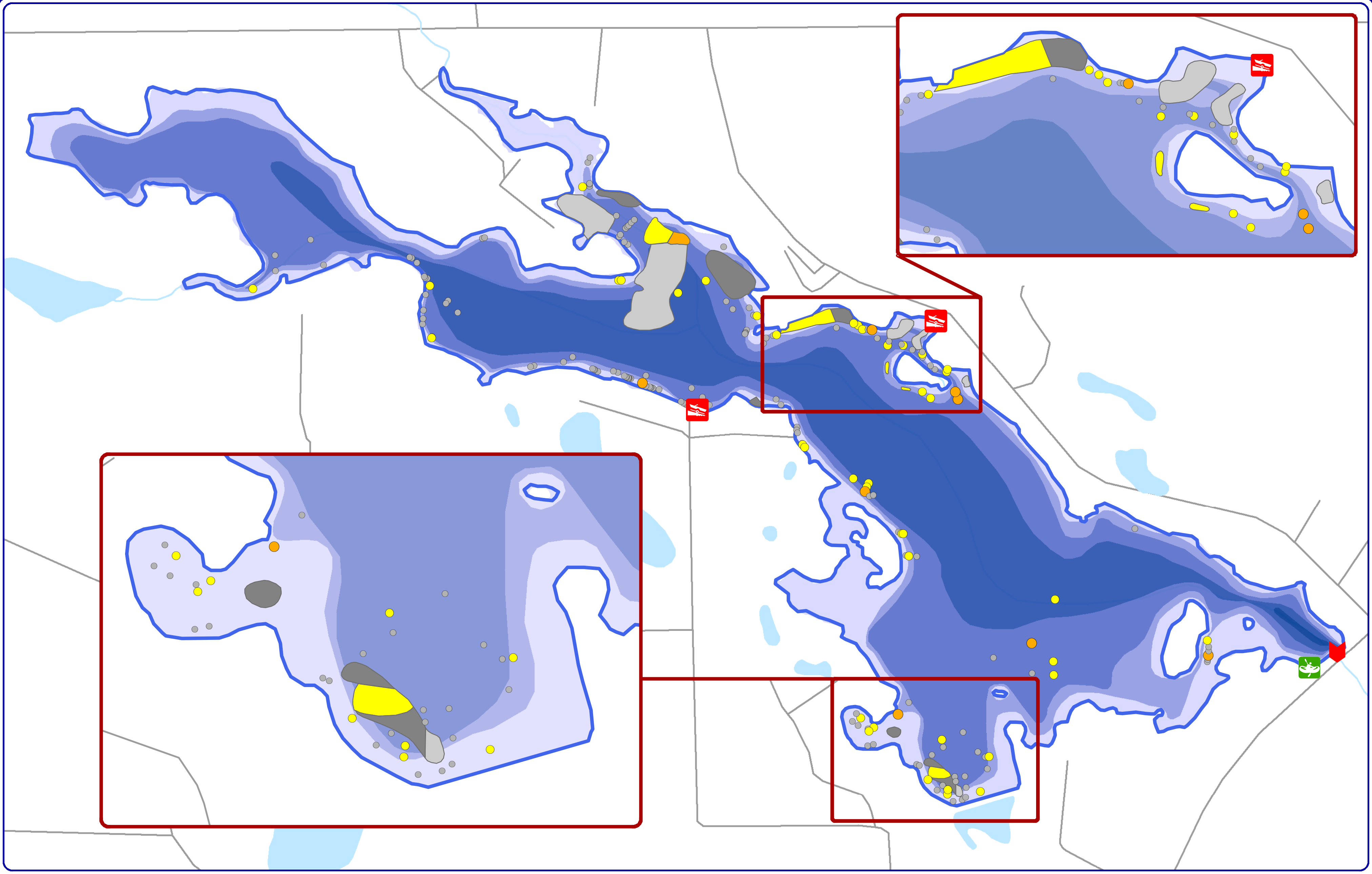
Legend

Survey Date: October 6th, 2022

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting *(None)*
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony
- Public Boat Landing
- Carry-In Access

Map 10
Lawrence Lake
Marquette County, Wisconsin

Late Season Eurasian watermilfoil Survey Results



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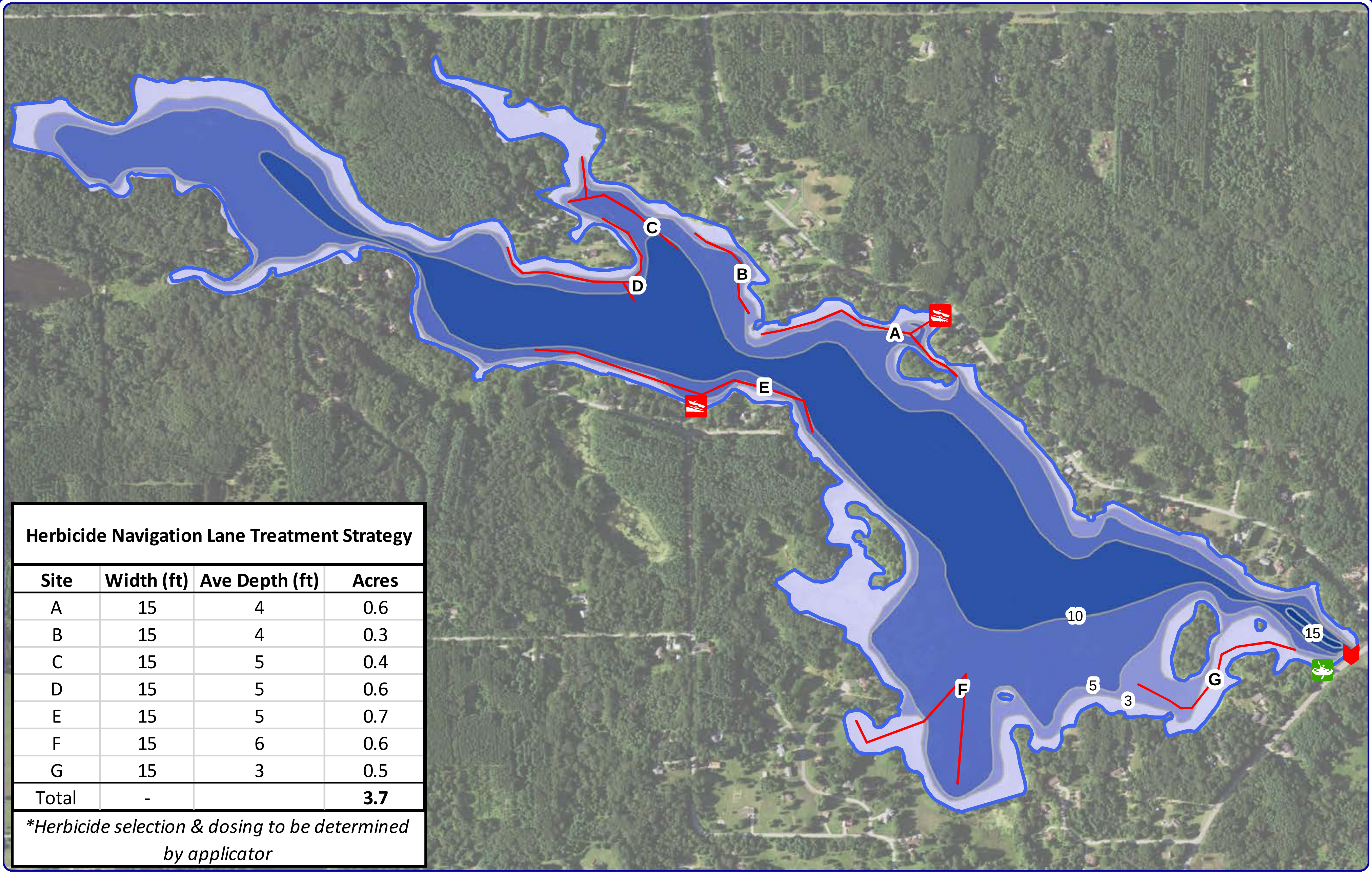
Sources:
Roads and Hydro: WDNR
Bathymetry: WDNR
Aquatic Plants: Onterra, 2022
Map Date: 6/24/2022 JMB
Filename:Lawrence_CLP_June22.mxd

Map 11
Lawrence Lake
Marquette County, Wisconsin

Curly-leaf Pondweed Survey Results



Herbicide Navigation Lane Treatment Strategy

Site	Width (ft)	Ave Depth (ft)	Acres
A	15	4	0.6
B	15	4	0.3
C	15	5	0.4
D	15	5	0.6
E	15	5	0.7
F	15	6	0.6
G	15	3	0.5
Total	-		**3.7**

**Herbicide selection & dosing to be determined by applicator*

N W E S

900

Feet

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920.338.8860
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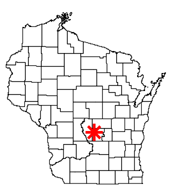
Sources
Hydro: WDNR
Aquatic Plants: Onterra, 2022
Orthophotography: NAIP, 2022
Map date: 4-3-2024 - TWH
Filename: Lawrence_HerbLanes.mxd



Project Location in Wisconsin

Legend

Proposed Treatment Lanes
15' width, 3.7 total acres

Dam

Carry-In Access

Boat Landing

Map 12
Lawrence Lake
Marquette County, Wisconsin

Potential Navigation Lane Treatment Strategy