Lac Vieux Desert Lake

Vilas County, Wisconsin & Gogebic County, Michigan

Comprehensive Management Plan

October 2012

Sponsored by:

Lac Vieux Desert Lake Association
WDNR Grant Program

LPL-1281-09 & LPL-1282-09

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

Onterra LLC
Lake Management Planning

Lac Vieux Desert

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Created by: Eddie Heath, Tim Hoyman, Brenton Butterfield, and Dan Cibulka
Onterra, LLC
De Pere, WI

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Lac Vieux Desert Planning Committee

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Data has been specifically provided for use in this report by the Wisconsin Department of Natural Resources, Great Lakes Indian Fish and Wildlife Commission, Wisconsin Valley Improvement Company, US Forest Service, and the Invasive Species Control Coalition of Watersmeet.

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1.0 INTRODUCTION

Lac Vieux Desert, Vilas County, WI and Gogebic County, Michigan, is a headwater drainage lake with a maximum depth of 42 feet, over 19 miles of shoreline (including islands) and a surface area of 4,247 acres. Lac Vieux Desert drains into the Wisconsin River and its water is maintained within 1.37 feet by a dam operated by the Wisconsin Valley Improvement Company. This eutrophic lake has a relatively small watershed when compared to the size of the lake. Lac Vieux Desert contains 51 native plant species, of which common waterweed is the most common plant. Two non-native aquatic plants, Eurasian water milfoil and curly-leaf pondweed are known to exist within the lake, while the non-native purple loosestrife has been located growing along the lake's shoreline.

Field Survey Notes

Many emergent plant species observed during community mapping surveys – incredible wildlife habitat here! Boating across the lake, alternating small dense colonies of small pondweed, flat stemmed pondweed, and other species were observed. Great expanses of wild rice.

Photograph 1-1 Lac Vieux Desert, Vilas County, WI and Gogebic County, MI.

Lake at a Glance – Lac Vieux Desert

Morphology	
Acreage	4,247
Maximum Depth (ft)	40
Mean Depth (ft)	12
Shoreline Complexity	4.3
Vegetation	
Curly-leaf Survey Date	June 25, 2009 and May 25, 2010
Comprehensive Survey Date	July 2009 (WDNR)
Number of Native Species	51
Threatened/Special Concern Species	None
Exotic Plant Species	Curly-leaf pondweed & Eurasian water milfoil: Purple loosestrife *(shoreland species)*
Simpson's Diversity	0.89
Average Conservatism	6.3
Water Quality	
Trophic State	Eutrophic
Limiting Nutrient	Phosphorus
Water Acidity (pH)	8.1
Sensitivity to Acid Rain	Not sensitive
Watershed to Lake Area Ratio	4:1

Lac Vieux Desert is a highly sought after location amongst recreationists and anglers. Being the largest lake in Vilas County it receives considerable public use. In addition to the 3 main public boat landings, Lac Vieux Desert supports a National Forest Campground, tribal campground, and numerous resorts. Lac Vieux Desert is heavily used by tournament anglers, including being one of the tournament lakes for the Wisconsin Muskie Tour's (WMT) Double Header, the Midwest Musky Classic, the Valley of the Giants, and the Swen Fishing Tournament Chicken Open.

These intense public use opportunities most likely contributed to Lac Vieux Desert becoming infested with Eurasian water milfoil and other invasive species, including Banded mystery snail, Chinese mystery snail, Freshwater jellyfish, and Rusty crayfish. The presence of Eurasian water milfoil is of primary concern because of the fertile nature of this lake, it would likely serve as a perfect host to this invasive plant. In 2008 the presence of Eurasian water milfoil was verified by the Wisconsin Department of Natural Resources (WDNR) after it was located by members of the Invasive Species Control Coalition of Watersmeet (ISCCW Lakeguards). Subsequent data was collected by the Great Lakes Indian Fish and Wildlife Commission (GLIFWC).

Although Eurasian water milfoil management is in the forefront of the association's minds, the LVDLA understands the importance of understanding the Lac Vieux Desert ecosystem as a whole to ensure current management actions are properly coordinated and all management alternatives are fully understood. The LVDLA also understands the importance of educating stakeholders on the ecology and management of the lake so realistic management goals can be achieved.

With this in mind, the LVDLA sought this management project for three main reasons: 1) to learn the extent of the exotic plants which occur in their lake, 2) to understand their lake ecosystem more fully, and 3) to be eligible to receive additional WDNR grant funds to address AIS and other goals of lake stakeholders. The data collected from this lake management project will serve as a baseline set of data for which future management planning projects can call upon. Therefore, this project is important not only in the management and protection of the lake, but also in its likely restoration. Specifically, this management plan outlines the specific steps necessary to restore and protect important native habitat within and around Lac Vieux Desert.

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, the completion of a stakeholder survey, and updates within the lake group's newsletter.

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

Kick-off Meeting

On June 27th, 2009, a project kick-off meeting was held at the Stateline Restaurant and Catering in Land O' Lakes to introduce the project to the general public. The meeting was announced through a mailing and personal contact by LVDLA board members. The approximately 22 attendees observed a presentation given by Eddie Heath, an aquatic ecologist with Onterra. Mr. Heath'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.

Stakeholder Survey

During September 2009, a seven-page, 26-question survey was mailed to 301 riparian property owners in the Lac Vieux Desert watershed. About 44 percent of the surveys were returned and those results were entered into a spreadsheet by members of the Lac Vieux Desert Planning Committee. The data were summarized and analyzed 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.

Planning Committee Meeting I

On December 9th, 2010, Eddie Heath of Onterra met with five members of the Lac Vieux Desert Planning Committee. The WDNR Lake Coordinator and a representative from the Lac Vieux Desert Band of the Lake Superior Chippewa were both invited but were unable to be in attendance. The primary focus of this meeting was the delivery of the study results and conclusions to the committee. All study components including, Eurasian water milfoil treatment results, 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, water levels, fisheries, and the presence of invasive species in the lake.

Planning Committee Meeting II

On February 8th, 2011, Eddie Heath met with four members of the Planning Committee to discuss the stakeholder survey results and begin developing management goals and actions for the Lac Vieux Desert management plan. Also in attendance was Ted Ritter, Invasive Species Coordinator for Vilas County.

Project Wrap-up Meeting

On July 19, 2012; the LVDLA held a special meeting regarding the completion of the Lac Vieux Desert Lake Management Planning Project. 20 people were in attendance at this meeting. Eddie Heath presented the results of the many studies that had been completed on the lake since 2009. He also answered many questions about the lake and how it should be managed.

Management Plan Review and Adoption Process

In March 2011, a draft of the Implementation Plan was provided to the Planning Committee for review. Based upon comments received, an additional management goal was created and provided to the Planning Committee for review in April 2011.

In May 2011, a draft of the Lac Vieux Desert Lake Management Plan was supplied to the WDNR, LVD Tribe, MDNR, GLIFWC and the LVDLA Planning Committee for review. These comments were integrated into an official first draft distributed in October 2011.

The official first draft was provided to all agencies listed above, in addition to the WVIC and the USFS in October 2011. The ISCCW was forwarded this report in September of 2012. Brief comments were received from the MDNR soon after this document was distributed, and more formal comments were received from the WDNR Lakes Specialist on July 18, 2012 and the USFS on September 14, 2012. This report reflects the integration of all comments received. The final report will be reviewed by the LVDLA Board of Directors and a vote to adopt the management plan will be held during the association's next annual meeting.

3.0 RESULTS & DISCUSSION

3.1 Lake Water Quality

Primer on 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, not all chemical attributes collected may have a direct bearing on the lake's ecology, but may be more useful as indicators of other problems. Finally, 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 analysis 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 ecology of the lake. In other words, the water quality that impacts and controls the fishery, plant production, and even the aesthetics of the lake are related here. Specific forms of water quality analysis are used to indicate not only the health of the lake, but also to provide a general understanding of the lake's ecology and assist in management decisions. Each type of available analysis is elaborated on below.

Comparisons with Other Datasets

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 similar lakes in the area. In this document, a portion of the water quality information collected in Lac Vieux Desert are compared to other lakes in the region and state (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 Lac Vieux Desert water quality analysis:

> **Phosphorus** is the nutrient that controls the growth of plants in the vast majority of Wisconsin lakes. It is important to remember that in lakes, the term "plants" includes both *algae* and *macrophytes*. Monitoring and evaluating concentrations of phosphorus within the lake helps to create a better understanding of the current and potential growth rates of the plants within the lake.
>
> **Chlorophyll-*a*** is the green pigment in plants used during *photosynthesis*. Chlorophyll-*a* concentrations are directly related to the abundance of free-floating algae in the lake. Chlorophyll-*a* values increase during algal blooms.
>
> **Secchi disk transparency** is a measurement of water clarity. Of all limnological parameters, it is the most used and the easiest for non-professionals to understand. Furthermore, measuring Secchi disk transparency over long periods of time is one of the best methods of monitoring the health of a lake. The measurement is conducted by

lowering a weighted, 20-cm diameter disk with alternating black and white quadrates (a Secchi disk) into the water and 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 et al. 1994, Dinius 2007, and Smith et al. 1991).

Lillie and Mason (1983) is an excellent source of data for comparing lakes within specific regions of Wisconsin. They divided the state's lakes into five regions each having lakes of similar nature or apparent characteristics. Vilas County lakes are included within the study's Northeast (Figure 3.1-1) and are among 242 lakes randomly sampled from the region that were analyzed for water clarity (Secchi disk), chlorophyll-*a*, and total phosphorus. These data along with data corresponding to statewide natural lake means and historic data from Lac Vieux Desert are displayed in Figures 3.1-2 – 3.1-4. Please note that the data in these graphs represent values collected only during the summer months (June-August) from the deepest location in Lac Vieux Desert (Map 1). 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 (see discussion under Internal Nutrient Loading on page 9). Surface samples in Lac Vieux Desert were collected at a depth of 3 feet.

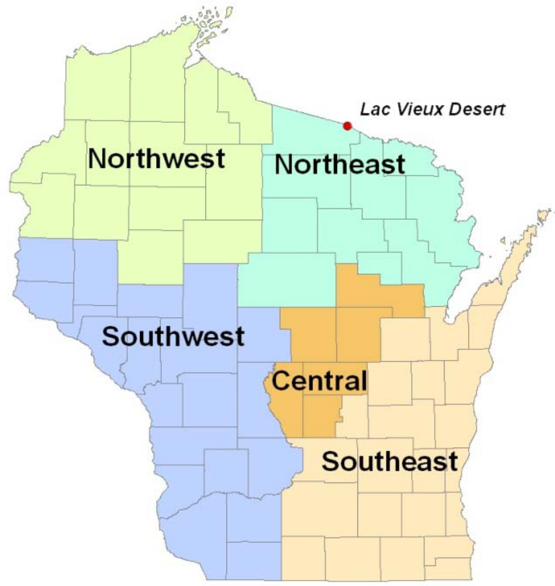

Figure 3.1-1. Location of Lac Vieux Desert within the regions utilized by Lillie and Mason (1983).

Apparent Water Quality Index

Water quality, like beauty, is often in the eye of the beholder. A person from southern Wisconsin that has never seen a northern lake may consider the water quality of their lake to be good if the bottom is visible in 4 feet of water. On the other hand, a person accustomed to seeing the bottom in 18 feet of water may be alarmed at the clarity found in the southern lake.

Lillie and Mason (1983) used the extensive data they compiled to create the *Apparent Water Quality Index* (WQI). They divided the phosphorus, chlorophyll-*a*, and clarity data of the state's lakes into ranked categories and assigned each a "quality" label from "Excellent" to "Very Poor". The categories were created based upon natural divisions in the dataset and upon their experience. As a result, using the WQI as an assessment tool is very much like comparing a particular lake's values to values from many other lakes in the state. However, the use of terms like, "Poor", "Fair", and "Good" bring about a better understanding of the results than just comparing averages or other statistical values between lakes. The WQI values corresponding to the phosphorus, chlorophyll-*a*, and Secchi disk values for Lac Vieux Desert are displayed on Figures 3.1-2 – 3.1-4.

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. 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.

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.

Carlson (1977) presented a trophic state index that gained great acceptance among lake managers. Because Carlson developed his TSI equations on the basis of association among water clarity, chlorophyll-*a*, and total phosphorus values of a relatively small set of Minnesota Lakes, researchers from Wisconsin (Lillie et. al. 1993), developed a new set of relationships and equations based upon the data compiled in Lillie & Mason (1983). This resulted in the Wisconsin Trophic State Index (WTSI), which is essentially a TSI calibrated for Wisconsin lakes. The WTSI is used extensively by the WDNR and is reported along with lake data collected by Citizen Lake Monitoring Network volunteers.

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

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, fishkills 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.

Lake stratification occurs when temperature gradients are developed with depth in a lake. During stratification the lake can be broken into three layers: The *epiliminion* 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.

Internal Nutrient Loading

In lakes that support strong stratification, 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 the spring and fall turnover events, these high concentrations of phosphorus are mixed within the lake and utilized by algae and some macrophytes. This cycle continues year after year and is termed "internal phosphorus loading"; a phenomenon that can support nuisance algae 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 screen non-candidate and candidate lakes following the general guidelines below:

Non-Candidate Lakes

- Lakes that do not experience hypolimnetic anoxia.
- Lakes that do not stratify for significant periods (i.e. months 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.

Lac Vieux Desert Water Quality Analysis

Lac Vieux Desert Long-term Trends

Little historic water quality data exists for Lac Vieux Desert, making beneficial long-term trend analysis impossible. WVIC has collected water quality data on the system under its Quarterly Sampling Program from 1979 to 1983. WVIC is currently collecting data for long-term-trend analysis, which is part of the WDNR program, for 3 consecutive years in each 10-year period as a part of its 30-year Federal Energy Regulatory Commission License.

Despite the existence of semi-sporadic data for the lake beginning in the late 1970's, it is unreasonable to attempt to draw conclusions on changes in water quality when large gaps exist in the dataset. Natural annual fluctuations in water quality can and do occur in Wisconsin lakes, so without consistent yearly data it is impossible to tell if perceived changes in water quality, especially in the short-term, are due to environmental circumstances or the influence of human activities. Despite this limitation, sufficient recent data exists to evaluate the current water quality status of Lac Vieux Desert.

Figure 3.1-2 contains average total phosphorus data collected from Lac Vieux Desert. Summer averages from 2009 are not all that different from data collected in previous years, besides perhaps 2001 in which phosphorus spiked to 43 μg/L. These values can all be found within WQI categories of "Good" and "Fair", with the weighted average of all years ranking as "Good". This average is only slightly higher than averages found in Wisconsin natural lakes, and is higher than similar lakes located in the Northeast region of the state (Figure 3.1-2).

Unlike the phosphorus data, the chlorophyll-*a* data displays much more variability. Phosphorus and chlorophyll-*a* are two parameters that can be highly correlated, however there are many factors that contribute to algal abundance in lakes including sunlight, temperature, and the biomass of macrophytes. Some of these factors, particularly those that are weather-related, can vary dramatically from month to month and year to year. In fact, USGS researchers documented very high algae blooms in late summer of 2003 which they suspected were fairly common for the lake (USGS 2005). However in 2009, during an exceptionally cold summer, chlorophyll-*a* samples were relatively low compared to previous years (Figure 3.1-3). This is a fine example of the year to year variability that can exist. What is important to note is that when averaging all chlorophyll-*a* values collected on Lac Vieux Desert, the weighted average is lower than both the state and regional average for this water quality parameter (Figure 3.1-3).

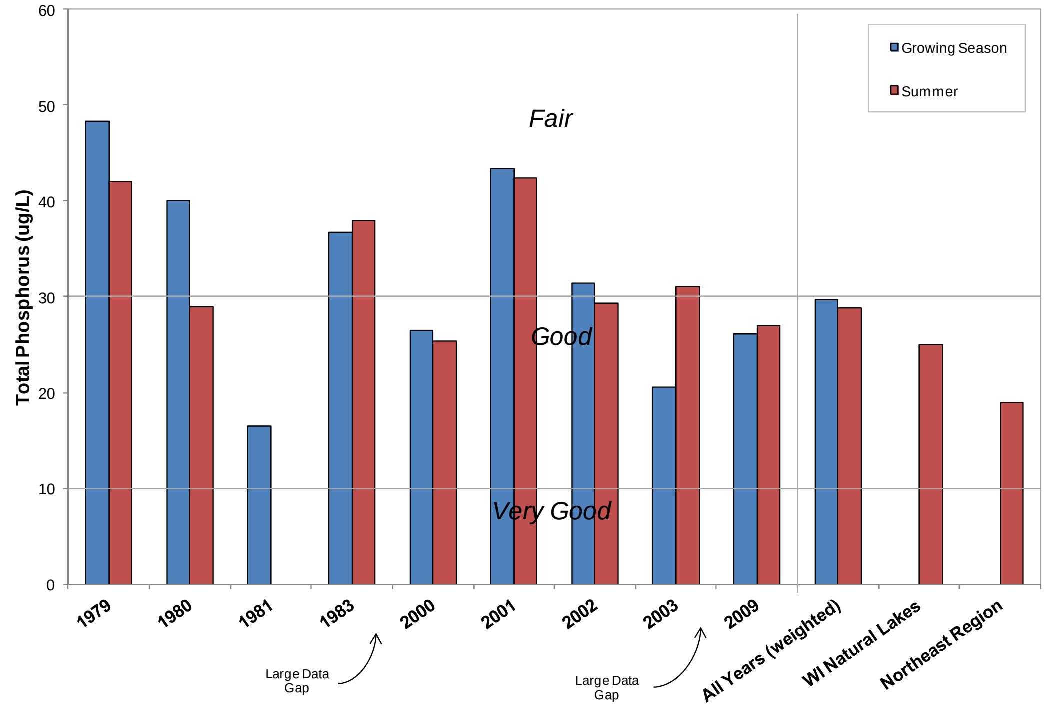

Figure 3.1-2. Lac Vieux Desert, regional, and state total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

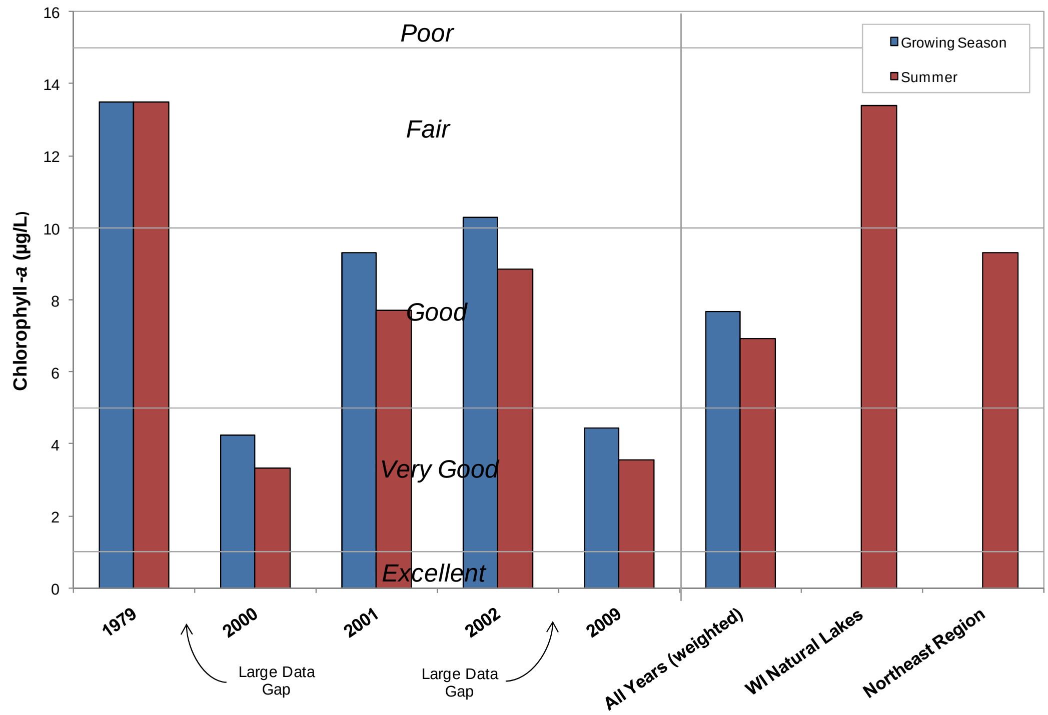

Figure 3.1-3. Lac Vieux Desert, regional, and state chlorophyll-*a* concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

Secchi disk transparency has been measured off-and-on over numerous years on Lac Vieux Desert. The same data gaps exist, making a long-term trend distinction impractical, and there were several years in which the measurements were taken outside of the summer season. Measurements taken at this time of the year are important because it is during this time that plankton growth is near its peak, and suspended solids may be higher as well due to increased wind, boat traffic, and stream inputs. This allows for the researcher to identify when the water clarity is at the "low end of the spectrum". Weighted summer averages from the years on record returns a value that ranks slightly lower than averages seen in similar Wisconsin and Northeast region lakes, yet still ranks on the border between "Fair" and "Good" (Figure 3.1-4).

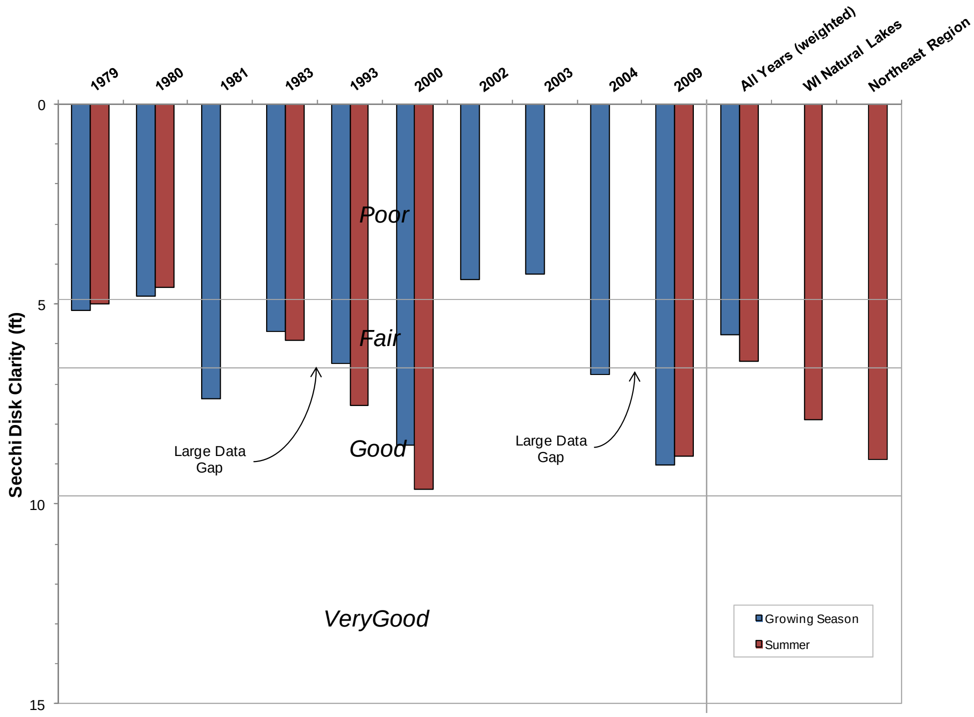

Figure 3.1-4. Lac Vieux Desert, regional, and state Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

Limiting Plant Nutrient of Lac Vieux Desert

Using midsummer nitrogen and phosphorus concentrations from Lac Vieux Desert, a nitrogen:phosphorus ratio of 19:1 was calculated. This finding indicates that Lac Vieux Desert is indeed phosphorus limited as are the vast majority of Wisconsin lakes. In general, this means that cutting phosphorus inputs may limit plant growth within the lake.

Lac Vieux Desert Trophic State

Figure 3.1-5 contain the WTSI values for Lac Vieux Desert. The WTSI values calculated with Secchi disk, chlorophyll-*a*, and total phosphorus values range in values spanning from eutrophic to middle mesotrophic. In general, the best values to use in judging a lake's trophic state are the biological parameters; therefore, relying primarily on total phosphorus and chlorophyll-*a* WTSI values, it can be concluded that Lac Vieux Desert is a lower eutrophic lake.

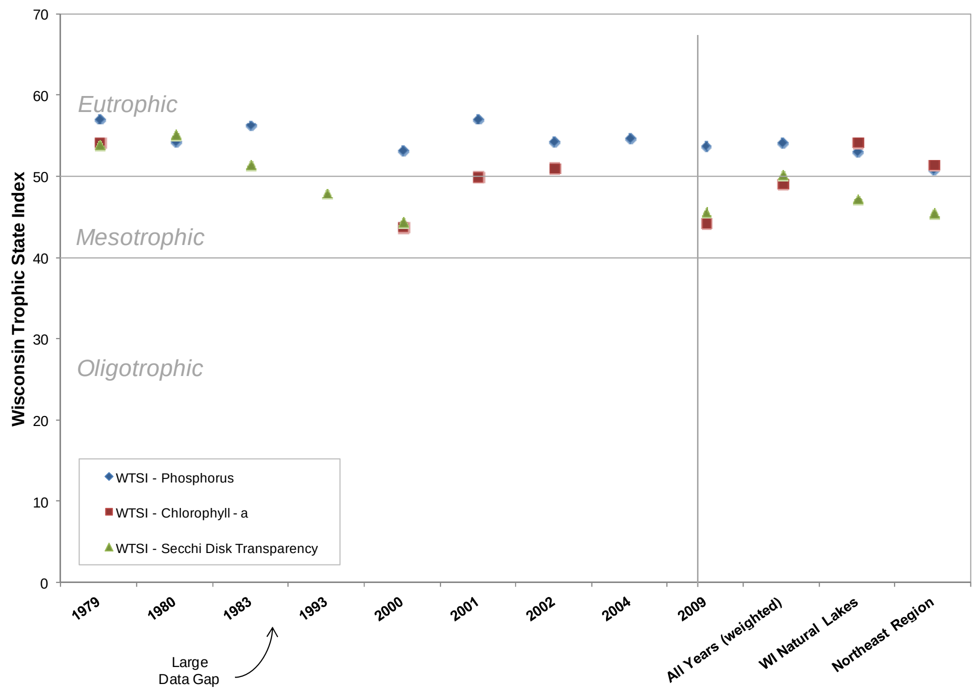

Figure 3.1-5. Lac Vieux Desert, regional, and state Wisconsin Trophic State Index values. Values calculated with summer month surface sample data using Lillie et al. (1993).

Dissolved Oxygen and Temperature in Lac Vieux Desert

Dissolved oxygen and temperature information was collected by Onterra staff in 2009 and winter of 2010. Graphs of these data are displayed in Figure 3.1-6.

Lac Vieux Desert was found to mix well in the spring, and stratify only periodically during June of 2009. This is not uncommon in lakes that are large in size but moderate in depth. Energy from the wind is sufficient to mix the lake from top to bottom, distributing oxygen throughout the epilimnion and hypolimnion and keeping water temperatures fairly constant within the water column. Lac Vieux Desert's west – east orientation places it directly in line to receive strong westwardly winds. Its elongated shape creates a large maximum *fetch* – a term used to describe the longest length of open water on a lake. Wave energy builds up considerably along the fetch and is able to mix the water more so than on bodies of water that have a shorter maximum fetch.

Dissolved oxygen levels remained sufficient to support aquatic life commonly found in northern Wisconsin lakes throughout the entire summer. In February of 2010, dissolved oxygen dropped below 3.0 mg/L at roughly 10 feet, and reached anoxic conditions near the bottom of the deep hole. Although little dissolved oxygen was found in the deeper water much of the lake is less than 15 ft deep, allowing for plenty of oxygenated areas for fish to harbor the winters in.

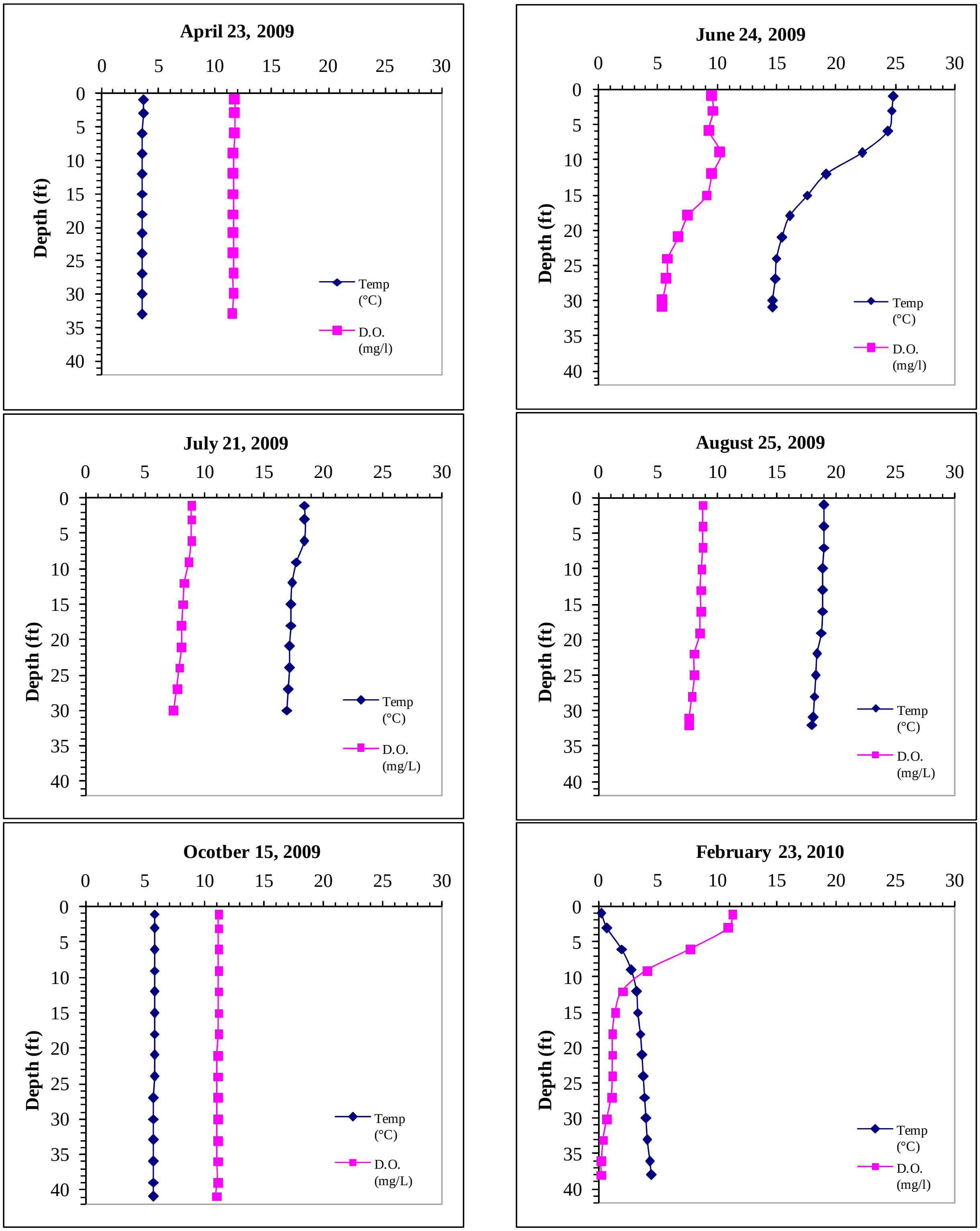

Figure 3.1-6. Lac Vieux Desert dissolved oxygen and temperature profiles.

Additional Water Quality Data Collected at Lac Vieux Desert

Alkalinity, pH, and calcium analysis was also performed on some of the water quality samples collected from Lac Vieux Desert. Alkalinity values ranged between 40.6 and 39.9 mg/l as $CaCO_3$ during the summer months indicating that the lake has a higher buffering capacity against acid rain. During the same time, the lake's pH hovered around 8.1 or slightly above neutral. The pH value is normal for a lake such as Lac Vieux Desert and is well within the optimal range for zebra mussels. However, calcium analysis from a sample collected during June 2009 returned a value of 10.1 mg/l, which is at the very low end for zebra mussels.

3.2 Watershed Assessment

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.

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

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

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 exceeding 10-15:1, 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 (high residence time, i.e., years), there may be a buildup of phosphorus in the sediments that may reach sufficient levels over time that internal nutrient loading may become a problem. 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 affect 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 can be 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.

According to the USGS study completed in 2005 (USGS 2005), the Lac Vieux Desert's 22,016 acre watershed is largely dominated by forest (60% or 13,166 acres), wetland (20% or 4,295 acres) and the lake surface (19% or 4,247 acres) with low density urban, pasture/grass and mixed agriculture making up smaller quantities of the watershed (Figure 3.2-1). Lac Vieux Desert is a relatively large lake, but is also surrounded by a relatively large watershed. Because of this, the watershed to lake area ratio is moderate to small (a ratio of 4:1). This ratio indicates that land cover located within this watershed plays an important role in the lake's water quality.

Input of the watershed land cover data (Figure 3.2-1) within WiLMS produced a loading estimate of 2,578 lbs of phosphorus annually (Figure 3.2-2 and Appendix D) to Lac Vieux Desert. While this may seem to be an incredible amount of phosphorus, remember that the incredible volume of Lac Vieux Desert must be taken into consideration. As a result, this annual load is moderate to slightly above moderate for a lake of this size. In fact, because the lake surface is so large, it is the primary contributor to the phosphorus load. The lake surface (19% of the watershed) is responsible for 44% of this annual load, which occurs as a result of atmospheric deposition. Forested land, which occupies 60% of the watershed, is responsible for 41% of the phosphorus load. Wetlands within the watershed rank third in phosphorus contribution, at 15% of the annual load, while the urban, agriculture, and pasture land contribute negligible quantities of phosphorus to the lake on an annual basis (Figure 3.2-2).

A 2005 USGS study indicated that sedimentation (input of sediment from surrounding lands) in Lac Vieux Desert is lower than expected. There are two reasons for this; first, the small watershed to lake area ratio, which limits the area from which sediment can be drawn, and second, the five tributary streams that contribute to Lac Vieux Desert flow through low-gradient wetlands before entering the lake (USGS 2005). These wetlands essentially work as small settling basins and allow sediment and nutrients to settle out before flowing downstream.

Additionally, anthropogenic (man-made) nutrient inputs from sewage effluent may be minimal. The USGS report noted that lakeside homeowners have improved upon septic systems in the past 30 years, including not only installing new systems reconstructing old ones and improving drain fields as well (USGS 2005). However despite the new technology being incorporated to lakeside residence septic systems, the authors noted that northern Wisconsin lakes have seen an increase in year-round residences as opposed to residences that were formerly used seasonally. On Question #2 of the Lac Vieux Desert stakeholder survey (Appendix B – "What type of property do you own on Lac Vieux Desert?"), 32% of respondents indicated their residence was used year-round. The increased use of these septic systems may contribute increased loads of phosphorus to the lake, though researchers did not speculate that this was occurring to an alarming degree on Lac Vieux Desert. The reason for this is two-fold, 1) chloride concentrations (linked to septic-tank or road-salt input) were fairly low during the study, and 2) the current biological productivity has not changed from past years (USGS 2005).

Almost all of the phosphorus entering Lac Vieux Desert comes from sources that should not (forests and wetlands) or cannot (lake surface) be changed. Although this means that the Lac Vieux Desert watershed need not be improved on a large scale, it also means that impacts from the immediate shoreland are of greater importance. From GIS mapping of the Lac Vieux Desert watershed and field accounts from the 2005 USGS report, it is apparent that the only urban land uses in the watershed are along the shoreline of the lake. Therefore, installation and maintenance of shoreland buffer areas, use of phosphorus-free fertilizers, and reductions in impervious surfaces all become key aspects in minimizing the amount of phosphorus entering Lac Vieux Desert.

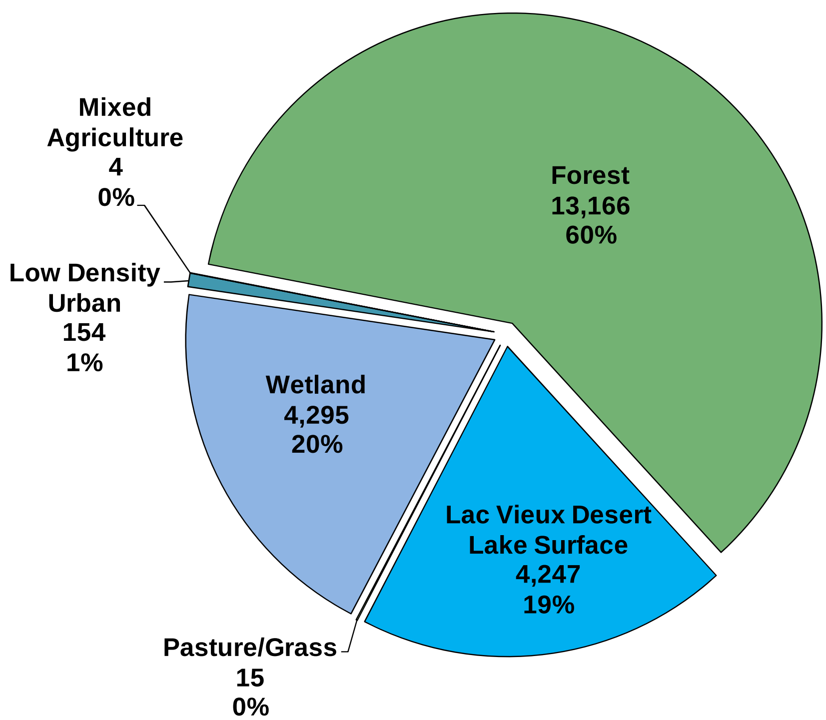

Figure 3.2-1. Lac Vieux Desert watershed land cover types in acres. Based upon Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) (WDNR, 1998).

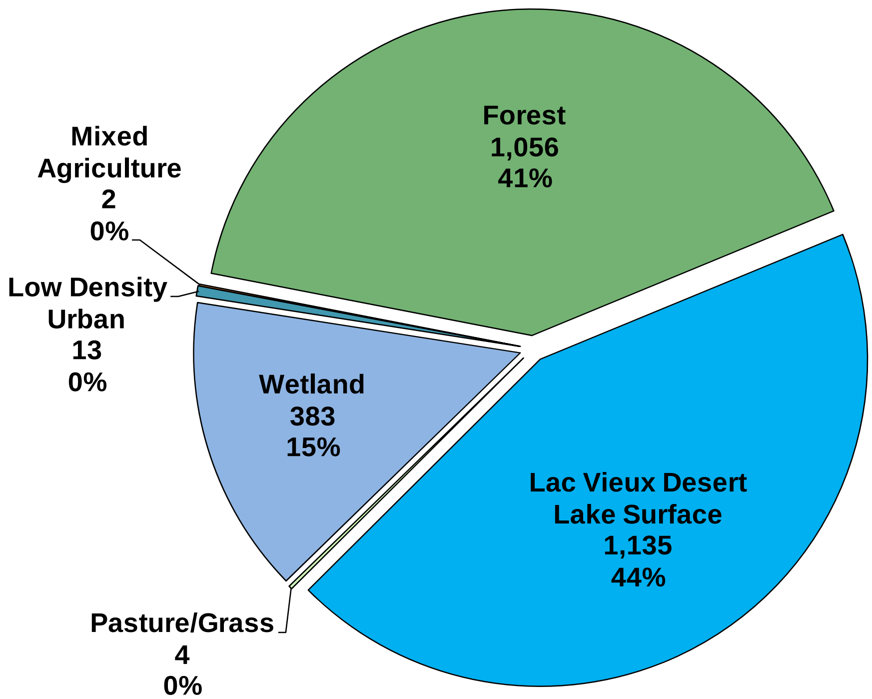

Figure 3.2-2. Lac Vieux Desert watershed phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

3.3 Aquatic Plants

Introduction

Although the occasional lake user considers 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.

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 shoreline 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 numbers of predator fish and a stunted pan-fish population. *Exotic* plant species, such as Eurasian water-milfoil (*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 *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 most of these techniques are not applicable to Lac Vieux Desert, 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 Lac Vieux Desert 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.

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 et al. 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 shoreline. 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 shoreline sediments vulnerable to wave action caused by boating and wind (Jennings et al. 2003, Radomski and Goeman 2001, and 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 and Schindler 2004).

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.

Cost

The cost of native, aquatic and shoreland plant restorations is highly variable and depend on the size of the restoration area, planting densities, the species planted, and the type of planting (e.g. seeds, bare-roots, plugs, live-stakes) being conducted. Other factors may include extensive grading requirements, removal of shoreland stabilization (e.g., rip-rap, seawall), and protective measures used to guard the newly planted area from wildlife predation, wave-action, and erosion. In general, a restoration project with the characteristics described below would have an estimated materials and supplies cost of approximately $4,200.

- The single site used for the estimate indicated above has the following characteristics:
  - An upland buffer zone measuring 35’ x 100’.
  - An aquatic zone with shallow-water and deep-water areas of 10’ x 100’ each.
  - Site is assumed to need little invasive species removal prior to restoration.
  - Site has a moderate slope.
  - Trees and shrubs would be planted at a density of 435 plants/acre and 1210 plants/acre, respectively.
  - Plant spacing for the aquatic zone would be 3 feet.
  - Each site would need 100’ of biolog to protect the bank toe and each site would need 100’ of wavebreak and goose netting to protect aquatic plantings.
  - Each site would need 100’ of erosion control fabric to protect plants and sediment near the shoreline (the remainder of the site would be mulched).
  - There is no hard-armor (rip-rap or seawall) that would need to be removed.
  - The property owner would maintain the site for weed control and watering.

Advantages	***Disadvantages***
• Improves the aquatic ecosystem through species diversification and habitat enhancement. • Assists native plant populations to compete with exotic species. • Increases natural aesthetics sought by many lake users. • Decreases sediment and nutrient loads entering the lake from developed properties. • Reduces bottom sediment re-suspension and shoreline erosion. • Lower cost when compared to rip-rap and seawalls. • Restoration projects can be completed in phases to spread out costs. • Many educational and volunteer opportunities are available with each project.	• Property owners need to be educated on the benefits of native plant restoration before they are willing to participate. • Stakeholders must be willing to wait 3-4 years for restoration areas to mature and fill-in. • Monitoring and maintenance are required to assure that newly planted areas will thrive. • Harsh environmental conditions (e.g., drought, intense storms) may partially or completely destroy project plantings before they become well established.

Manual Removal

Manual removal methods include hand-pulling, raking, and hand-cutting. 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. One manual cutting technique involves throwing a specialized "V" shaped cutter into the plant bed and retrieving it with a rope. The raking method entails the use of a two-sided straight blade on a telescoping pole that is swiped back and forth at the base of the undesired plants.

In addition to the hand-cutting methods described above, powered cutters are now available for mounting on boats. Some are mounted in a similar fashion to electric trolling motors and offer a 4-foot cutting width, while larger models require complicated mounting procedures, but offer an 8-foot cutting width. Please note that the use of powered cutters may require a mechanical harvesting permit to be issued by the WDNR.

When using the methods outlined above, it is very important to remove all plant fragments from the lake to prevent re-rooting and drifting onshore followed by decomposition. It is also important to preserve fish spawning habitat by timing the treatment activities after spawning. In Wisconsin, a general rule would be to not start these activities until after June 15th.

Cost

Commercially available hand-cutters and rakes range in cost from $85 to $150. Power-cutters range in cost from $1,200 to $11,000.

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.

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 water-milfoil 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 affects 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 (*Phragmites australis*) and reed canary grass (*Phalaris arundinacea*). • Permitting process may require an environmental assessment that may take months to prepare. • Unselective.

Mechanical Harvesting

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.

Costs

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.

Chemical Treatment

There are many herbicides available for controlling aquatic macrophytes and each compound is sold under many brand names. Aquatic herbicides fall into two general classifications:

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 does not result in a sustained effect because the root crowns, roots, or rhizomes are not killed.
2. *Systemic herbicides* spread throughout the entire plant and often result in complete mortality if applied at the right time of the year.

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.

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.

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 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. Some herbicides are applied at a high dose with the anticipation that the exposure time will be short. Granular herbicides are usually applied at a lower dose, but the release of the herbicide from the clay carrier is slower and increases the exposure time.

Below are brief descriptions of the aquatic herbicides currently registered for use in Wisconsin.

Fluridone (Sonar®, Avast!®) Broad spectrum, systemic herbicide that is effective on most submersed and emergent macrophytes. It is also effective on duckweed and at low concentrations has been shown to selectively remove Eurasian water-milfoil. Fluridone slowly kills macrophytes over a 30-90 day period and is only applicable in whole lake treatments or in bays and backwaters were dilution can be controlled. Required length of contact time makes this chemical inapplicable for use in flowages and impoundments. Irrigation restrictions apply.

Diquat (Reward®, Weedtrine-D®) Broad spectrum, contact herbicide that is effective on all aquatic plants and can be sprayed directly on foliage (with surfactant) or injected in the water. It is very fast acting, requiring only 12-36 hours of exposure time. Diquat readily binds with clay particles, so it is not appropriate for use in turbid waters. Consumption restrictions apply.

Endothall (Hydrothol®, Aquathol®) Broad spectrum, contact herbicides used for spot treatments of submersed plants. The mono-salt form of Endothall (Hydrothol®) is more toxic to fish and aquatic invertebrates, so the dipotassium salt (Aquathol®) is most often used. Fish consumption, drinking, and irrigation restrictions apply.

2,4-D (Navigate®, DMA IV®, etc.) Selective, systemic herbicide that only works on broad-leaf plants. The selectivity of 2,4-D towards broad-leaved plants (dicots) allows it to be used for Eurasian water-milfoil without affecting many of our native plants, which are monocots. Drinking and irrigation restrictions may apply. This herbicide is not permitted for use in the State of Michigan.

Triclopyr (Navitrol®, Renovate®) Selective, systemic herbicide that is effective on broad leaf plants and, similar to 2,4 D, will not harm native monocots. Triclopyr is available in liquid or granular form, and can be combined with Endothal in small concentrations (<1.0 ppm) to effectively treat Eurasian water-milfoil. Triclopyr has been used in this way in Minnesota and Washington with some success.

Glyphosate (Rodeo®) Broad spectrum, systemic herbicide used in conjunction with a *surfactant* to control emergent and floating-leaved macrophytes. It acts in 7-10 days and is not used for submergent species. This chemical is commonly used for controlling purple loosestrife (*Lythrum salicaria*). Glyphosate is also marketed under the name

Roundup®; this formulation is not permitted for use near aquatic environments because of its harmful effects on fish, amphibians, and other aquatic organisms.

Imazapyr (Habitat®) Broad spectrum, system herbicide, slow-acting liquid herbicide used to control emergent species. This relatively new herbicide is largely used for controlling common reed (giant reed, *Phragmites*) where plant stalks are cut and the herbicide is directly applied to the exposed vascular tissue.

Cost

Herbicide application charges vary greatly between $400 and $1000 per acre depending on the chemical used, who applies it, permitting procedures, and the size of the treatment area.

Advantages	***Disadvantages***
• Herbicides are easily applied in restricted areas, like around docks and boatlifts. • 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 water-milfoil. • Some herbicides can be used effectively in spot treatments.	• Fast-acting herbicides may cause fishkills 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. • Many herbicides are nonselective. • Most herbicides have a combination of use restrictions that must be followed after their application. • Many herbicides are slow-acting and may require multiple treatments throughout the growing season. • Overuse may lead to plant resistance to herbicides

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 waterhyacinth weevils (*Neochetina spp.*) and hydrilla stem weevil (*Bagous spp.*) to control waterhyacinth (*Eichhornia crassipes*) and hydrilla (*Hydrilla verticillata)*, respectively. Fortunately, it is assumed that Wisconsin's climate is a bit harsh for these two invasive plants, so there is no need for either biocontrol insect.

However, Wisconsin, along with many other states, is currently experiencing the expansion of lakes infested with Eurasian water-milfoil 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 some research has shown promise in reducing Eurasian water-milfoil stands in Wisconsin, Washington, Vermont, and other states (http://enviroscienceinc.com/case-studies/). However, a wealth of additional research does not support these claims (Jester et al., 1999).

Research is currently being conducted to discover the best situations for the use of the insect in battling Eurasian water milfoil. Currently the milfoil weevil is not a WDNR grant-eligible method of controlling Eurasian water milfoil due to the uncertainty of its efficacy.

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 water-milfoil 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 many 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, like variable water levels or negative, like increased shoreland development or the introduction of an exotic species, the plant community will respond. Plant communities respond in a variety of ways; there may be a loss of one or more species, certain life forms, such as emergents or floating-leaf communities may disappear from certain areas of the lake, or there may be a shift in plant dominance between species. 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 Lac Vieux Desert; 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 species that were found within the lake, both exotic and native. The list also contains the life-form of each plant found, its scientific 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 life-forms that are present, can be an early indicator of changes in the health of the lake ecosystem.

Frequency of Occurrence

Frequency of occurrence describes how often a certain 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 Lac Vieux Desert, plant samples were collected from plots laid out on a grid that covered the entire lake. Using the data collected from these plots, an estimate of occurrence of each plant species can be determined. In this section, two types of data are displayed: littoral frequency of occurrence and relative frequency of occurrence. Littoral frequency of occurrence is used to describe how often each species occurred in the plots that are less than the maximum depth of plant growth (littoral zone). Littoral frequency is displayed as a percentage. Relative frequency of occurrence uses the littoral frequency for occurrence for each species compared to the sum of the littoral frequency of occurrence from all species. These values are presented in percentages and if all of the values were added up, they would equal 100%. For example, if water lily had a relative frequency of 0.1 and we described that value as a percentage, it would mean that water lily made up 10% of the population.

In the end, this analysis indicates the species that dominate the plant community within the lake. Shifts in dominant plants over time may indicate disturbances in the ecosystem. For instance, low water levels over several years may increase the occurrence of emergent species while decreasing the occurrence of floating-leaf species. Introductions of invasive exotic species may result in major shifts as they crowd out native plants within the system.

Species Diversity

Species diversity is probably the most misused value in ecology because it is often confused with species richness. Species richness is simply the number of species found within a system or community. Although these values are related, they are far from the same because diversity also takes into account how evenly the species occur within the system. A lake with 25 species may not be more diverse than a lake with 10 if the first lake is highly dominated by one or two species and the second lake has a more even distribution.

A lake with high species diversity is much more stable than a lake with a low diversity. This is analogous to a diverse financial portfolio in that a diverse lake plant community can withstand environmental fluctuations much like a diverse portfolio can handle economic fluctuations. For example, a lake with a diverse plant community is much better suited to compete against exotic infestation than a lake with a lower diversity.

One factor that influences species diversity is the “development factor” of the shoreline. This is not the degree of human development or disturbance, but rather it is a value that attempts to describe the nature of the habitat a particular shoreline may hold. This value is referred to as the shoreline complexity. It specifically analyzes the characteristics of the shoreline and describes to what degree the lake shape deviates from a perfect circle. It is calculated as the ratio of lake perimeter to the circumference of a circle of area equal to that of the lake. A shoreline complexity value of 1.0 would indicate that the lake is a perfect circle. The further away the value gets from 1.0, the more the lake deviates from a perfect circle. As shoreline complexity increases, species richness increases, mainly because there are more habitat types, bays and back water areas sheltered from wind.

Floristic Quality Assessment

Floristic Quality Assessment (FQA) is used to evaluate the closeness of a lake's aquatic plant community to that of an undisturbed, or pristine, lake. The higher the floristic quality, the closer a lake is to an undisturbed system. FQA is an excellent tool for comparing individual lakes and the same lake over time. In this section, the floristic quality of Lac Vieux Desert will be compared to lakes in the same ecoregion and in the state (Figure 3.3-1).

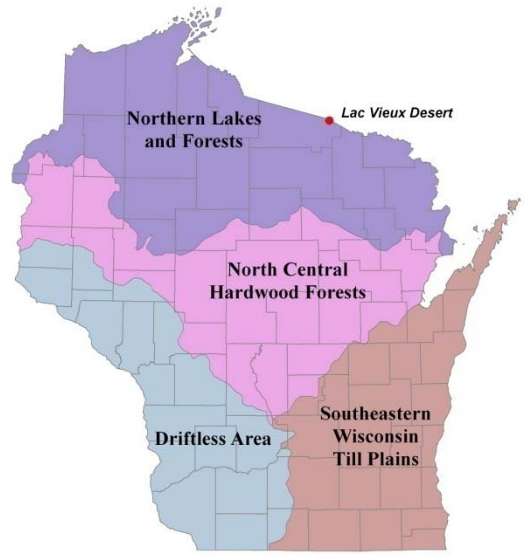

Figure 3.3-1. Location of Lac Vieux Desert within the ecoregions of Wisconsin. After Nichols 1999.

The floristic quality of a lake is calculated using its species richness and average species conservatism. As mentioned above, species richness is simply the number of species that occur in the lake, for this analysis, only native species are utilized. Average species conservatism utilizes the coefficient of conservatism values for each of those species in its calculation. A species coefficient of conservatism value indicates that species likelihood of being found in an undisturbed (pristine) system. The values range from one to ten. Species that are normally found in disturbed systems have lower coefficients, while species frequently found in pristine systems have higher values. For example, cattail, an invasive native species, has a value of 1, while common hard and softstem bulrush have values of 5, and Oakes pondweed, a sensitive and rare species, has a value of 10. 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.

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.

Community Mapping

A key component of the aquatic plant survey is the creation of an aquatic plant community map. The map represents a snapshot of the important plant communities in the lake as they existed during the survey and is valuable in the development of the management plan and in comparisons with surveys completed in the future. A mapped community can consist of submergent, floating-leaf, or emergent plants, or a combination of these life-forms. Examples of submergent plants include wild celery and pondweeds; while emergents include cattails, bulrushes, and arrowheads, and floating-leaf species include white and yellow pond lilies. Emergents and floating-leaf communities lend themselves well to mapping because there are distinct boundaries between communities. Submergent species are often mixed throughout large areas of the lake and are seldom visible from the surface; therefore, mapping of submergent communities is more difficult and often impossible.

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 water milfoil are the primary targets of this extra attention.

Eurasian water-milfoil is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties (Figure 3.3-2). Eurasian water-milfoil 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 water-milfoil 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 water-milfoil 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.

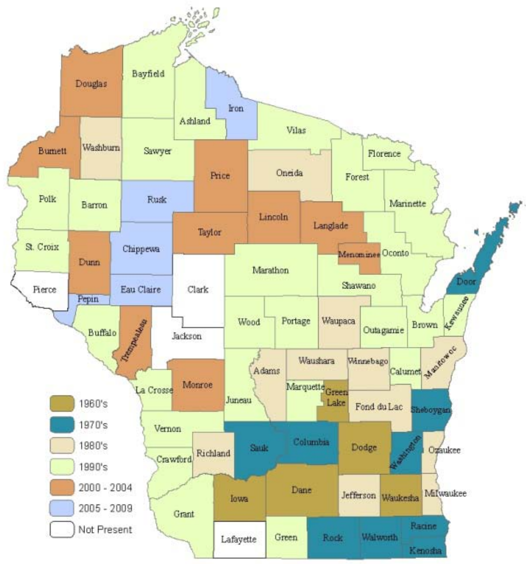

Figure 3.3-2. Spread of Eurasian water milfoil within WI counties. WDNR Data 2009 mapped by Onterra.

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 water-milfoil, 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.

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 water milfoil 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 Plant Survey Results

As mentioned above, numerous plant surveys were completed as a part of this project. On June 25, 2009, a survey was completed on Lac Vieux Desert that focused upon curly-leaf pondweed . During this meander-based survey, a few fragments of curly-leaf pondweed were found floating within Outlet Bay, but the location of where these fragments originated within the lake could not be found. Additional curly-leaf pondweed fragments were discovered near the main boat landing in Thunder Bay in mid-July during water quality sampling. On May 25, 2010, another meander-based survey of the entire lake was conducted in an attempt to locate actively-growing curly-leaf pondweed, but again this did not yield any occurrences.

Median Value This is the value that roughly half of the data are smaller and half the data are larger. A median is used when a few data are so large or so small that they skew the average value to the point that it would not represent the population as a whole.

The point intercept survey was conducted on Lac Vieux Desert late July 2009 by the WDNR. Additional surveys were completed by Onterra on Lac Vieux Desert to create the aquatic plant community maps (Map 2) in early August 2009. During the point-intercept and aquatic plant mapping surveys, 54 species of plants were located in Lac Vieux Desert (Table 3.3-1). Three of these species are considered to be non-native species: Eurasian water milfoil, curly-leaf pondweed, and purple loosestrife. A more detailed discussion of these exotic species can be found in the Non-native Aquatic Plant section below.

Aquatic plants were found growing to a maximum depth of 19 feet, with the largest number of point intercept locations between 10 and 11 feet containing aquatic plants (Figure 3.3-3). This is a testament to the good water clarity of Lac Vieux Desert. Approximately 91% of the point-intercept sampling locations that fell within the maximum depth of plant growth contained aquatic vegetation. Figure 3.3-4 shows that of the 54 plant species found in the littoral, or plant growing zone, of Lac Vieux Desert, common waterweed was the most frequently encountered species, followed closely by coontail and flat-stem pondweed. Common waterweed and coontail lack true root structures and their locations within the lake are often subject to water movement and their tendency to become entangled in other plants, rocks, or debris. Flat-stem pondweed is a rooted plant with long slender leaves, and as its name suggests possesses a conspicuously flattened stem. All three of these species are very common throughout Wisconsin and are usually found growing in lakes of higher productivity, like Lac Vieux Desert. By examining the relative frequency of occurrence (Figure 3.3-5), we see that these top three species are each found in a higher abundance than the least common 21 species in the lake.

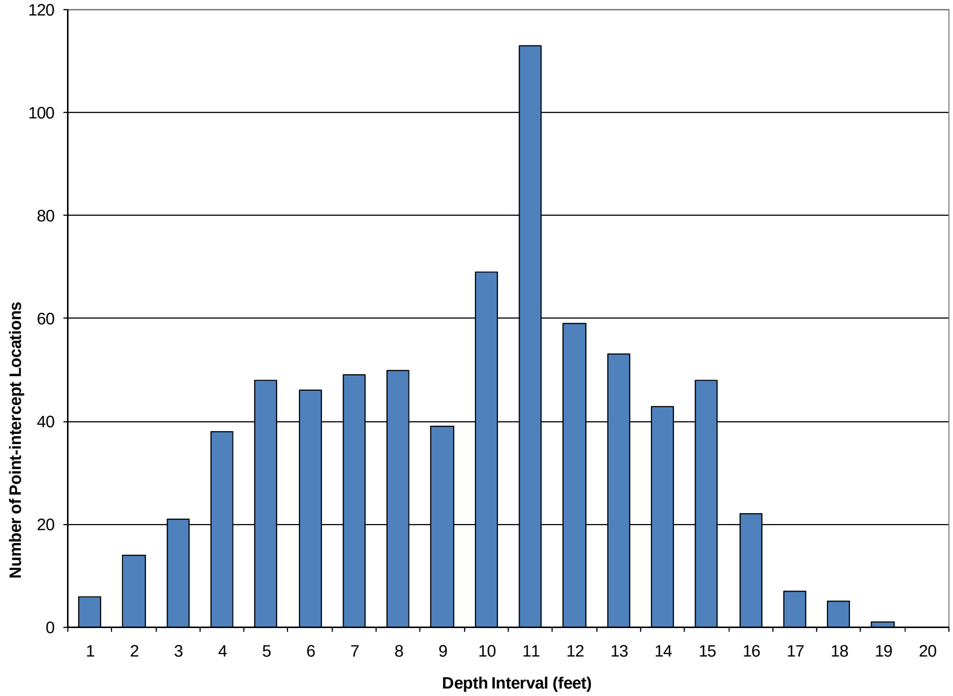

Figure 3.3-3 Lac Vieux Desert aquatic plant depth distribution. Created using data from WDNR 2009 survey.

Northern water milfoil, arguably Wisconsin's most common native milfoil species, was also fairly widespread throughout Lac Vieux Desert. It does well in lakes with soft sediments and high water clarity. Northern water milfoil is often falsely identified as Eurasian water milfoil, especially since it is known to take on the 'reddish' appearance of Eurasian water milfoil as the plant reacts to sun exposure as the growing season progresses. The feathery foliage of northern water milfoil traps detritus and provides habitat for filamentous algae, in turn creating valuable habitat for aquatic invertebrates. Because northern water milfoil prefers high water clarity, its populations are declining state-wide as lakes are becoming more eutrophic.

Figure 3.3-6 shows that the species richness of Lac Vieux Desert is very high with 51 native aquatic plant species, which is well above the ecoregion and state level. In general, as a given area increases the number of species encountered increases. Lac Vieux Desert is a very large lake with many habitats differing in substrate type, water depth, and water movement. All of these varying habitat characteristics lead to a species-rich environment. For example, flat-stem pondweed and northern water milfoil are usually found growing in soft sediments, while variable pondweed and quillworts are likely to be found inhabiting areas with courser substrates, such as sand. Data collected from the point-intercept survey indicate that approximately 81% of the sampling locations had a soft, organic substrate, 17% contained sand, and 2% contained rock (Map 5).

Table 3.3-1. Aquatic plant species located in Lac Vieux Desert during the July and August 2009 surveys.

Life Form	Scientific Name	Common Name	Coefficient of Conservatism (c)
Emergent	*Bolboschoenus fluviatilis*	River bulrush	5
	Calla palustris	Water arum	9
	Carex comosa	Bristly sedge	5
	Carex lacustris	Lake sedge	6
	Dulichium arundinaceum	Three-way sedge	9
	Equisetum fluviatile	Water horsetail	7
	Eleocharis palustris	Creeping spikerush	6
	Iris versicolor	Northern blue flag	5
	Juncus effusus	Soft rush	4
	Lythrum salicaria	Purple loosestrife	Exotic
	Phragmites australis	Giant reed	1
	Schoenoplectus pungens	Three-square rush	5
	Sagittaria latifolia	Common arrowhead	3
	Scirpus cyperinus	Wool-grass	4
	Schoenoplectus acutus	Hardstem bulrush	5
	Typha latifolia	Broad-leaved cattail	1
	Zizania palustris	Northern wild rice	8
FL	*Nymphaea odorata*	White water lily	6
	Nuphar variegata	Spatterdock	6
FL/E	*Sparganium angustifolium*	Narrow-leaf bur-reed	9
	Sparganium eurycarpum	Common bur-reed	5
	Sparganium fluctuans	Floating-leaf bur-reed	10
Submergent	*Chara sp.*	Muskgrasses	7
	Ceratophyllum demersum	Coontail	3
	Elodea canadensis	Common waterweed	3
	Heteranthera dubia	Water stargrass	6
	Isoetes echinospora	Spiny-spored quilwort	8
	Myriophyllum spicatum	Eurasian water milfoil	Exotic
	Myriophyllum alterniflorum	Alternate-flowered water milfoil	10
	Megalodonta beckii	Water marigold	8
	Myriophyllum sibiricum	Northern water milfoil	7
	Nitella sp.	Stoneworts	7
	Najas flexilis	Slender naiad	6
	Potamogeton illinoensis	Illinois pondweed	6
	Potamogeton crispus	Curly-leaf pondweed	Exotic
	Potamogeton friesii	Fries' pondweed	8
	Potamogeton amplifolius	Large-leaf pondweed	7
	Potamogeton gramineus	Variable pondweed	7
	Potamogeton strictifolius	Stiff pondweed	8
	Potamogeton praelongus	White-stem pondweed	8
	Potamogeton robbinsii	Fern pondweed	8
	Potamogeton richardsonii	Clasping-leaf pondweed	5
	Potamogeton pusillus	Small pondweed	7
	Potamogeton zosteriformis	Flat-stem pondweed	6
	Ranunculus aquatilis	White water-crowfoot	8
	Sagitaria sp. (rosette)	Arrowhead rosette	N/A
SE	*Eleocharis acicularis*	Needle spikerush	5
	Juncus pelocarpus	Brown-fruited rush	8
	Sagittaria graminea	Grass-leaved arrowhead	9
	Sagittaria cuneata	Arum-leaved arrowhead	7
FF	*Lemna minor*	Lesser duckweed	5
	Lemna trisulca	Forked duckweed	6
	Spirodela polyrhiza	Greater duckweed	5

E = Emergent
FL = Floating Leaf
FL/E = Floating Leaf and Emergent
S/E = Submergent and Emergent
FF = Free Floating

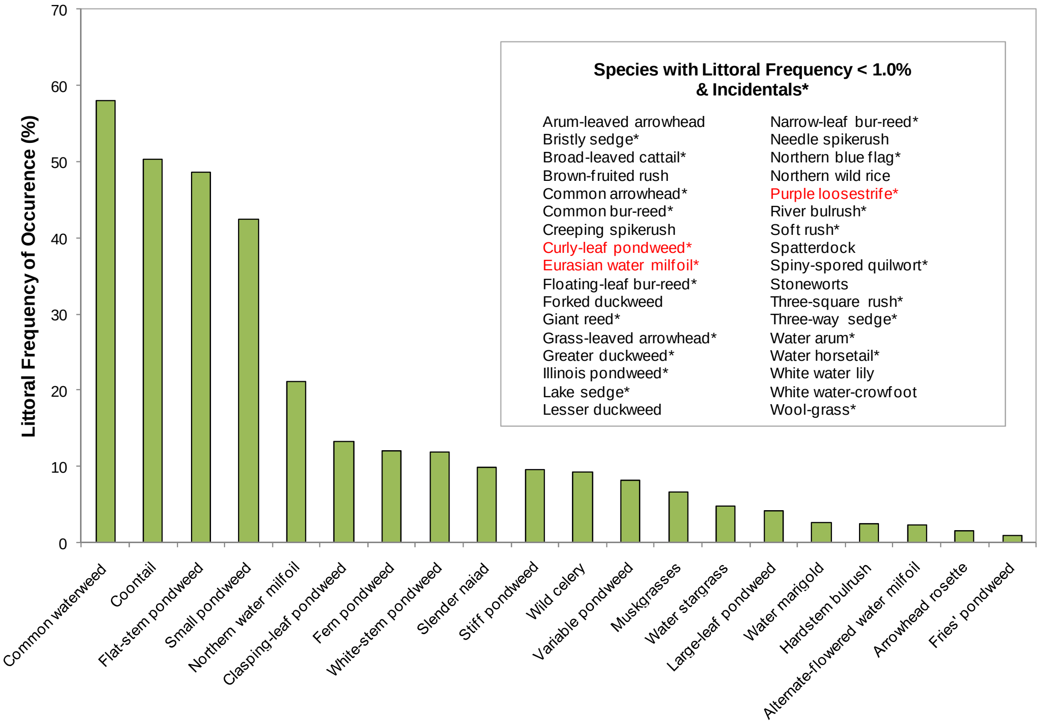

Figure 3.3-4 Lac Vieux Desert aquatic plant littoral frequency of occurrence. Created using data from WDNR and Onterra summer 2009 surveys. Exotic species indicated with red.

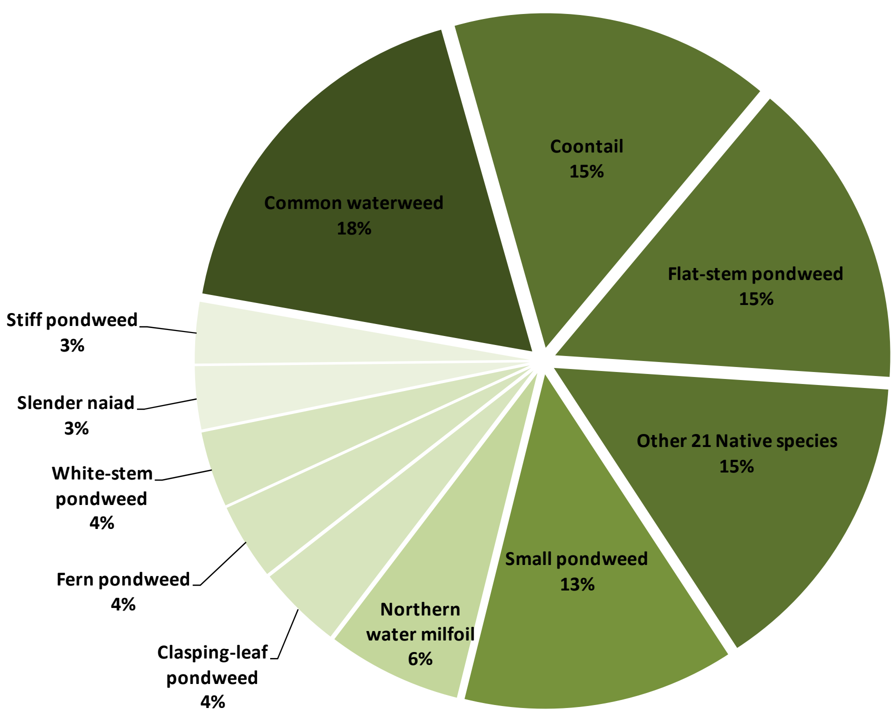

Figure 3.3-5. Lac Vieux Desert aquatic plant relative frequency of occurrence. Created using data from WDNR and Onterra summer 2009 surveys. Exotic species indicated with red.

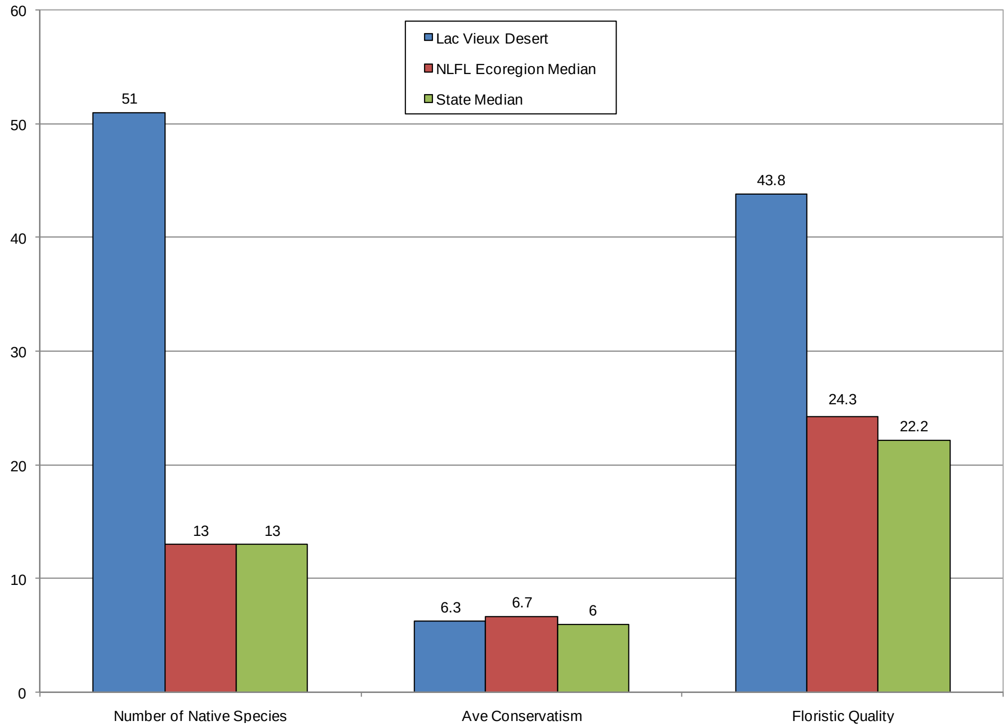

Figure 3.3-6. Lac Vieux Desert Floristic Quality Assessment. Created using data from WDNR and Onterra summer 2009 surveys. Analysis following Nichols (1999).

Lac Vieux Desert contains a high number of aquatic plant species, and because of this, one may assume that the system would also have high species diversity. As discussed earlier, how evenly the species are distributed throughout the system also influences the diversity. The diversity index for Lac Vieux Desert's plant community (0.89) indicates that the lake has a relatively even distribution (relative frequency) of plant species throughout the lake and the community is dominated by one or few species. The data also show that the average conservatism value (6.3) is higher than the state median but slightly below the ecoregion median. This shows that the aquatic plant community of Lac Vieux Desert is more indicative of a pristine condition than other lakes in the state, but it does contain some species that are tolerant to environmental disturbance.

Combining the lake's species richness and average conservatism values to produce its Floristic Quality Index (FQI) results in an exceptionally high value of 43.8 (equation shown below), which is well above the median values of the state and ecoregion (Figure 3.3-5).

FQI = Average Coefficient of Conservatism (6.3) * √ Number of Native Species (51)
FQI = 41.0

The high quality of Lac Vieux Desert's plant community is also indicated by the high incidence of emergent and floating-leaf plant communities that occur throughout the lake. The 2009 community map indicates that approximately 437 acres (10%) of the 4,410-acre lake contains these types of plant communities (Table 3.3-2).

Table 3.3-2. Lac Vieux Desert acres of plant community types from the 2009 community mapping survey.

Plant Community	Acres
Emergent	66.7
Mixed Floating-leaf and Emergent	370.5
Total	437.2

Continuing the analogy that the community map represents a 'snapshot of the important plant communities, a replication of this survey in the future will provide a valuable understanding of the dynamics of these communities within Lac Vieux Desert, especially regarding their change with unnaturally maintained water levels (dammed system with an operating window of 1.37 ft). This is important, because these communities are often negatively affected by recreational use and shoreland development. Radomski and Goeman (2001) found a 66% reduction in vegetation coverage on developed shorelines when compared to undeveloped shorelines in Minnesota Lakes. Furthermore, they also found a significant reduction in abundance and size of northern pike (*Esox lucius*), bluegill (*Lepomis macrochirus*), and pumpkinseed (*Lepomis gibbosus*) associated with these developed shorelines.

Wild Rice Management Plan

First dammed for logging operations in 1870, the Wisconsin Valley Improvement Company (WVIC) began operating the dam in 1907 with the sole intent of using the lake as a reservoir to aid in hydroelectric power generation downstream in the Wisconsin River. In 1937, the WVIC replaced the wooden logging dam with the concrete structure that exists currently.

Photograph 3.3-1 Wild Rice (*Zizania palustris*) Large rice bed growing in Rice Bay, Lac Vieux Desert.

Lac Vieux Desert is one of 21 WVIC water storage reservoirs used to produce as nearly a uniform flow of water as practicable in the Wisconsin and Tomahawk rivers by storing in reservoirs surplus water for discharge when water supply is low to improve the usefulness of the rivers for all public purposes and to reduce flood damage. Figure 3.3-7 shows the operation cycle for these storage reservoirs. During the spring rains and snow melt, the water is stored in the reservoirs to be released during the summer to augment low flows. Some water storage occurs again during the early fall to replenish water supplies released during the summer. Over the winter months, the water is released to help maintain a uniform flow and allow storage capacity in the flowages once the spring rains come again. As alluded to above, this cycle is the 'ideal' storage-release plan when precipitation is at normal levels. Sustained drought or high precipitation periods cause this plan to be altered to prevent flooding of private property, maintain minimal flows in the Wisconsin River.

In 1991, the WVIC began the Federal Energy Regulatory Commission (FERC) relicensing process. During that process, five governmental entities (the Forest Service, in consultation with the Department of the Interior (Bureau of Indian Affairs and U.S. Fish and Wildlife Service), Lac Vieux Desert Band of the Lake Superior Chippewa Indians, Wisconsin Department of Natural Resources, Michigan Department of Natural Resources, and GLIFWC) concluded that the operating regime of the this facility has been detrimental to wild rice populations on Lac Vieux Desert. Essentially, these entities believe that the maximum water level was too high leading to populations reductions of wild rice over time.

Wild rice is an emergent aquatic grass that grows in shallow water of lakes and slow-moving rivers. Wild rice has cultural significance to the Chippewa Tribal Communities where the grain was an important component of Native American diets. Wild rice is also an important diet component for waterfowl, muskrats, deer, and many other species. Established wild rice plant communities can provide valuable nursery and brooding habitat for wetland bird and amphibian species as well as spawning habitat for various fish. Perhaps one of the most overlooked benefits of having established wild rice communities is their ability to utilize excessive plant nutrients, stabilize soils, and form natural wave breaks to protect shoreland areas.

Wild rice is an annual plant that relies strictly on seed production to maintain its population from year-to-year. As described above and shown in Figure 3.3-7, water levels of Lac Vieux Desert are managed to be high during spring. The five entities believe that the high water levels of the lake at that time of year have severely limited seed production and germination, leading to drastic population reductions of wild rice over time. As the name “Rice Bay” suggests, this area historically contained large amounts of wild rice but in 2000, only contained approximately 10 acres of wild rice (Figure 3.3-10).

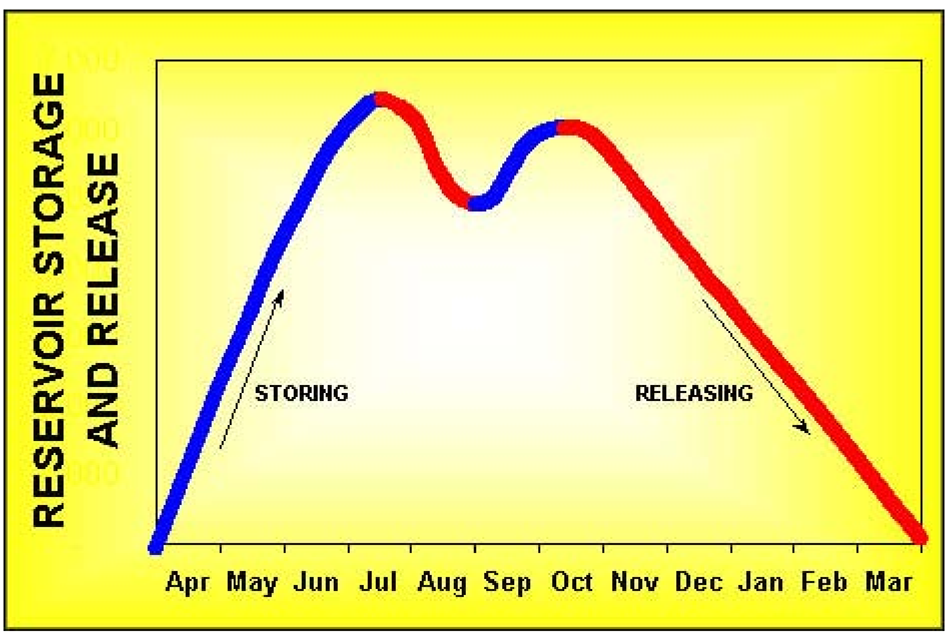

Figure 3.3-7. WVIC reservoir system operation cycle. Figure extracted from WVIC website.

As part of the FERC operation license, the minimum and maximum water levels are set for each waterbody. As a natural lake reservoir, Lac Vieux Desert’s water levels are maintained within a relatively narrow range in comparison to the five man-made reservoirs which exhibit changes of water levels that could span 10-20 feet in a single year. In addition to establishing a range of water levels, minimum outflows are also set to make sure the downstream riverine systems are not negatively impacted by abnormally low flows. For instance in Lac Vieux Desert, even if water levels are at the minimum threshold, the dam still needs to release 5.5 cubic feet per second of water flow to the Wisconsin River.

Article 114 of the WVIC's current FERC license requires a 10-year trial period of wild rice restoration and monitoring in Lac Vieux Desert. After 6 years of appeals and litigation, this plan established a trial period from 2003-2012 where the maximum water level was reduced by 0.8 feet (approximately 9.5 inches). Collected by the WVIC telemeter station, the water levels of Lac Vieux Desert since 2002 are shown in Figure 3.3-8. For the most part, water levels were maintained within this 1.4 foot (approximately 16 ¾ inches) window. Precipitation within the drainage basin of this headwater lake greatly affects the ability of water levels to be maintained within this window and allow the WVIC to utilize its water storage capacity effectively.

Figure 3.3-8. Lac Vieux Desert daily water levels from 2003-2010. Data provided by WVIC and complied by Onterra.

Figure 3.3-9 displays the Drought Monitor Index Values for Lac Vieux Desert Lake from the first monitoring date in August of each year (NDMC 2011). Of the nine years of August data displayed in Figure 3.3-9, the watershed of LVD was in a dry condition twice and a drought condition 5 times. Annual precipitation was below normal in 2006-2009, in multiple years by more than 20% (NCDC 2011). Based upon conversations with GLIFWC and the USFS, low precipitation during many years almost completely inhibited the lake levels to reach the new adjusted maximum, especially since 2006.

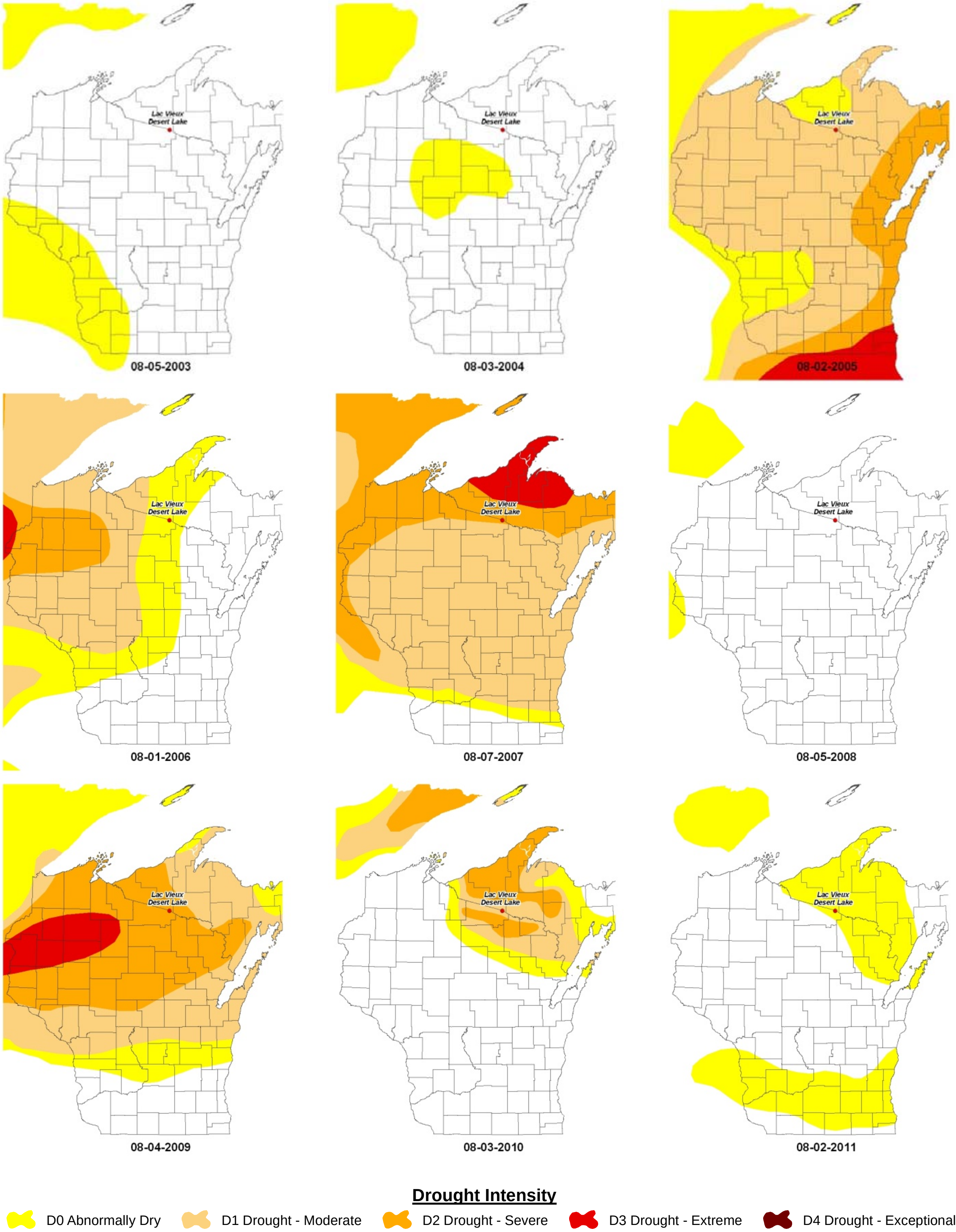

Figure 3.3-9. U.S. Drought Monitor Index Values for first week in August 2003-2011. ESRIC shapefile data downloaded from the National Drought Mitigation Center website.

The main wild rice populations of Lac Vieux Desert are primarily contained within two bays, referred to locally as Misery and Rice Bays (Map 1). Along with altering the water level regime of Lac Vieux Desert to foster wild rice populations, approximately 14,000 pounds of wild rice seed was sown by hand into Rice Bay at an intended application rate of 50 pounds per acre. Misery Bay was not seeded, as the wild rice is thought to inhabit the entire suitable habitat available in this location.

A mid-term monitoring and evaluation report (USDA 2009) was released in 2009. Figure 3.3-10 shows that the acreage of rice in Lac Vieux Desert has increased from a total of 25.4 acres in 2002 (before the trial period began) to 98 acres in 2010 (USDA 2009, and Peter David personal comm.). Almost the entirety of this increase of wild rice acreage was within Rice Bay which is not a surprise considering water depth limits expansion of wild rice acreage in Misery Bay. The goal of the plan states that it wishes to restore "approximately 80-100 acres of wild rice in 7 out of 10 years" (USDA 2009). According to the data presented in Figure 3.3-10, the objectives have been met in only 3 out of 8 years, albeit an increase of approximately 73 acres of wild rice since 2002 with almost 100 acres of wild rice being present on Lac Vieux Desert in 2010 (Figure 3.3-10).

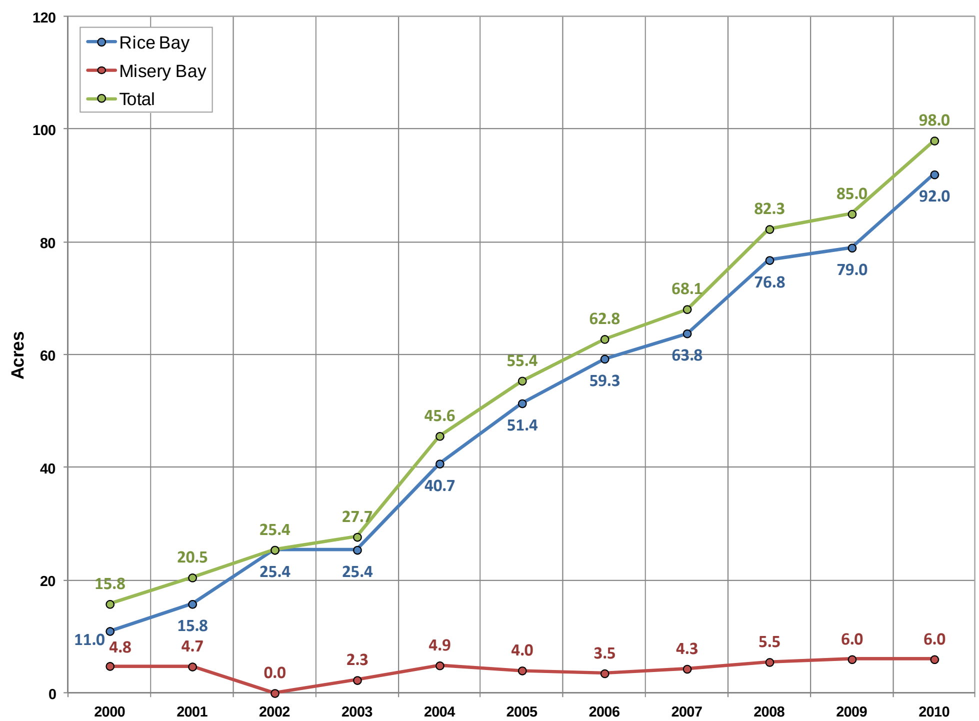

Figure 3.3-10. Lac Vieux Desert wild rice acreage 2000 - 2008. Data provided by GLIFWC and compiled by Onterra in a format similar to that included within the Lac Vieux Desert Wild Rice Enhancement Plan Mid-term Monitoring and Evaluation Report 2009.

While some Lac Vieux Desert riparians are in favor of the wild rice restoration project, many voiced their concerns during the planning project and these concerns are well documented within the comments section of the stakeholder survey (Appendix B). Basically, stakeholders have related the wild rice plan with the low water levels observed in their lake. It is their understanding that without the wild rice plan being in effect, the water levels would not be as low as they observed, particularly since 2006. Many have also correlated a perceived increase in nuisance aquatic plant growth with the low water levels.

In a survey sent to Lac Vieux Desert stakeholders, they indicated that excessive aquatic plant growth is one of their top three concerns regarding Lac Vieux Desert (Appendix B, Question #17). Approximately 85% responded that aquatic plant growth impacts their enjoyment on Lac Vieux Desert some to all of the time, and 70% feel that aquatic plant control is needed in the lake (Appendix B, Question #18 and #19). The aquatic plants that are impeding recreational activities on Lac Vieux Desert are native species.

Figure 3.3-11 shows that average annual water levels are approximately 7.7 inches lower during the summer months (approximately 3.7 inches lower annually) since the maximum water level was set 9.6 inches lower in January 2003. During this period numerous lakes in Wisconsin and Michigan, particularly in this part of the region, have also observed very low water levels. Being a headwater drainage lake, Lac Vieux Desert's water level is particularly vulnerable to low precipitation.

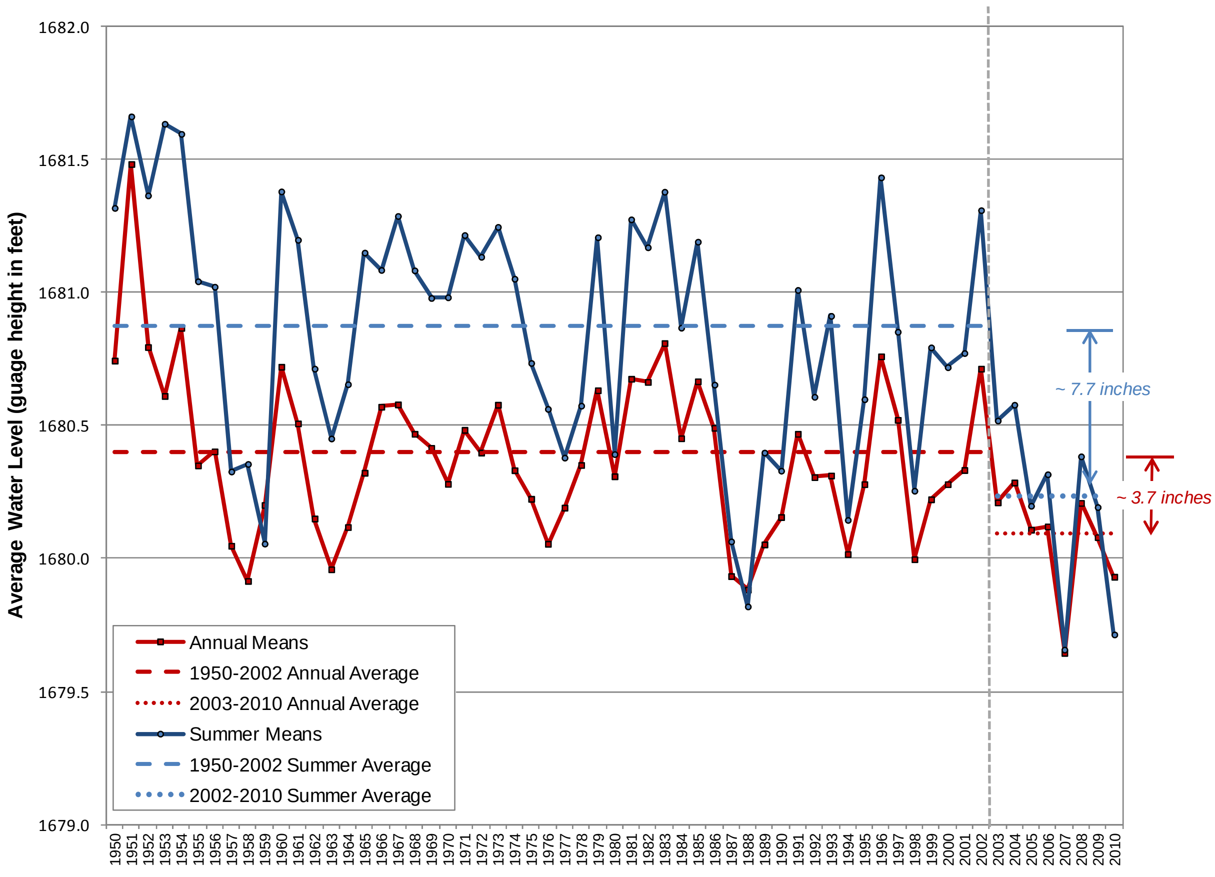

Figure 3.3-11. Lac Vieux Desert average annual water levels from 1950-2010. Data provided by WVIC and complied by Onterra. June, July, and August values comprise the summer means.

As stated above, since 2006, the below normal precipitation associated with the drought affected the water levels of the system. In WVIC's 1996 FERC license (Article 114), the US Forest Service ordered the new lower maximum operating target water level elevation of 1680.73 feet (NGVD). In compliance with this Article, "upon reaching 1680.73 feet, the gates shall be opened, as necessary, to maintain 1680.73 feet." During 2003, 2004, 2005, 2008 and 2010, WVIC was required to release water when 1680.73 feet was reached. Under the previous maximum water level of 1681.53 feet, this water would have been stored which would have increased the summer water levels particularly during the drought years.

Also indicated above, Lac Vieux Desert supports a high biomass of aquatic plants. For the most part, native plants grow to the height of the water in which they reside, with only their reproductive structures breaking the surface. When water levels become low over the course of the summer, the foliage of these plants is now at the water's surface and can manifest the nuisance conditions. Carefully studying Figure 3.3-8, one can see that since the halfway-point in each year (minor gridline referring to June 1), the water levels decrease in almost every year over the course of the summer – except in 2010. Stated another way, this data indicates that the water levels of the system decline as the summer progress. The WVIC's reservoir management plan includes retaining water during late summer (Figure 3.3-7), however drought conditions during many of those summers (Figure 3.3-9) impacted WVIC's ability to increase water levels during this timeframe. Therefore, during those years, the native plants reach the surface during a higher water level and then as water levels fall, their biomass is exacerbated at the surface. Due to higher water levels occurring late in the summer of 2010, it is likely that issues with aquatic plants were not manifested to the same extent during that year. During the years of low precipitation, the natural and planned (WVIC) water level reductions intensify the occurrence and perception of nuisance native plant issues within Lac Vieux Desert. As explained in the previous paragraph, the adjusted maximum water level of 1680.73 feet could exacerbate these nuisance conditions.

It is unrealistic to quantitatively define the term "nuisance," as this designation is subjective by nature. However, WDNR Science Services researchers indicate that nuisance levels of certain plant species likely occur when their frequency of occurrences exceed 35% (Alison Mikulyuk, personal comm.). Plants that can potentially cause nuisance conditions are those that can grow to and/or near the water surface and contain a high biomass (i.e bushy appearance) at or near the surface. In Lac Vieux Desert, common waterweed, coontail, flat-stem pondweed, and small pondweed all exceed this relatively arbitrary benchmark with northern water milfoil populations only slightly below this threshold (Figure 3.3-12). Coontail and common waterweed, at these levels, have the potential to impact navigation, especially when the plants collect into dense surface mats. Even at these frequencies, flat-stem pondweed and small pondweed are often not considered a nuisance due to their thin leaf structures. However, these plants were noted to be especially dense in some areas during the 2010 surveys. At times, northern water milfoil can be found forming dense monocultures similar to their exotic relative, Eurasian water milfoil. Although northern water milfoil colonies typically do not reach the surface, decreasing water levels during the summer can bring these plants into the range that can hamper navigation.

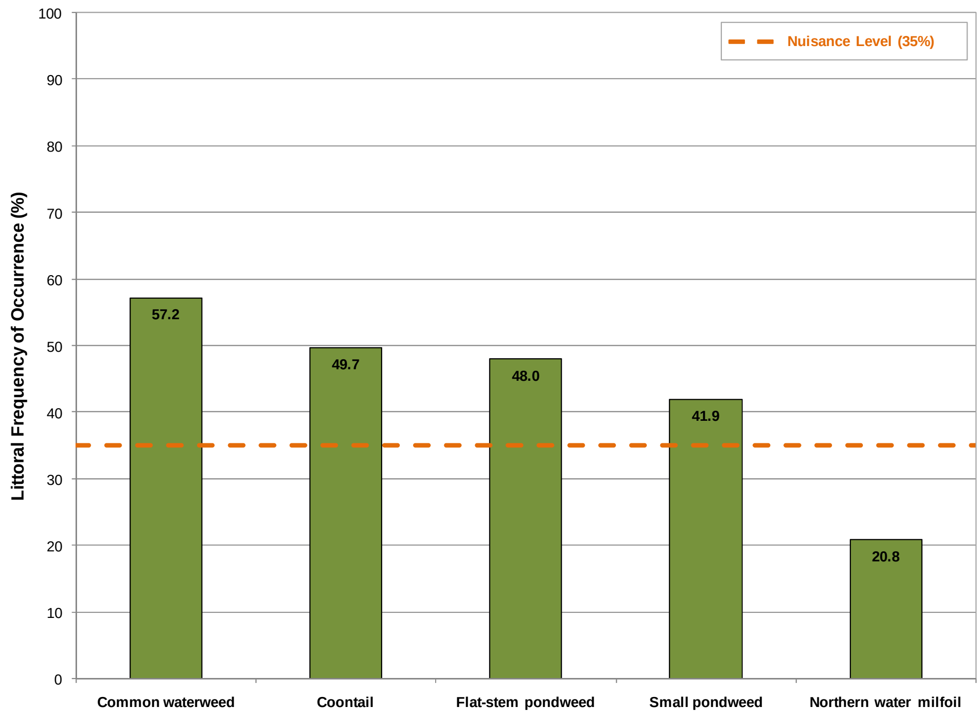

Figure 3.3-12. Lac Vieux Desert littoral frequency of potentially nuisance native aquatic plants. Created using data from WDNR 2009 survey.

At each location within the point-intercept survey, a total rake fullness rating was attributed. If the rake was overflowing with plants, it was given a rake fullness rating of 3. If the rake was about half full with plants, it was given a 2 rating; and if only a few plants were on the rake, a rake fullness rating of 1 was given. Map 4 shows that approximately 10% of the sample locations that contained plants were given a rake fullness rating of 3 and approximately 57% of the locations were assigned a rake fullness rating of 2. According to this data, the highest biomass of plants can be found within Thunder Bay and extending outward from Outlet Bay.

Non-native Aquatic Plants

Curly-leaf Pondweed

As stated above, no curly-leaf pondweed was actually observed growing in Lac Vieux Desert during the various studies associated with the planning project, but a few floating fragments were encountered. It was presumed possible that these fragments were not from plants growing in Lac Vieux Desert, but rather were brought in on a boat trailer from other lakes. Especially considering there were two separate incidences where fragments were observed, it seemed far more likely that these plants did originate from a small colony or isolated plants somewhere within Lac Vieux Desert. In 2012, the ISCCW Lakeguards did locate rooted curly-leaf pondweed populations within the lake.

It is Onterra's experience that curly-leaf pondweed does very well in nutrient-rich, productive lakes like Lac Vieux Desert, and with time these plants may expand into small plant colonies and begin displacing native plant communities. However, some lake managers believe that curly-leaf pondweed for some reason is not as aggressive in northern Wisconsin lakes. Rather than acting invasively it becomes naturalized, integrating itself into the native plant community without creating a significant ecological disturbance.

Eurasian water milfoil

In 2008, Eurasian water milfoil (EWM) was located in Lac Vieux Desert by members of the Invasive Species Control Coalition of Watersmeet and verified by the Wisconsin Department of Natural Resources. Subsequent data was collected by the Great Lakes Indian Fish and Wildlife Commission (GLIFWC).

In 2009, the WDNR awarded the Lac Vieux Desert Lake Association with AIS Rapid Response Grant Funds to aid in the costs associated with the new infestation. On May 27, 2009, Onterra ecologists visited the lake and mapped the existing EWM (Map 3). The EWM consisted of numerous clumps northwest of the boat landing in Thunder Bay. During the early summer of 2009, approximately 1.8 acres were treated with granular 2,4-D at an application rate of 150 lbs per acre (2.10 ppm 2,4-D acid equivalent based on an average depth of 5 feet).

On May 19, 2010, Onterra ecologists visited the treatment area to determine if the site warranted further treatment. They found only four occurrences of EWM each made up of a few single plants. Using a rake, they believed they were able to remove all (foliage and roots) of the observed EWM making a 2010 treatment unnecessary. Another whole-lake meander survey conducted on May 25, 2010 did not locate any additional occurrences of Eurasian water milfoil.

On September 3, 2011 a few Eurasian water milfoil occurrences were located on the Michigan side of the lake in Slaughter Bay (Map 6). This survey was conducted by Bill Artwich who is contracted by ISCCW Lakeguards to perform aquatic invasive species surveys on a number of specified Watersmeet Township lakes each summer. These occurrences are located in front of National Forest property (in Michigan, the riparian property boundaries extend out from one's property to the center of the lake) which prompted the involvement of Ottawa National Forest Botanist, Ian Shackleford. On September 26, 2011 Mr Shackleford along with another US Forest Service biologist, John Pagel, visited the lake with the intent of removing the newly located plants using snorkeling techniques. They located two of the three plants marked earlier by Mr. Artwich and removed them, although the root system of the more robust plant of the two likely was not fully extracted.

Special Note: Additional Eurasian water milfoil occurrences were located by the GLIFWC, ISSCW, and USFS after this management plan was finalized, but before printing. These locations have been integrated into Map 7 for reference.

Purple loosestrife

Three occurrences of purple loosestrife were located on two of the islands in Lac Vieux Desert (Map 2). Purple loosestrife is a perennial herbaceous plant native to Europe and was likely brought over to North America as a garden ornamental. This plant escaped from its garden landscape into wetland environmental where it is able to out-compete our native plants for space and resources.

The infestation of purple loosestrife on Lac Vieux Desert is likely a recent occurrence. There are a number of effective control strategies for combating this aggressive plant, including herbicide application, biological control by beetles, and manual hand removal. At this time, hand removal by volunteers is likely the best option as outlined within the Implementation Plan Section. Additional purple loosestrife monitoring would be required to ensure the eradication of the plant from the shorelines of Lac Vieux Desert.

Giant Reed

During the aquatic plant community mapping survey, some larger colonies of a tall emergent plant known as giant reed (*Phragmites australis*) were located (Map 2). It is believed that populations of common reed existed in pre-colonial Wisconsin, but exotic strains from Europe have been introduced and have invaded the genetic line of the native strain. Genetic identification of the plant is needed to determine whether the plant is a native or non-native strain; however the majority of these plants occurrences are exotic. A pressed specimen of this species from Lac Vieux Desert Lake was sent to Dr. Robert Freckman at University of Wisconsin – Steven's Point where morphologically it appeared to be a native strain.

Although this plant appears to be morphologically native, it is recommended that this population be monitored for expansion. If it appears that the plant is spreading along the shorelines of Lac Vieux Desert Lake, the regional WDNR Lake Specialist should be contacted to coordinate sending in plant specimens for genetic testing. If the common reed is determined to be an exotic strain, it should be removed by cutting and bagging the seed heads and applying herbicide to the cut ends. This management strategy is most effective when completed in late summer or early fall when the plant is actively storing sugars and carbohydrates in its root system in preparation for over-wintering. If this or other populations expand greatly, a management action would need to be developed to coordinate its control.

3.4 Lac Vieux Desert Fisheries Data Integration

Fishery management is an important aspect in the comprehensive management of a lake ecosystem; therefore, a brief summary of readily available data is included here as 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 numerous fisheries biologists overseeing Lac Vieux Desert Lake (WDNR, MDNR, GLIFWC, and LVD Tribe). The US Forest Service and WVIC work jointly with these agencies to assist in various fisheries surveys and other forms of lake monitoring.

The goal of this section is to provide a summary overview of some of the data that exists, particularly in regards to specific issues (e.g. spear fishery, water levels, angling regulations, etc) that were brought forth by the LVDLA stakeholders within the stakeholder survey and other planning activities. In some instances, the figures supplied by these entities were recreated by Onterra and displayed in the same fashion as included within other reports, such as the Lac Vieux Desert Wild Rice Enhancement Plan Mid-term Monitoring and Evaluation Report (2009).

Lac Vieux Desert Fishing Activity

Based on data collected from the stakeholder survey (Appendix B), open water fishing was the highest ranked important or enjoyable activity on Lac Vieux Desert, followed by ice fishing (Question #10). Approximately 77% of these same respondents rated the quality of fishing on the lake as being fair to excellent (Question #7); however, approximately 94% believe that the quality of fishing has remained the same or gotten worse since they have obtained their property (Question #8).

Table 3.4-1 and Table 3.4-2 show the popular game fish and non-game fish species that are present in the system. In Lac Vieux Desert, there is great concern amongst lake stakeholders regarding not only the fishery, but the abundant aquatic plants that reside in the lake. 84.5% of stakeholder survey respondents indicated that native plant communities sometimes or always impact their enjoyment of the lakes (Appendix B, Question #18) and 70.5% of survey respondents feel aquatic plant control is needed on the lake (Appendix B, Question #19). Additionally, "Aquatic invasive species" ranks as the top concern of these stakeholders, and "Excessive aquatic plant growth" ranks second (Appendix B, Question #17). Actions to control Eurasian water milfoil (herbicide applications) have already taken place on a small scale within the lake. Should additional aquatic plant (native or non-native) management happen on Lac Vieux Desert it will be important to understand how this management may impact fish species. Herbicide applications or mechanical harvesting should occur in May or early June when the water temperatures are below 65°F. Species that spawn in late spring or early summer may be impacted as water temperatures and spawning locations often overlap, and vital nursery areas for emerged fry could become vulnerable. Again, please note that at this time intensive aquatic plant management is not recommended.

Table 3.4-1. Gamefish present in Lac Vieux Desert with corresponding biological information (Becker, 1983)**.**

Common Name	Scientific Name	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Black Bullhead	*Ictalurus melas*	5	April - June	Matted vegetation, woody debris, overhanging banks	Amphipods, insect larvae and adults, fish, detritus, algae
Black Crappie	*Pomoxis nigromaculatus*	7	May - June	Near *Chara* or other vegetation, over sand or fine gravel	Fish, cladocera, insect larvae, other invertebrates
Bluegill	*Lepomis macrochirus*	11	Late May - Early August	Shallow water with sand or gravel bottom	Fish, crayfish, aquatic insects and other invertebrates
Largemouth Bass	*Micropterus salmoides*	13	Late April - Early July	Shallow, quiet bays with emergent vegetation	Fish, amphipods, algae, crayfish and other invertebrates
Muskellunge	*Esox masquinongy*	30	Mid April - mid May	Shallow bays over muck bottom with dead vegetation, 6 - 30 in.	Fish including other muskies, small mammals, shore birds, frogs
Northern Pike	*Esox lucius*	25	Late March - Early April	Shallow, flooded marshes with emergent vegetation with fine leaves	Fish including other pikes, 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 (ter. and aq.)
Rock Bass	*Ambloplites rupestris*	13	Late May - Early June	Bottom of course sand or gravel, 1cm-1m deep	Crustaceans, insect larvae, and other inverts
Smallmouth Bass	*Micropterus dolomieu*	13	Mid May - June	Nests more common on North and West shorelines, over gravel	Small fish including other bass, crayfish, insects (aq. and ter)
Walleye	*Sander vitreus*	18	Mid April - Early May	Rocky, wavewashed shallows, inlet streams on gravel bottoms	Fish, fly and other insect larvae, crayfish
Yellow Perch	*Perca flavescens*	13	April - Early May	Sheltered areas, emergent and submergent veg	Small fish, aquatic invertebrates

Table 3.4-2 Non-gamefish present in Lac Vieux Desert. Information provided by Steve Gilbert (WDNR).

Common Name	Scientific Name	Common Name	Scientific Name
Bluntnose minnow	*Pimephales notatus*	Shorthead Redhorse	*Moxostoma macrolepidotum*
Burbot	*Lota lota*	Trout Perch	*Percopsis omiscomaycus*
Common Shiner	*Luxilus cornutus*	White Sucker	*Catostomus commersoni*
Golden Shiner	*Notemigonus crysoleucas*		

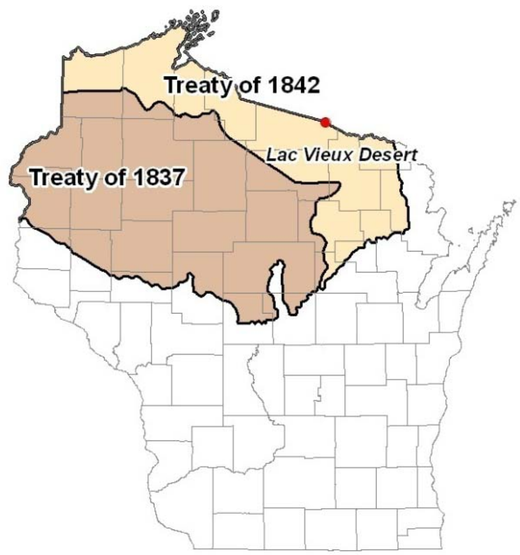

Figure 3.4-1. Location of Lac Vieux Desert within the Native American Ceded Territory (GLIFWC 2010A). This map was digitized by Onterra; therefore it is a representation and not legally binding.

Approximately 22,400 square miles of northern Wisconsin was ceded to the United States by the Lake Superior Chippewa tribes in 1837 and 1842 (Figure 3.4-1). Lac Vieux Desert falls within the ceded territory based on the Treaty of 1842. This allows for a regulated open water spear fishery by Native Americans on specified systems. This highly structured process begins with an annual meeting between tribal and state management authorities. Reviews of population estimates are made for ceded territory lakes, and then an "allowable catch" is established, based upon estimates of a sustainable harvest of the fishing stock (age 3 to age 5 fish). This figure is usually about 35% of a lake's fishing stock, but may vary on an individual lake basis. In lakes where population estimates are out of date by 3 years, a standard percentage is used. The allowable catch number is then reduced by a percentage agreed upon by biologists that reflects the confidence they have in their population estimates for the particular lake. This number is called the "safe harvest level". The safe harvest is a conservative estimate of the number of fish that can be harvested by a combination of tribal spearing and state-licensed anglers. The safe harvest is then multiplied by the Indian communities claim percent, or declaration. This result is called the quota, and represents the maximum number of fish that can be taken by tribal spearers (Spangler, 2009). Daily bag limits for walleye are then reduced for hook-and-line anglers to accommodate the tribal quota and prevent over-fishing. Bag limits reductions may be increased at the end of May on lakes that are lightly speared. The tribes have historically selected a percentage which allows for a 2 fish daily bag limit for hook-and-line anglers (USDI 2007).

Spearers target muskellunge, walleye, during the open water season, and occasionally also harvest northern pike, and bass. The spear harvest is monitored through a nightly permit system and a complete monitoring of the harvest (GLIFWC 2010B). Creel clerks and tribal wardens are assigned to each lake at the designated boat landing. A catch report is completed for each boating party upon return to the boat landing. In addition to counting every fish harvested, the first 100 walleye (plus all those in the last boat) are measured and sexed. An updated nightly quota is determined each morning by 9 a.m. based on the data collected from the successful spearers. Harvest of a particular species ends once the quota is met or the season ends. In 2011, a new reporting requirement went into effect on lakes with smaller quotas. Starting with the 2011 spear harvest season, on lakes with a harvestable quota of 75 or fewer fish, reporting of harvests may take place at a location other than the landing of the speared lake.

Spearing rights are exercised on Lac Vieux Desert Lake by the Mole Lake (Sokaogon) and Lac Vieux Desert Tribes in Wisconsin and Michigan, respectively. While differences exist in the specifics of the tribal spear harvest program in Michigan and Wisconsin, its operation is very similar. The following paragraphs present data from both the Lac Vieux Desert and Mole Lake Tribes when available, but more readily available data exists from the Wisconsin perspective.

Walleye are the most commonly spear harvested species in Lac Vieux Desert (Table 3.4-3), while muskellunge are being harvested twice during the open water spear fishery by the Mole Lake Tribe (Table 3.4-4). These open water spear harvest records are provided in Table 3.4-3 and 3.4-3. One common misconception noted from the stakeholder survey (Appendix B – Written Comments) is that the spear harvest targets the large spawning females. Table 3.4-3 and Figure 3.4-2 clearly show that the opposite is true with only 6.5% of the Mole Lake's total walleye harvest (368 of 5,679 fish) since 1998 comprising of female fish on Lac Vieux Desert. Tribal spearers may only take two walleyes over twenty inches per nightly permit; one between 20 and 24 inches and one of any size over 20 inches (GLIWC 2010B). This regulation limits the harvest of the larger, spawning female walleye.

Table 3.4-3. Walleye spear harvest records for Lac Vieux Desert Lake by Mole Lake and LVD Tribes (GLIFWC annual reports for Lac Vieux Desert, Krueger 1998-2009 and data provided by Mark Luehring, GLIFWC).

Year	Mole Lake Tribal Total	Lac Vieux Desert Tribal Total	Total
1998	293	254	547
1999	178	188	366
2000	631	191	822
2001	687	254	941
2002	434	0	434
2003	855	619	1474
2004	593	536	1129
2005	771	299	1070
2006	596	296	892
2007	647	224	871
2008	425	225	650
2009	828	453	1281

Table 3.4-4. Open water muskellunge spear harvest records for Lac Vieux Desert Lake by Mole Lake Tribe (GLIFWC annual reports for Lac Vieux Desert, Krueger 1998-2009).

Year	Tribal Quota	Total Harvest	% Quota	Mean Length* (in)
1998	14	3	21.4	34.2
1999	18	0	-	-
2000	17	0	-	-
2001	19	0	-	-
2002	18	1	5.6	36.0
2003	17	0	-	-
2004	17	0	-	-
2005	16	0	-	-
2006	17	0	-	-
2007	17	0	-	-
2008	34	0	-	-
2009	18	3	16.7	39.9

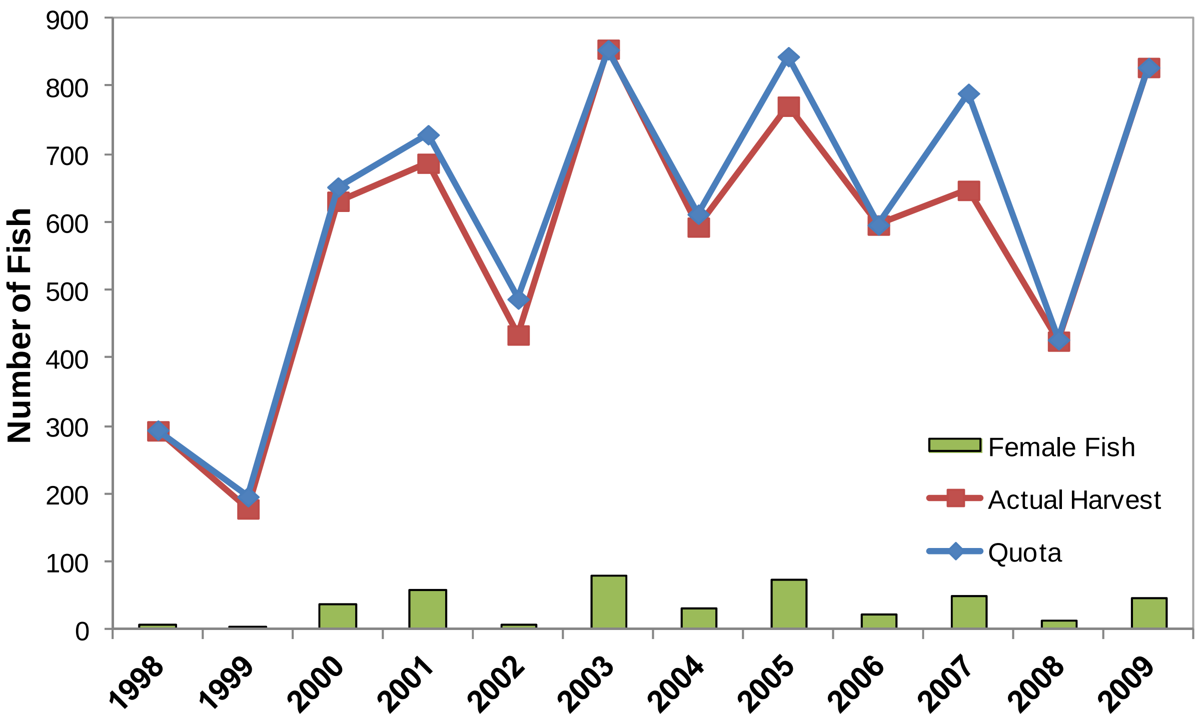

Figure 3.4-2. Walleye spear harvest data by Mole Lake Tribe. Annual total walleye harvest and female walleye harvest are displayed since 1998 from GLIFWC annual reports for Lac Vieux Desert (Krueger 1998-2009).

Because of the intensive efforts by the WDNR, GLIFWC, Forest Service and WVIC, a wealth of information has been collected on the fishery of Lac Vieux Desert. As explained above, this helps managers determine regulations for the waterbody in terms of setting the safe harvest and quotas for tribal spearing, as well as setting hook and line angler bag and length limits on an annual basis. For example, in 2006, in addition to annual tribal harvest surveys, studies were conducted by the WDNR to estimate the adult gamefish populations in Lac Vieux Desert as well as hook and line angler harvest. The gamefish populations were estimated through mark-recapture surveys, where fish are sampled once and "marked" using a fin clip. The adult population is sampled again days later in hopes that some of these marked fish are recaptured. When this occurs, a mathematical relationship can be used to estimate abundance. During this same year, angler effort and fish harvest was estimated by creel surveys. During a creel survey, anglers are polled as they leave the lake in terms of their fishing habits, effort, and harvests.

In 2006, the WDNR estimated Lac Vieux Desert to hold over 10,000 adult walleye, or about 2.4 per acre. A total of 892 walleye were harvested by tribal spearers (Mole and LVD tribes), while through creel estimates anglers harvested about 3,061 walleye. Figure 3.4-3 displays what estimates reveal occurred to the 2006 adult walleye population in Lac Vieux Desert. During this year, hook and line anglers harvested 32% of the estimated population, while tribal spearing accounted for 9% of the population represented.

Lac Vieux Desert is a popular fishing destination, which is confirmed by the 2006 creel survey. In total, anglers spent 192,910 hours or 44.9 hours per acre fishing this lake. This effort is greater than the statewide lake average and Vilas County lake average. Walleye was the most sought after gamefish during 2006, with 79,989 hours of directed effort. In summary, angler fishing effort on Lac Vieux Desert is significant.

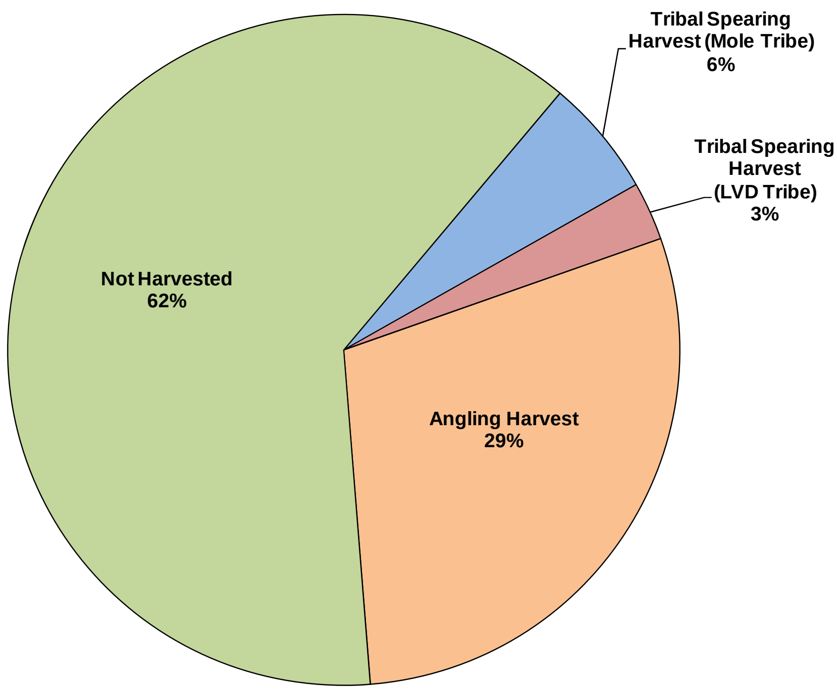

Figure 3.4-3. Lac Vieux Desert 2006 walleye population summary. Figure describes the fate of 2006 adult walleyes within the lake. Total adult population determined by spring 2006 WDNR surveys. Angler harvest determined by a 2006 WDNR creel survey. Tribal spearing harvests provided by GLIFWC (annual report for Lac Vieux Desert, Krueger 2006) and Mark Luehring, GLIFWC.

Fishing Regulations

Because Lac Vieux Desert is located within ceded territory, special fisheries regulations may occur. In addition to this, special fishing regulations may be placed on this lake because it is located on the Wisconsin / Michigan boundary. In Vilas County, the minimum length limit on walleye is 15 inches and a there is a daily bag limit of 3. An adjusted walleye bag limit pamphlet is distributed each year by the WDNR which explains the more restrictive bag limits that may pertain to Lac Vieux Desert. In 2010, the daily bag limit was set at 2 for the lake, while the length limit remained at 15 inches (for the Wisconsin side of Lac Vieux Desert). Anglers fishing the Michigan side of the lake have a daily bag limit of 5 walleyes. In short, an angler must abide by the bag limits based upon their geographical location on Lac Vieux Desert (the Wisconsin side or Michigan side) and not based upon whether they have a Wisconsin or Michigan fishing license, though a license from either state is required. Anglers are limited to a daily catch of 5 fish if they choose to fish both sides of the lake; a catch of 7 fish, 2 from Wisconsin and 5 from Michigan, is not allowed.

In addition to special bag limits, other regulations differ and apply for fishing Lac Vieux Desert. For example, trolling (fishing from a moving boat) regulations differ from the Wisconsin side to the Michigan side. Anglers, regardless of state residency or license, can legally troll on the Michigan side of Lac Vieux Desert, while this fishing practice is illegal on the Wisconsin side. It is illegal to use goldfish, alewife or crayfish as bait (or to possess them at all) in Wisconsin waters, however it is only illegal to use or possess crayfish in Michigan waters. On the entire lake, muskellunge harvests are set at 1 fish per day, with a minimum length of 40 inches. This length limit may be changed annually based upon tribal declarations.

The WDNR has identified Lac Vieux Desert as a "quality" muskellunge fishery. The lake has produced many large fish of this species, including the state and world record hybrid muskellunge (51 lbs. 3 oz – 1919). The WDNR has declared Lac Vieux Desert a Class A2 muskellunge fishery, meaning the lake is known for producing many fish, but larger fish make up a smaller percent of the total population. Based on surveys conducted in 2006 and 2007, the WDNR estimated 536 muskellunge (0.12 fish/acre) over 30 inches to be present in Lac Vieux Desert (USGS 2009). Because this is a quality fishery, special regulations may be set for muskellunge within the waterbody. However, in 2010 the bag limit and length restriction for muskellunge in Lac Vieux Desert remained at the level set for all of Vilas County (1 fish per day, minimum length of 40 inches).

Lac Vieux Desert Fish Stocking

To assist in meeting fisheries management goals, the fisheries managers may stock fish in a waterbody that were raised in nearby state run hatcheries. Stocking of a lake is sometimes done to assist the population of a species due to a lack of natural reproduction in the system, or to otherwise enhance angling opportunities. Fish can be stocked as fry, fingerlings or even as adults.

In recent years, both muskellunge and walleye have been stocked in Lac Vieux Desert. The WDNR harvested walleye eggs from Lac Vieux Desert between 1986 and 1999. The eggs were reared at the Woodruff Hatchery and stocked in other area waters. This activity brought forth numerous concerns from stakeholders and for reasons deemed "more social than biological," some of the reared walleyes were put back into the lake (USDA 2009). Figures 3.4-4 and 3.4-5 display the stocking that has occurred on the lake. Stocking has been made possible through the efforts of the WDNR, LVD Tribe, and Lac Vieux Desert Association, who has funded the stocking for all extended growth walleye noted in Figure 3.4-4.

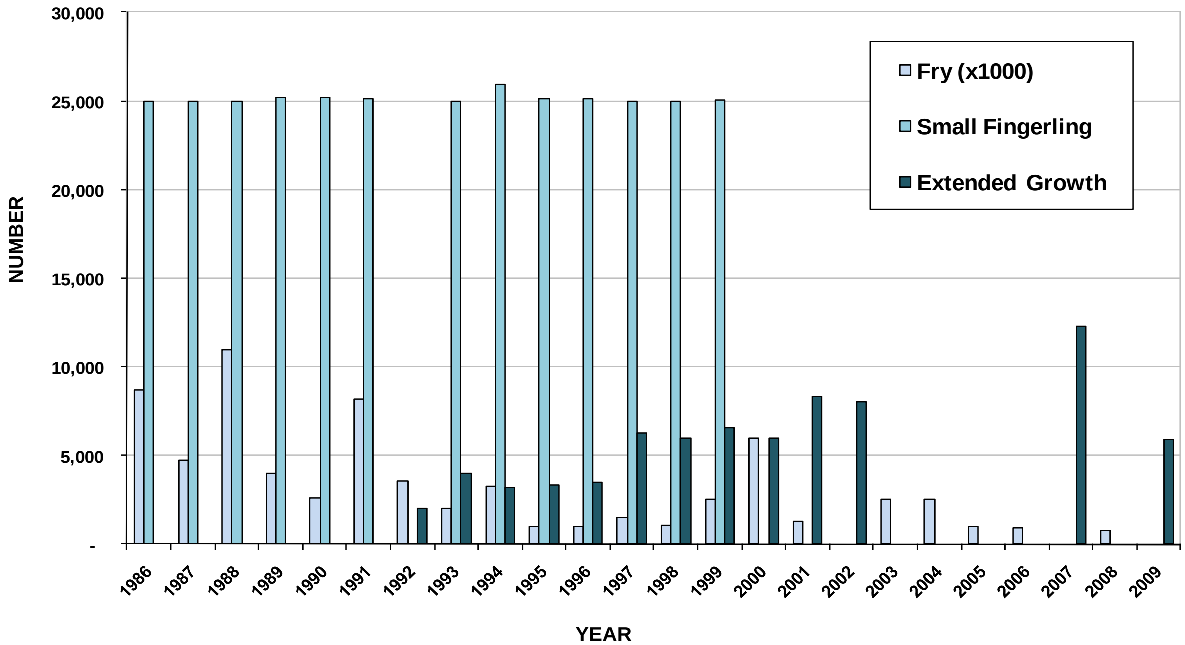

Figure 3.4-4. Lac Vieux Desert walleye stocking totals from 1986-2009. Figure provided by Steve Gilbert (WDNR) and adapted by Onterra. Figure includes stocking efforts by the WDNR, LVD Tribe and the Lac Vieux Desert Association.

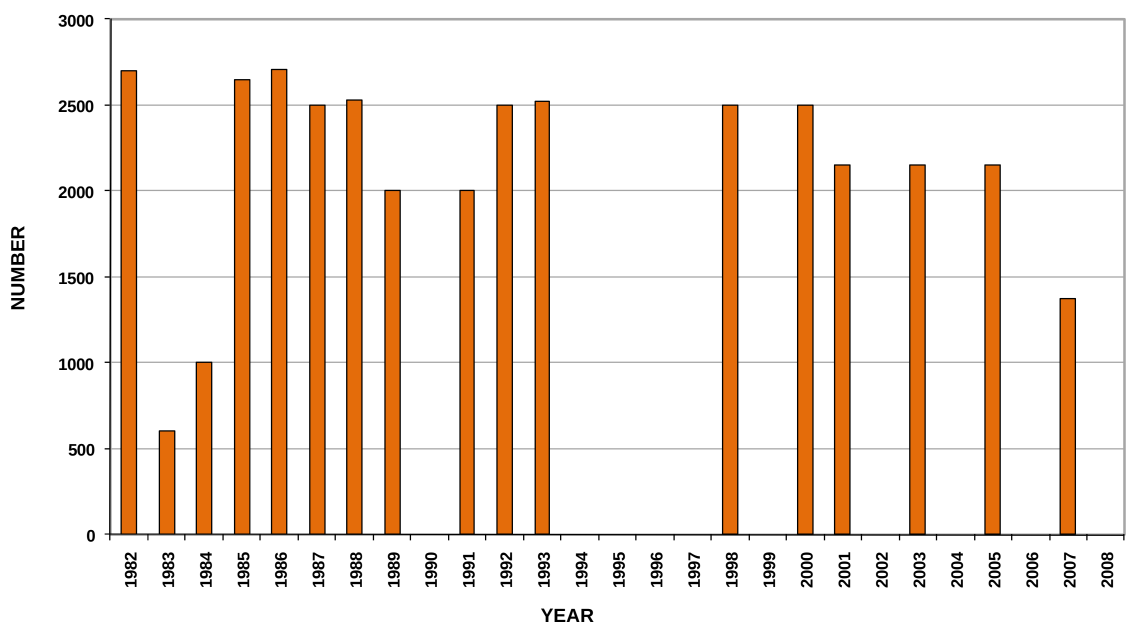

Figure 3.4-5. Lac Vieux Desert muskellunge stocking totals from 1982-2008. Figure provided by Steve Gilbert (WDNR) and adapted by Onterra.

The Lac Vieux Desert Tribe started their fish hatchery program in 1992 and has actively stocked walleye in lakes that receive pressure from the spear harvest. Adult walleyes would be briefly captured from Lac Vieux Desert Lake in fyke nets for biologists to collect their eggs and milt before they would be released back into the lake. In the past, some fry were returned to Lac Vieux Desert Lake and others were placed into the two half-acre rearing ponds built in 2009.

Lac Vieux Desert Rice Study and Fish Monitoring

As part of an USDA ten year study concerning the wild rice on Lac Vieux Desert (this was discussed in the aquatic vegetation section), fish relative abundance studies and creel census reports are being monitored during this time period. These surveys are being conducted during baseline (2001) conditions, as well as half-way through (2006) and following (2012) the rice study. Agencies participating in fisheries data collection and analysis include GLIFWC, Woodruff WDNR, Park Falls WDNR, and the Michigan DNRE (USDA 2009).

Between the 2001 and 2006 surveys, investigators found a total of 18 different fish species in Lac Vieux Desert. The dominance of these fish species were very similar between 2001 and 2006, with the lake being dominated by walleye and yellow perch. Northern pike were found in moderate numbers, with muskellunge being found in low to moderate numbers both years. Both large and smallmouth bass were found in relatively low amounts.

Thus far, the study has indicated two changes occurring with the Lac Vieux Desert fishery. The first is that black crappie numbers are steadily increasing. Secondly, walleye recruitment is decreasing within the lake. Recruitment is the process of adding new individuals to the populations and fall young of year (YOY) surveys provide a good understanding of walleye reproduction. As shown on Figure 3.4-6, walleye recruitment was considered above average for naturally reproducing lakes for almost all year between 1995 and 2002. Since then, recruitment has been below the average for naturally reproducing lakes and since 2006, below the average for stocked lakes.

Within the Wild Rice Plan Mid-Term Monitoring and Evaluation Report several factors are related to this decline including the long history of “boom and bust” walleye recruitment on the lake, and the prolonged period of drought that northern Wisconsin has been experiencing since 2003 (USDA 2009). By combining population estimate studies done by both GLIFWC and the WDNR, Figure 3.4-7 illustrates the impact this may be having on the walleye population. Some research has indicated that when crappie abundance is high, predation on larval walleyes is also high and reduces walleye recruitment, regardless of other conditions such as water temperature or water level (Quist et al. 2003). It is unclear if adult black crappie numbers are at levels that would affect other species at this point. This may be another factor related to the “boom and bust” cycle that biologists believe occurs in Lac Vieux Desert’s walleye population. Despite the lack in walleye recruitment, fisheries managers believe that the overall adult walleye population, along with northern pike and muskellunge populations, has remained stable between 2001 and 2006 (USDA 2009). However, comparisons between walleye population estimates from 2000 to 2009 show a declining population. But as Figure 3.4-7 indicates, the walleye population in Lac Vieux Desert Lake has fluctuated consistently since 1990 and attributing the recent trend to any one factor is not possible. Additionally, data has been collected between two agencies (WDNR and GLIFWC) using similar, though not entirely comparable methodologies, so comparisons must be made with caution.

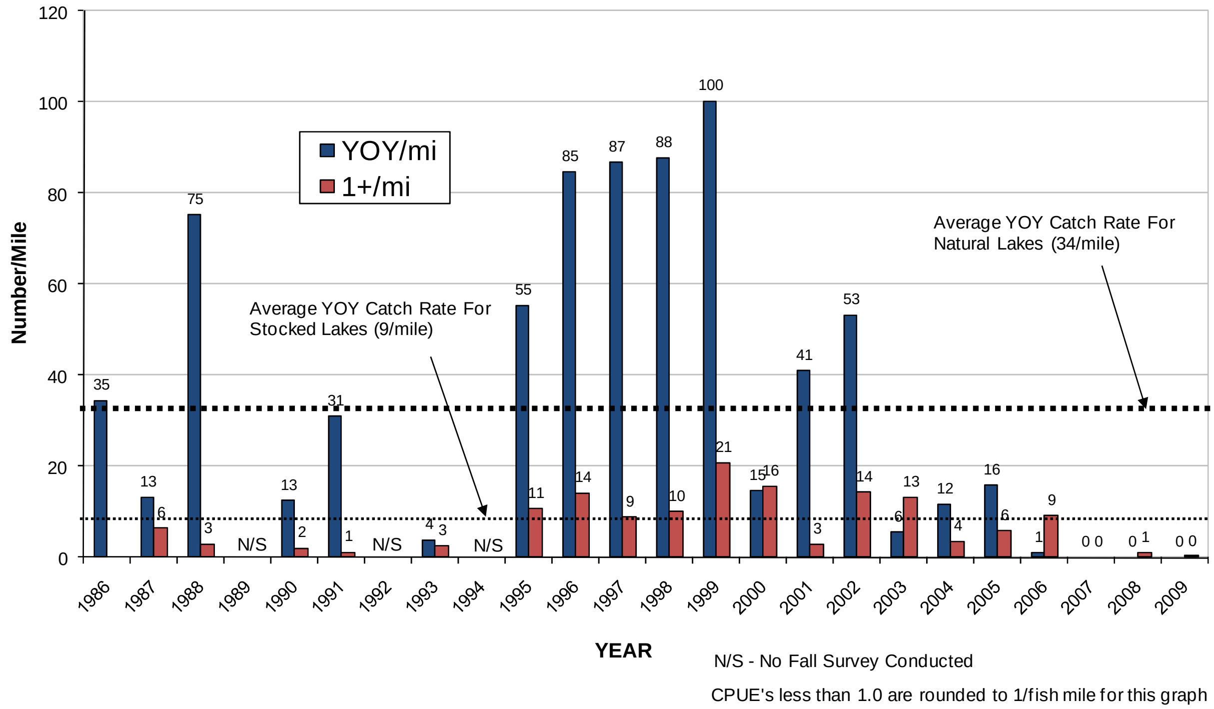

Figure 3.4-6. Lac Vieux Desert fall walleye recruitment history. Data provided by Steve Gilbert (WDNR) and adapted by Onterra. N/S indicates no fall survey was conducted.

Lac Vieux Desert Substrate Type

As discussed in the Aquatic Plant section, it was determined through the 2009 WDNR point-intercept survey that the majority of the substrate in Lac Vieux Desert (81%) is muck, with smaller areas of sand (17%) and rock (2%) (Map 5). Substrate and habitat are critical to fish species that do not provide parental care to their eggs, in other words, the eggs are left after spawning and not tended to by the parent fish. Muskellunge is one species that does not provide parental care to its eggs (Becker 1983). Muskellunge broadcast their eggs over woody debris and detritus, which can be found above sand or muck. These organic materials suspend the eggs above the substrate, so they do not get buried in sediment and suffocate. Walleye is 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 in muck as well.

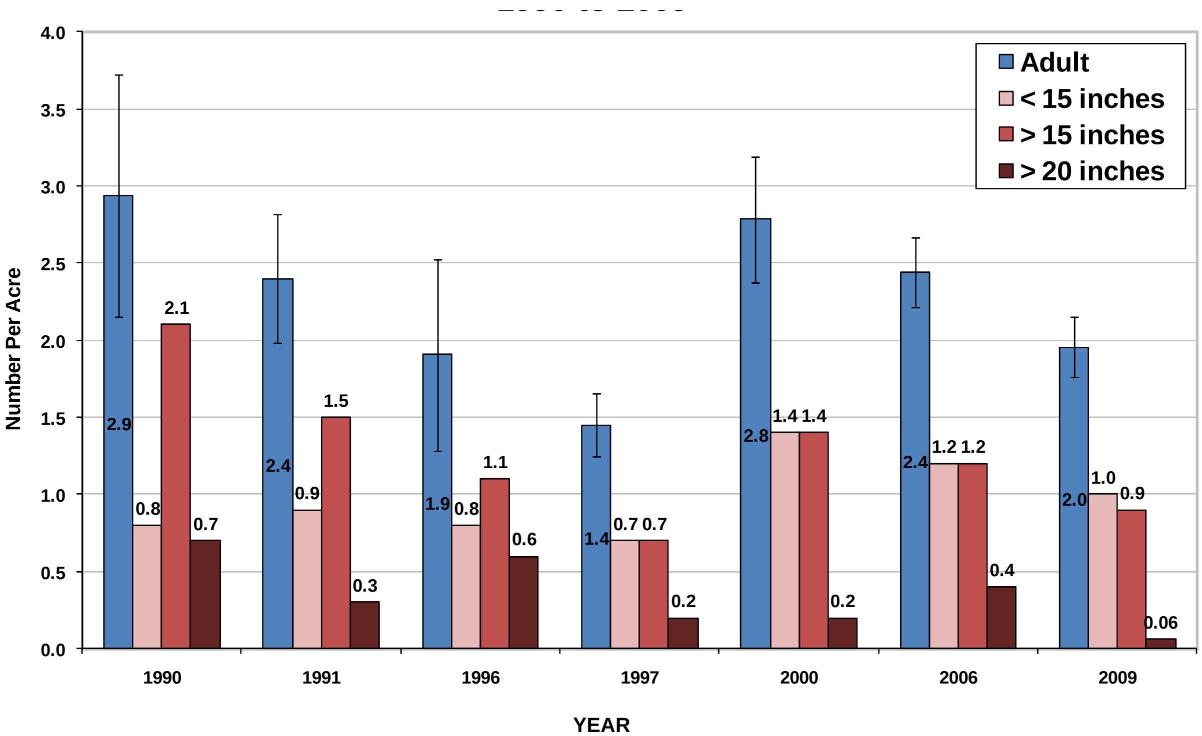

Figure 3.4-7. Lac Vieux Desert walleye population estimates. Estimates of the Lac Vieux Desert walleye population by year. Data provided by Steve Gilbert (WDNR) and adapted by Onterra. Surveys conducted in 1990 and 2006 by WDNR, and 1991, 1996, 1997, 2000 and 2009 by GLIFWC.

4.0 SUMMARY & CONCLUSIONS

The design of this project was intended to fulfill three objectives:

1) Collect baseline data to increase the general understanding of the Lac Vieux Desert Lake ecosystem.
2) Collect detailed information regarding invasive plant species within the lake with a primary focus Eurasian water milfoil which was recently discovered before the project began.
3) Collect sociological information from Lac Vieux Desert Lake stakeholders regarding their use of the lake and their thoughts pertaining to the past and current conditions of the lake and its management.

The three objectives were fulfilled during the project and have lead to a good understanding of the Lac Vieux Desert Lake ecosystem, the folks that care about the lake, and what needs to be completed to protect and enhance it.

As learned during the course of this project, Lac Vieux Desert is a very healthy, productive, and clean lake. There are a number of reasons why this is so. The primary factor in the determination of a lake's health is the condition of its watershed. Lac Vieux Desert does have a fairly large sized watershed, along with several input streams, classifying it as a drainage lake. At the lake's outlet is the beginning of the Wisconsin River, which then travels around 430 miles until it drains into the Mississippi river south of Prairie du Chien. As discussed in the Watershed Section, Lac Vieux Desert's watershed is only slightly larger (a ratio of 4:1) than the area of the lake. Furthermore, the vast majority of the watershed is forested or covered in wetlands, which is beneficial in that these land types are able to filter surface-runoff water before it enters the lake, removing nutrients and sediment. In fact, WiLMS modeling predicted that of all areas contributing phosphorus to the lake, atmospheric deposition upon the surface area of the lake ranked highest, at 44% of the annual load. At this time, the only area of concern would be the watershed's immediate shoreline, which has seen substantial development along some areas of the lake.

It is unfortunate that more water quality data has not been collected on Lac Vieux Desert over the years. However, from the data that has been collected, several conclusions may be made. First, water quality parameters are not "out of line" with what would be expected for the lake. Average annual phosphorus concentrations are comparable to similar lakes statewide and regionally, while chlorophyll-*a* and Secchi disk clarity parameters rank well when compared to these lakes. Secondly, the values collected over the years seem to show some variation. Lac Vieux Desert is likely impacted heavily by annual weather and climactic conditions, which would include precipitation, air temperature and water level.

One thing is certain, the nutrient content of Lac Vieux Desert's water is sufficient to support a healthy population of aquatic plants. Couple this with the large littoral zone of the lake (plants were found up to 19 feet of water), and the potential for large stands of aquatic plants is bound to occur. Between Onterra and WDNR plant surveys, a total of 51 native species were found on the lake. Furthermore, there were many aquatic plant species which could be classified as submergent, emergent, or floating-leaf species. One of the widespread emergent species is

Zizania palustris, or northern wild rice, which is culturally significant and provides terrific spawning and rearing habitat for fish, as well as habitat and food for many other organisms.

These rich aquatic plant communities also aid in the defense against an infestation of invasive aquatic plant species. The presence of Eurasian water milfoil in Lac Vieux Desert was noticed very quickly, and dealt with swiftly. Collaborative efforts have taken place to monitor and control Eurasian water milfoil on Lac Vieux Desert between many groups. The spread of Eurasian water milfoil into the Michigan waters also poses some additional concerns.The Implementation Plan that follows this section details a strategy to continuously monitor the lake for invasive plant species. This plan is well suited for a lake in which numerous managing entities exist, and calls for continued cooperative effort between these entities, which in the end is in the best interest of the management of the lake.

Within the comments section of the stakeholder survey, one of the most common concerns relates to the water levels of Lac Vieux Desert (Appendix B). While it is true that water levels have been controlled due to the ongoing management of wild rice in the lake, as pointed out in the aquatic plant section there are more factors at work here when determining the volume of water in this large lake. Precipitation in the region of this headwater system is a primary force in determining how much water Lac Vieux Desert will hold in a given year, and during the past 8-10 years conditions have not been ideal for Northern Wisconsin. Lac Vieux Desert water level concerns have emerged because of two primary reasons, navigation hindrance and a lack of fish (specifically walleye) recruitment. While fluctuating water levels may play a role in both of these issues, there are a multitude of factors that must be considered. As discussed in the Aquatic Plant Section and the 2009 USDA report, the conditions in Lac Vieux Desert allow for abundant plant growth, water levels aside. While the alteration of water levels may influence the plant abundance some, there will always be issues with aquatic plant growth and navigation in Lac Vieux Desert. With regards to the fishery, as described in the Fisheries Section, WDNR biologists believe there is a strong "boom-and-bust" cycle in the walleye fishery of Lac Vieux Desert. This cycle may be heavily influenced by crappie predation on walleye fry. The impact of water levels upon the fishery is unknown at this point.

It is important to remember that through the process of the Lac Vieux Desert Wild Rice Plan, all aspects of the lake in contention (aquatic plants, water levels, fisheries) are being monitored by professional agencies so that a better understanding of their working relationships may be achieved. These issues are and may remain a challenge for the various managing groups overseeing Lac Vieux Desert. The Implementation Plan that follows this section highlights steps to preserve and maintain the quality of this system. These steps include obvious actions that will physically take place on the lake, such as continued water quality monitoring and aquatic invasive species monitoring. However, the most important action involved in preserving, understanding and managing Lac Vieux Desert will be to continue communication between lake stakeholders, local and state government agencies, and tribal biologists to ensure all voices are heard. While it will be nearly impossible to please everyone entirely, these conversations must be had and compromises must be made in order to manage Lac Vieux Desert in a holistically, responsibly and ecologically sound manner.

5.0 IMPLEMENTATION PLAN

The intent of this project was to complete a *comprehensive* management plan for Lac Vieux Desert Lake. As described in the proceeding sections, a great deal of study and analysis were completed involving many aspects of the ecosystem. This section stands as the actual "plan" portion of this document as it outlines the steps the LVDLA will follow in order to manage Lac Vieux Desert Lake, its watershed, and the association itself.

The implementation plan is broken into individual *Management Goals*. Each management goal has one or more management actions that if completed, will lead to the specific management goal being met. Each management action contains a timeframe for which the action will be taken, a facilitator that will initiate or carry out the action, a description of the action, and if applicable, a list of prospective funding sources and specific actions steps.

Management Goal 1: Increase Lac Vieux Desert Lake Association's Capacity to Communicate with Lake Stakeholders

Management Action: Support an Education Committee to promote safe boating, water quality, public safety, and quality of life on Lac Vieux Desert.

Timeframe: Begin summer 2011

Facilitator: Board of Directors to form Education Committee

Description: Education represents an effective tool to address issues that impact water quality such as lake shore development, lawn fertilization, and other issues such as air quality, noise pollution, and boating safety. An Education Committee will be created to promote lake protection through a variety of educational efforts.

Currently, the LVDLA periodically distributes newsletters to association members which allow for exceptional communication within the lake group. This level of communication is important within a management group because it builds a sense of community while facilitating the spread of important association news, educational topics, and even social happenings. It also provides a medium for the recruitment and recognition of volunteers. Perhaps most importantly, the dispersal of a well written newsletter can be used as a tool to increase awareness of many aspects of lake ecology and management among association members. By doing this, meetings can often be conducted more efficiently and misunderstandings based upon misinformation can be avoided. Educational pieces within the association newsletter may contain monitoring results, association management history, as well as other educational topics listed below.

In addition to creating a regularly published association newsletter a variety of educational efforts will be initiated by the Education Committee. These may include educational materials, awareness events and demonstrations for lake users as well as activities which solicit local and state government support. This committee will also investigate the creation of an association website and/or other social media such as Facebook. This will directly increase the association's ability to communicate with interested stakeholders by allowing them to post information and social messages.

Example Educational Topics:

Specific topics brought forth in other management actions
Aquatic invasive species monitoring updates
Boating safety and ordinances (slow-no-wake zones and hours)
Catch and release fishing
Noise, air, and light pollution
Shoreland restoration and protection
Septic system maintenance
Fishing Regulations

Action Steps:

1. Recruit volunteers to form Education Committee.
2. Investigate if WDNR small-scale Lake Planning Grant would be appropriate to cover initial setup costs.
3. The LVDLA Board will identify a base level of annual financial support for educational activities to be undertaken by the Education Committee.

Management Goal 2: Facilitate Partnerships with Other Management Entities

Management Action: Enhance LVDLA's involvement with other entities that have a hand in managing (management units) Lac Vieux Desert.

Timeframe: Begin summer 2011

Facilitator: Board of Directors to appoint LVDLA representatives

Description: The LVDLA's initial purpose was to create a group of interested lake owners to establish a fish stocking initiative for the lake. Over time, the Association expanded its purpose to preserve and protect the lake and its surroundings to enhance the water quality, fishery, safety, and aesthetic value of the lake as a public recreational facility for today and future generations. The waters of Wisconsin belong to everyone and therefore this goal of protecting and enhancing these shared resources is also held by other entities. Some of these entities are governmental while others organizations are similar to the LVDLA in that they rely on voluntary participation.

It is important that the LVDLA actively engage with all management entities to enhance the association's understanding of common management goals and to participate in the development of those goals. This also helps all management entities understand the actions that others are taking to reduce the duplication of efforts. While not an inclusive list, the primary management units regarding Lac Vieux Desert are the WDNR, MDNR, Michigan Department of Environmental Quality (MDEQ), Lac Vieux Desert Band of the Lake Superior Chippewa Indians (LVD Tribe), Vilas County Land and Water Conservation Department (VCLWCD), the Vilas County Lakes Association (VCLA), the Invasive Species Control Coalition of Watersmeet (ISCCW Lakeguards), the US Fish Forest Service (USFS – Ottawa National Forest in Michigan, Chequamegon-Nicolet

National Forest in Wisconsin), and the Wisconsin Valley Improvement Company (WVIC). Each entity will be specifically addressed below.

States of Wisconsin and Michigan The WDNR and MDNR/MDEQ are responsible for managing the natural resources of the State of Wisconsin and Michigan, respectively. Primary interaction with the WDNR and MDNR/MDEQ is from an advisory and regulatory perspective. The LVDLA has worked closely with the WDNR Regional Lakes Coordinator (Kevin Gauthier – 715.365.8937) and that relationship should continue. Lac Vieux Desert contains a highly valued fishery. The LVDLA should be in contact with the WDNR fisheries biologist (Steve Gilbert – 715.358.9229) and the MDNR fisheries biologist (George Madison – 906.353.6651) at least once a year to discuss fish stocking plans and other pertinent fisheries-related issues. As discussed within the Fisheries Section, Lac Vieux Desert falls within the ceded territory based on the Treaty of 1842 (Figure 3.4-1). This treaty grants specific off-reservation rights to the Native American community including a regulated spear fishery. The WDNR fisheries biologists are involved with this process and a direct link to GLIFWC biologists is not necessary.

County and County-wide Associations Lake conservation specialists at the VCLWCD (Mariquita Sheehan – 715.479.3721 or Ted Ritter – 715.479.3738) are available to discuss specific conservation projects applicable to Lac Vieux Desert. While it is important to foster a direct relationship with these entities, having LVDLA representatives participating in county-wide associations such as the VCLA and the ISCCW Lakeguards is the best way to ensure the association gains from this pooled knowledgebase of lake management and awareness. These representatives would attend all meetings and in their absence, an alternate would take their spot. Within every LVDLA newsletter (even if no meeting occurred), a permanent column (standing column) will be committed to a short summary of any meetings that occurred since the circulation of the last newsletter.

Tribe Coordination between the LVDLA and the LVD Tribe is critical to effectively manage this system. Likely the best way to keep continued contact with the LVD Tribe is through conversations with George Beck (906.358.4577) director of the Planning and Environmental Office of the LVD Tribe.

USFS Stretches of Lac Vieux Desert Lake's shoreline are part of the Ottawa National Forest (MI) and Chequamegon-Nicolet National Forest (WI). Ian Shackleford (906.932.1330 x-331), USFS biologist, is a great resource for invasive species issues. In March 2011, Mr. Shackleford was awarded with the National Invasive Species Award for Excellence in Washington D.C.

WVIC Lac Vieux Desert is operated under a Federal Energy Regulatory (FERC) License held by WVIC that requires the reservoir be operated between a maximum and minimum water level. WVIC has historical and ongoing reservoir operating data and environmental data that has been collected as a part of its FERC license requirements. WVIC could help "reduce the duplication of efforts" stated above, particularly as they relate to the collection of water quality data. The

WVIC could also assist in educating other entities as well as lake owners about the operation of the reservoir and the role it plays in the Wisconsin River system.

Management Goal 3: Maintain Current Water Quality Conditions

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

Timeframe: Continuation and expansion of current effort.

Facilitator: Planning Committee

Description: Monitoring water quality is an import 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. Early discovery of negative trends may lead to the reason as of why the trend is developing.

The Citizens Lake Monitoring Network (CLMN) is a WDNR program in which volunteers are trained to collect water quality information on their lake. At this time, there are no LVDLA members currently collecting data as a part of the CLMN. Volunteers trained by the WDNR as a part of the CLMN program begin by collecting Secchi disk transparency data for at least one year, then if the WDNR has availability in the program, the volunteer may enter into the *advanced program* and collect water chemistry data including chlorophyll-a, and total phosphorus. The Secchi disk readings and water chemistry samples are collected three times during the summer and once during the spring. Note: as a part of this program, these data are automatically added to the WDNR database and available through their Surface Water Integrated Monitoring System (SWIMS).

At a minimum, CLMN volunteers collecting Secchi disk data should be in place on Lac Vieux Desert. Currently, the advanced CLMN program is not accepting additional lakes to participate in the program. However, it is important to get volunteers on board with the base Secchi disk data CLMN program so that when additional spots open in the advanced monitoring program, volunteers from the Lac Vieux Desert will be ready to make the transition into more advanced monitoring.

It is the responsibility of the Planning Committee to coordinate new volunteers as needed. When a change in the collection volunteer occurs, it will be the responsibility of the Planning Committee to contact Sandra Wickman (715.365.8951) or the appropriate WDNR/UW Extension staff to ensure the proper training occurs and the necessary sampling materials are received by the new volunteer.

Action Steps:

Please see description above.

<u>Management Action:</u> Reduce phosphorus and sediment loads from shoreland watershed to Lac Vieux Desert.

Timeframe: Begin 2011

Facilitator: Education Committee

Description: As the watershed section discusses, the Lac Vieux Desert watershed is in good condition; however, watershed inputs still need to be focused upon, especially in terms of the lake's shoreland properties. These sources include faulty septic systems, shoreland areas that are maintained in an unnatural manner, impervious surfaces.

On April 14th, 2009, Governor Doyle signed the "Clean Lakes" bill (enacted as 2009 Wisconsin Act 9) which prohibits the use of lawn fertilizers containing phosphorus. Phosphorus containing fertilizers were identified as a major contributor to decreasing water quality conditions in lakes, fueling plant growth. This law went into effect in April 2010. While this law also bans the display and sale of phosphorus containing fertilizers, educating lake stakeholders about the regulations and their purpose is important to ensure compliance.

To reduce these negative impacts, the LVDLA will initiate an educational initiative aimed at raising awareness among shoreland property owners concerning their impacts on the lake. This will include newsletter articles and guest speakers at association meetings.

Topics of educational items may include benefits of proper septic system maintenance, methods and benefits of shoreland restoration, including reduction in impervious surfaces, and the options available regarding conservation easements and land trusts.

Action Steps:

1. Recruit facilitator.
2. Facilitator gathers appropriate information from WDNR, MDNR, UW-Extension, Vilas County, LVD Tribe, and other sources.
3. Facilitator summarizes information for newsletter articles and recruits appropriate speakers for association meetings.

<u>Management Action:</u> Complete Shoreland Condition Assessment as a part of next management plan update

Timeframe: Begin 2011

Facilitator: Board of Directors

Description: As discussed above, unnatural and developed shorelands can negatively impact the health of a lake, both by decreasing water quality conditions as well as removing valuable habitat for fish and other animal species that reside in and around the lake. Understanding the shoreland conditions around Lac Vieux Desert will serve as an educational tool for lake stakeholders as well as identify areas that would be suitable for restoration. Shoreland restorations would include both in-lake and shoreline habitat enhancements. In-lake enhancements would include the introduction of coarse woody debris in the littoral zone, a valuable fisheries habitat component around the shores of Lac Vieux Desert. Shoreline enhancements would include leaving 35-foot no-mow zones to act as a buffer between residences and the lake or by planting native herbaceous, shrub, and tree species as appropriate for Vilas and Oneida Counties in this sensitive area. Ecologically high-value areas delineated during the survey would also be selected for protection, possibly through conservation easements or land trusts (www.northwoodslandtrust.org).

Projects that include shoreline condition assessment and restoration activities will be better qualified to receive state funding in the future. These activities could be completed as an amendment to this management plan and would be appropriate for funding through the WDNR small-scale Lake Planning Grant program.

Action Steps: See description above.

Management Goal 4: Control Existing AIS within Lac Vieux Desert Lake While Preventing Introduction of Other AIS.

Management Action: Continue Clean Boats Clean Waters watercraft inspections at Lac Vieux Desert Lake public access locations
Category: Prevention & Education
Timeframe: In progress
Facilitator: Planning Committee
Description: Lac Vieux Desert Lake is a popular destination by recreationists and anglers, making the lake vulnerable to new infestations of exotic species. The intent of the boat inspections would not only be to prevent additional invasives from entering the lake through its public access points, but also to prevent the infestation of other waterways with invasives that originated in Lac Vieux Desert Lake. The goal would be to cover the landings during the busiest times in order to maximize contact with lake users, spreading the word about the negative impacts of AIS on our lakes and educating people about how they are the primary vector of its spread.

While members of the LVDLA have been trained on Clean Boats Clean Waters (CBCW) protocols, low volunteerism has not provided a consistent monitoring program at the public landing. The LVDLA understands this limitation and in recent years has donated funds to the ISCCW Lakeguards through membership dues. The ISCCW Lakeguards aids in monitoring the Lac Vieux Desert Landing including operating a portable power wash station that were funded by the Great Lakes Restoration Initiative in 2010, 2011, and 2012. Fully understanding the importance of CBCW inspections, paid watercraft inspectors may be sought in the future to ensure monitoring occurs at the public boat landings.

In addition to continuing these efforts, an Education Initiative comprised of developing materials and programs that will promote clean boating and responsible use of these waters (See Management Goal #1) should be enacted.

Action Steps:

1. Members of association periodically (perhaps once every three years) attend Clean Boats Clean Waters training session coordinated through the WDNR volunteer AIS Coordinator (Erin McFarlane – 715.346.4978) to update their skills to current standards.
2. Training of additional volunteers completed by those trained during the summer of 2011.
3. Begin inspections during high-risk weekends
4. Enter data into SWIMS and report results to the LVDLA
5. Promote enlistment and training of new volunteers to keep program fresh.

Management Action: Coordinate annual monitoring for Aquatic Invasive Species
Timeframe: Initiate in 2012
Facilitator: Vilas County Invasive Species Coordinator
Description: In lakes without Eurasian water milfoil and other invasive species, early detection of pioneer colonies commonly leads to successful control and in cases of very small infestations, possibly even eradication. Even in lakes where these plants occur, monitoring for new colonies is essential to successful control.

In addition to surveys conducted by Onterra as a part of the current project, periodic monitoring of Lac Vieux Desert Lake for aquatic invasive species has been conducted by Invasive Species Control Coalition of Watersmeet (ISCCW) Lakeguards, GLIFWC, LVD Tribe, and USFS. While these entities anticipate they will continue their monitoring programs, uncertainty of resources (time and money) prohibit them from long-term commitment of their involvement.

In addition, volunteers from the LVDLA would monitor aquatic invasive species within Lac Vieux Desert Lake after receiving training through the VCLWCD, UW Extension, or ISCCW Lakeguards as appropriate. Initial training would include identification of target species and native look-a-likes and expand to proper use of GPS for recording aquatic plant occurrences, note taking, and transfer of spatial data. If this form of training is not available through the organizations listed above, the LVDLA may seek professional training on these tasks.

Coordination of these activities is important to limit duplication of efforts and ensure that Lac Vieux Desert Lake's entire littoral zone is monitored annually for aquatic invasive species, especially Eurasian water milfoil and curly-leaf pondweed. The Invasive Species Coordinator for Vilas County (Ted Ritter) has agreed to coordinate monitoring activities until the LVDLA is able to take over aspects of this role. Previous to each field season (March-April), the Vilas County Invasive Species Coordinator would reach out to ISSCW, GLIFWC, LVD Tribe, and USFS to understand each entity's monitoring plans for the upcoming year. This information would be shared with the LVDLA and a determination would be made by the association whether they can fill in any monitoring gaps or if they will need to hire professionals (either through the ISSCW or a private consulting firm) to complete these tasks.

Towards the end of the field season (August-September), the Vilas County Invasive Species Coordinator would receive each entity's results and make the compiled information available to all the entities and the LVDLA to formulate a monitoring and control strategy (if needed) for the following year. As the name suggests, the role of the Vilas County Invasive Species Coordinator is for coordinating these activities and providing general guidance to the LVDLA; not to provide recommendations or make decisions related to control strategies.

Over the course of the project, it is anticipated that a core group of LVDLA volunteers with considerable levels of dedication to the continued monitoring program would emerge. Once this occurs, a transition will be made where the LVDLA can assume the role previously carried out by the Vilas County Invasive Species Coordinator.

Action Steps:

1. See description above.

Management Action: Initiate aquatic invasive species rapid response plan upon new or recurring exotic infestation

Timeframe: Initiate upon exotic infestation

Facilitator: Planning Committee with professional help as needed

Description: In the event that an aquatic invasive species is located during the monitoring activities discussed in the previous Management Action, the areas would be marked using GPS and would serve as *focus areas* for professional ecologists. Those focus areas would be surveyed by professionals during that plant species peak growth phase (late summer for Eurasian water milfoil, early summer for curly-leaf pondweed) and the results would be used to create a prospective treatment strategy for the following spring. Eurasian water milfoil is the primary aquatic invasive species being managed in this region of the state and the following paragraphs will contain specific information pertaining to this species.

Small isolated infestations of Eurasian water milfoil can most appropriately be controlled using manual removal methods, likely through scuba or snorkeling efforts with scuba methodologies likely being more suitable for Lac Vieux Deser Lake. The responsible use of this technique is supported by LVDLA stakeholders as indicated by approximately 61% of stakeholder survey respondents indicating that they are at least moderately supportive of a manual removal program (Appendix B, Question #20). Currently this is the method of control for the Eurasian water milfoil located in Thunder Bay and the newly discovered occurrences in Slaughter Bay (Map 6 and Map 7). Hand-removal techniques were conducted in 2012 by the USFS (both Ottawa and Chequamegon-Nicolet National Forests) and a Lac Vieux Desert Tribal youth group. In order for this technique to be successful, the entire plant (including the root) needs to be removed from the lake. During manual extraction, careful attention would need to be paid to all plant fragments that may detach during the control effort.

If Eurasian water milfoil occurrences exceed the amount that can be manually removed, the plants need to be professionally surveyed and mapped. During the fall/winter following the professional mapping survey, a control strategy would be developed. At this time, the most feasible method to control larger infestations is through herbicide applications, specifically early-spring treatments with 2,4-D. LVDLA stakeholders were supportive of an herbicide control program as indicate by almost 65% of respondents (Appendix B, Question #27).

Since the waters of Lac Vieux Desert Lake are located in both Wisconsin and Michigan, some unique questions were brought forth during the 2009 herbicide treatment in regards to obtaining the proper state permits. While coordination with both state agencies in advance of an herbicide treatment is necessary, herbicide application permits are likely only required by the state in which the herbicide is being applied but may be required by both states in some instances. Further, while riparian notification is required to conduct an herbicide treatment in both states, written permission is required for herbicide treatments conducted in Michigan due to the fact that the lakebed is owned by the riparian. These activities would be initiated by the LVDLA and their contracted herbicide applicator during the winter before the treatment. Please note that the permitting aspect may take considerable amounts of time so it's important that the permit process be started months in advance of a proposed treatment.

The presence of wild rice in proximity of potential herbicide treatments is also an issue that requires attention, as this species is also particularly vulnerable to early season herbicide treatments (Nelson et al., 2003). It remains unclear whether Eurasian water milfoil and/or curly-leaf pondweed have the ability to displace wild rice when populations overlap. Due to the cultural and ecological significance of wild rice, GLIWC and the LVD Tribe should be consulted well in advance of a potential herbicide treatment.

Approximately a week preceding the spring treatment, a refinement and verification survey would be conducted by professionals to ensure that the treatment areas adequately target the Eurasian water milfoil occurrences at the time of the treatment. Professionals would also visit the lake during the summer following the treatment to evaluate the control action and map the remaining Eurasian water milfoil to be used in developing the following year's control strategy.

As indicated within Management Goal 2, there are a number of agencies involved in the management of Lac Vieux Desert Lake. Successful partnerships between all stakeholders are important to formulate and implement a successful response and control program.

Action Steps:

1. Engage all stakeholders in the process.
2. Retain consultant to map aquatic invasive species occurrences.
3. Determine control strategy based upon professional findings.
4. Initiate hand-removal methods as applicable with guidance from the Hand Removal Pamphlet co-authored by the Lumberjack Resource Conservation & Development (RC&D) Council, Inc. & Golden Sands RC&D Council, Inc (2012)

5. Association, with help from an herbicide applicator if applicable, obtains the proper permits to implement management action.
   a. WDNR Plant Management and Protection Program: www.dnr.state.wi.us/lakes/plants
   b. MDEQ Aquatic Nuisance Control website: www.michigan.gov/deq/0,4561,7-135-3313_3681_3710---,00.html
   c. The UW Extension Lake List is a great resource for locating an herbicide applicator: www.uwsp.edu/cnr/uwexlakes/lakelist/businessSearch.asp
6. Association updates management plan to reflect changes in control strategy.

Management Action: Reduce occurrence of purple loosestrife on Lac Vieux Desert shorelands
Timeframe: Begin 2011
Facilitator: Planning Committee
Description: Purple loosestrife can be found in low occurrence along the shorelands of Lac Vieux Desert Lake's islands (Map 2). The purple loosestrife occurrences on Lac Vieux Desert appear to be at an early stage of development with only a few individual plants observed. As with any invasive species, early control strategies are more effective on the population. In regards to purple loosestrife, this hardy perennial is more resilient the longer it is allowed to grow in one location as its root crown becomes more robust. It also produces a large seed bank which germinates years after the parent plant is controlled and requires continued management.

Manually removing isolated purple loosestrife plants is likely the best control strategy at this time. Once the property owner grants permission to remove the plant, it should be dug out of the ground, roots and all. If flowers or seeds are present at the time of the extraction, the flower heads should be carefully cut off and bagged to make sure seeds don't inadvertently get spread around during removal. Plants and seed heads should either be burned or bagged and put into the garbage.

Information sources, such as the WDNR, MDNR, UW-Extension, VCLWCD, ISCCW Lakeguards, and GLIFWC will be used to properly identify purple loosestrife and provide guidance on the proper time to perform management actions.

Important aspects of this management action will be the monitoring and record keeping that will occur in association with the control efforts. These records will include maps indicating infested areas and associated documentation regarding the actions that were used to control the areas, the timing of those actions, and the results of the actions. These maps and records will be used to track and document the successfulness of the program and to keep the LVDLA and all management entities listed in Management Goal 2 updated.

Please Note: As indicated within the Aquatic Plant Section, populations of giant reed were also located on the shorelands of Lac Vieux Desert (Map 2). Based upon morphologic verification by the UW Steven's Point Herbarium, the giant reed occurrences are thought to be a native strain and therefore a control strategy is not included here. As indicated within that section, continued monitoring of these populations will be important to determine if the plant is acting invasively and if a more comprehensive understanding of this species and its occurrence within Lac Vieux Desert Lake is required.

Action Steps:

1. Recruit members to begin monitoring and control efforts
2. Group completes field surveys to identify infested areas
3. Initiate manual removal control methods
4. Monitor results and reapply control as necessary
5. Keep stakeholders and managers informed regarding program results

Management Goal 5: Improve Fishery Resource and Fishing

Management Action: Work with fisheries managers to enhance the walleye fishery on Lac Vieux Desert Lake

Timeframe: Ongoing

Facilitator: Rob Andersen

Description: As stated within the Fisheries Section, Lac Vieux Desert Lake stakeholders and fisheries managers would like to see an increase in the walleye populations. The WDNR fisheries biologist faults the lack of walleye recruitment, which cause remains unknown, and is not convinced that stocking of walleye will significantly affect the walleye population in Lac Vieux Desert Lake. Being founded on the idea of improving the fishery of the lake, the LVDLA feels that stocking of walleye is vital to the success of the lake's fishery. In spite of these differences, the WDNR and the LVDLA have entered an informal agreement where the lake association will be permitted to fund the stocking of the lake every-other year ***if*** fall recruitment surveys continually show low results. Pulse or every-other year stocking can lead to an understanding of natural reproduction versus stocking.

As a part of the Lac Vieux Desert Lake Wild Rice Plan, intense fish surveys have been completed in 2000, 2006, and 2009; and a future survey is scheduled for 2012. These surveys are aimed at evaluating whether the altered water level regime is impacting the fisheries. Once all this data is analyzed, the fisheries biologists will likely come forth with solid recommendations for the future management of the lake.

The LVDLA would like to continue its relationship with the WDNR, stocking walleye consistent with their informal agreement until a formal plan is reached. The LVDLA would also like to foster a relationship with the LVD Tribe where fish can be stocked into Lac Vieux Desert Lake from the tribe's nearby rearing ponds.

Action Steps:

1. See description above.

6.0 METHODS

Lake Water Quality

Baseline water quality conditions were studied to assist in identifying potential water quality problems in Lac Vieux Desert (e.g., elevated phosphorus levels, unnaturally caused anaerobic conditions, etc.). Water quality was monitored at the deepest point in the lake that would most accurately depict the conditions of the lake (Map 1). Samples were collected with a 3-liter Van Dorn bottle at the subsurface (S) and near bottom (B). Sampling occurred once in spring, fall, and winter and three times during summer. Samples were kept cool and nutrient and metal samples were preserved with acid following standard protocols. All samples were shipped to the Wisconsin State Laboratory of Hygiene for analysis. The parameters measured included the following:

	Spring		**June**		**July**		**August**		**Fall**		**Winter**	
Parameter	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**
Total Phosphorus	●	●	●	●	●	●	●	●	●	●	●	●
Dissolved Phosphorus	●	●			●	●					●	●
Chlorophyll a	●		●		●		●		●			
Total Kjeldahl Nitrogen	●	●			●	●					●	●
Nitrate-Nitrite Nitrogen	●	●			●	●					●	●
Ammonia Nitrogen	●	●			●	●					●	●
Laboratory Conductivity	●	●			●	●						
Laboratory pH	●	●			●	●						
Total Alkalinity	●	●			●	●						
Total Suspended Solids	●	●	●	●	●	●	●	●	●	●	●	●
Calcium	●											

In addition, during each sampling event Secchi disk transparency was recorded and a temperature, pH, conductivity, and dissolved oxygen profile was completed using a Hydrolab DataSonde 5.

Aquatic Vegetation

Curly-leaf Pondweed Survey

Surveys of curly-leaf pondweed were completed on Lac Vieux Desert on two separate occasions, June 25, 2009 and May 25, 2010 in order to correspond with the anticipated peak growth of the plant. Visual inspections were completed throughout the lake by completing a meander survey by boat.

Comprehensive Macrophyte Surveys

Point-intercept Survey

The point-intercept method as described in "Appendix C" of the Wisconsin Department of Natural Resource document, Aquatic Plant Management in Wisconsin, (April 2005) was used to complete this study. A point spacing of 144 meters was used resulting in approximately 860 points. The point-intercept survey was conducted by the WDNR on July 27 through July 29 of 2009.

Community Mapping

During the species inventory work, the aquatic vegetation community types within Lac Vieux Desert (emergent and floating-leaved vegetation) were mapped by Onterra using a Trimble GeoXT Global Positioning System (GPS) with sub-meter accuracy. Furthermore, all species found during the point-intercept surveys and the community mapping surveys were recorded to provide a complete species list for the lake.

AIS Data

In addition to surveys conducted by Onterra, aquatic invasive species surveys have been conducted during the timeframe of this study by GLIFWC, ISCCW, and USFS (Map 3, Map 6, and Map 7).

Watershed Analysis

The watershed analysis began with an accurate delineation of Lac Vieux Desert's drainage area using U.S.G.S. topographic survey maps and base GIS data from the WDNR. The watershed delineation was then transferred to a Geographic Information System (GIS). These data, along with land cover data from the Wisconsin initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) were then combined to determine the watershed land cover classifications. These data were modeled using the WDNR's Wisconsin Lake Modeling Suite (WiLMS) (Panuska and Kreider 2003)

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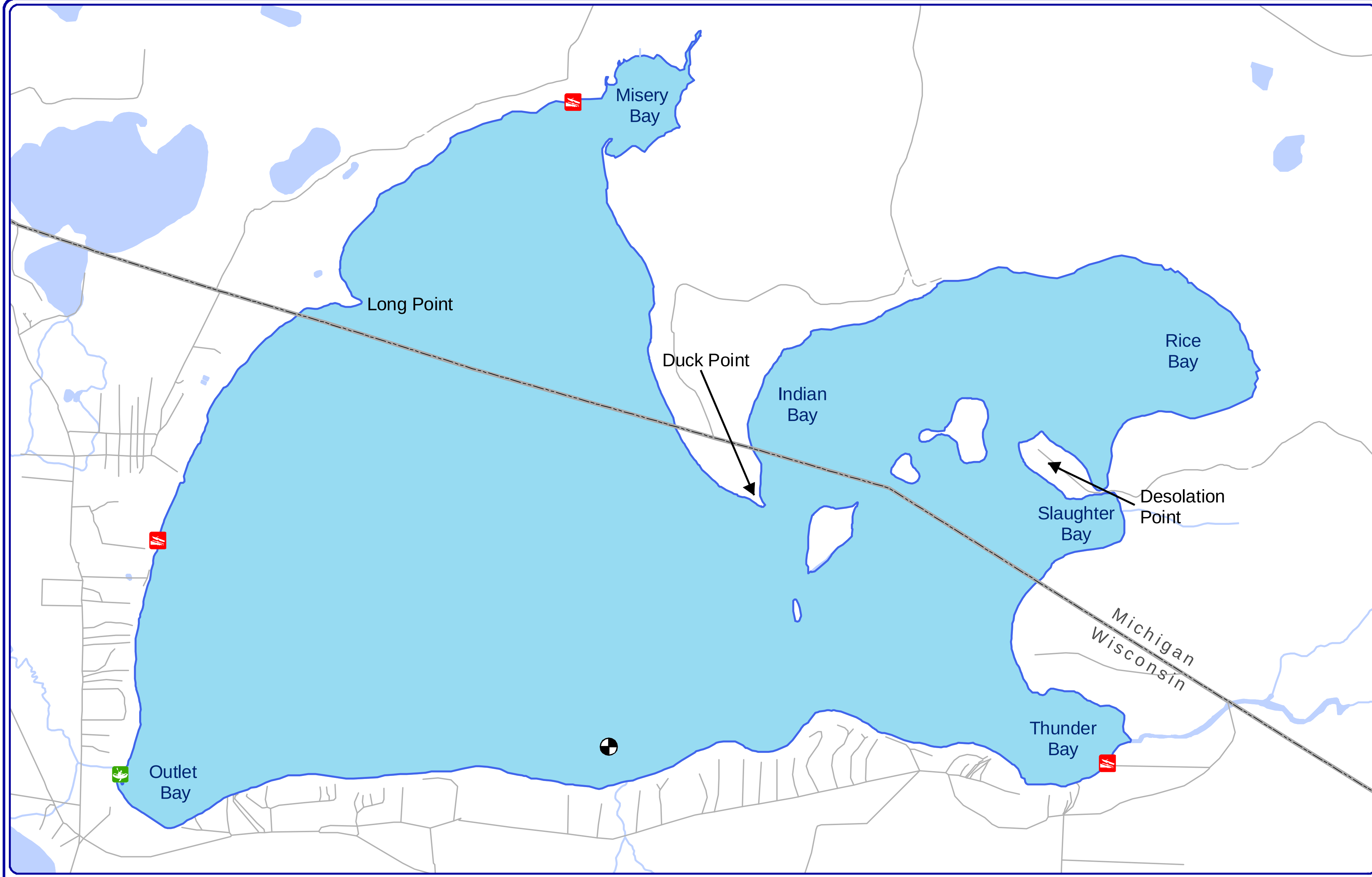

0.5
Miles

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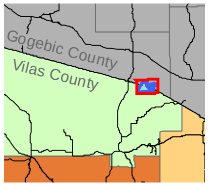
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Sources:
Roads & Hydro: WDNR, MDNR
Map date: October 24, 2008



Extent of large map shown in red.

Legend

Lac Vieux Desert ~ 4410 acres
WDNR Definition

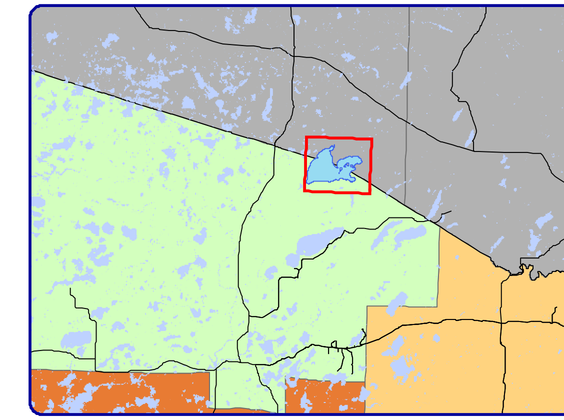
Water Quality Sampling Location

Map 1
Lac Vieux Desert Lake
Vilas County, Wisconsin
& Gogebic, Michigan
Project Location
& Water Quality Sampling Location

Map 2
Lac Vieux Desert

Vilas County, Wisconsin &
Gogebic County, Michigan

Aquatic Plant Communities



Extent of large map shown in red.

Legend

Exotic Plant Communities

Note: *Eurasian water milfoil locations are displayed on a separate map.*

- Purple Loosestrife

Small Plant Communities

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

Large Plant Communities

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

- Public Boat Landing

Sources:
Hydro: WDNR
Orthophotography: NAIP, 2010
Aquatic Plant Study: Onterra, 2009

Map Date: February 10, 2010

2,200
Feet

N W E S

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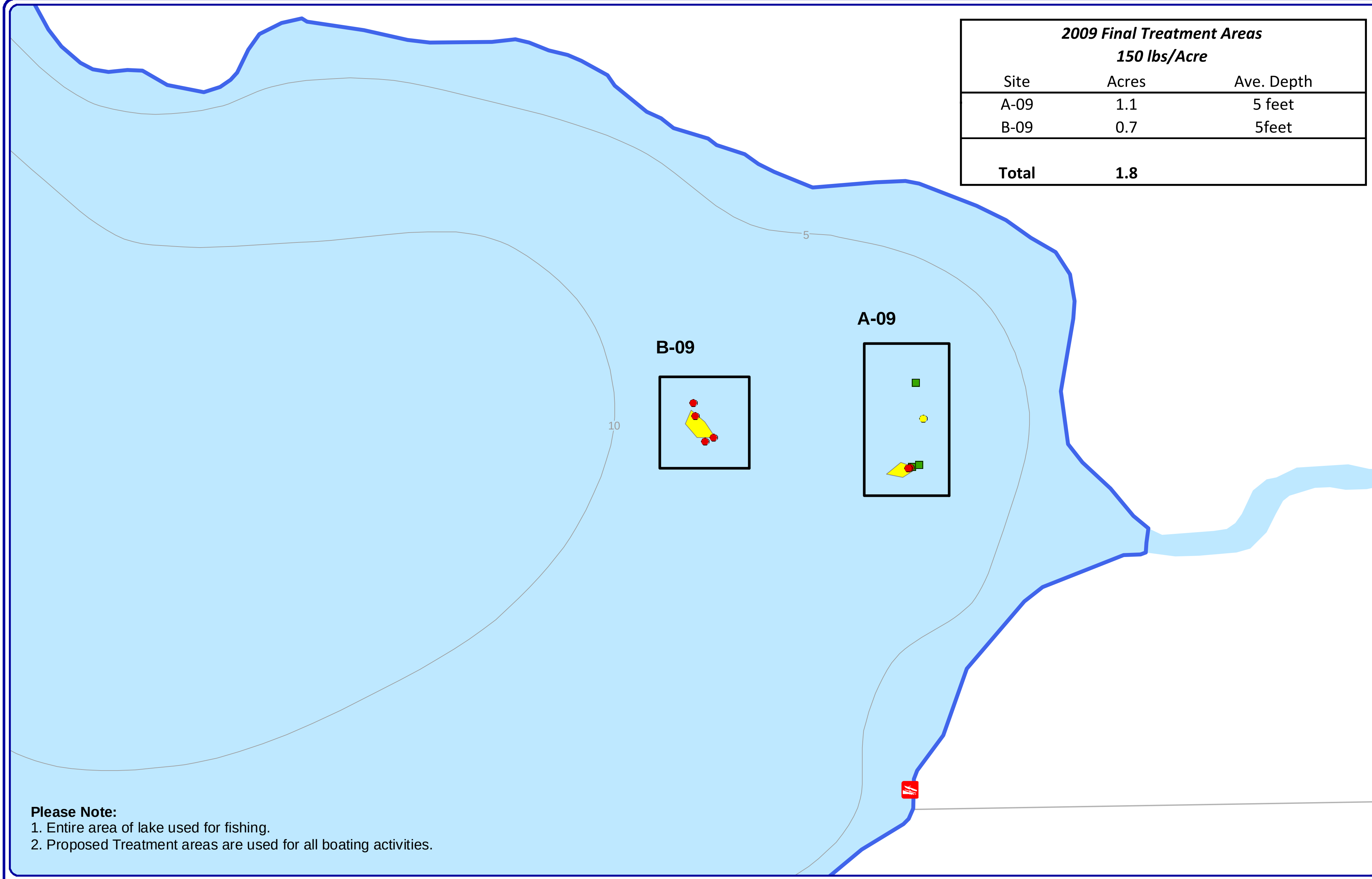
2009 Final Treatment Areas 150 lbs/Acre		
Site	Acres	Ave. Depth
A-09	1.1	5 feet
B-09	0.7	5feet
Total	**1.8**	



Please Note:
1. Entire area of lake used for fishing.
2. Proposed Treatment areas are used for all boating activities.

250
Feet

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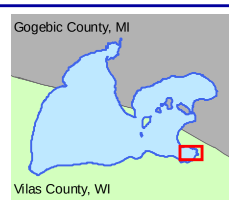
Sources:
Roads & Hydro: WDNR
Aquatic Plants: Onterra 2009
Bathymetry: WDNR - Digitized by Onterra
Map date: May 28, 2009
File Name: MapX_LVD_T2009_EWM_Perm1.mxd

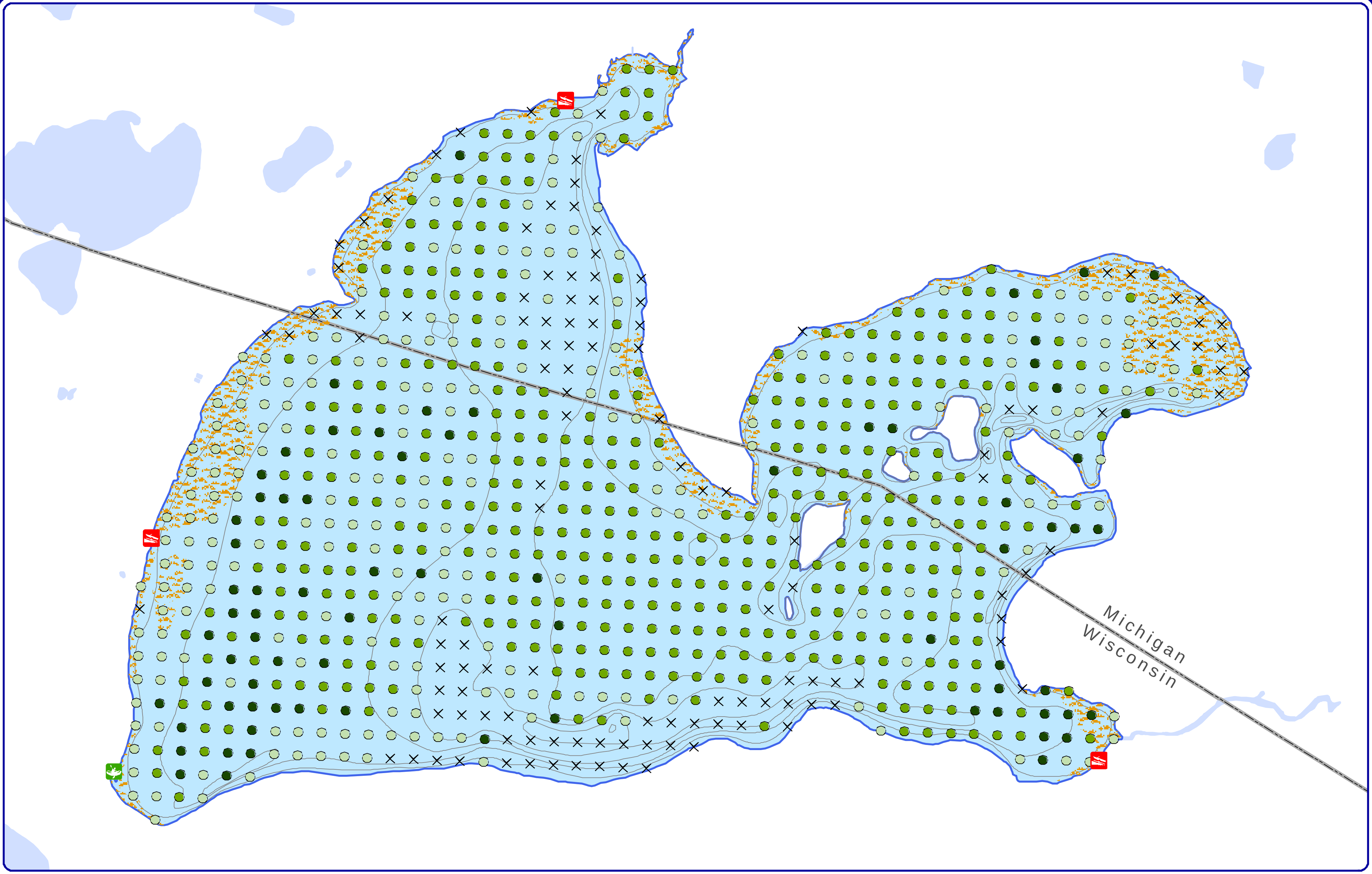


Extent of large map shown in red.

Summer 2008 EWM Survey Results
- EWM found by GLIFWC
- EWM found by Watersmeet ANS

Onterra May 2009 EWM Survey Results
- Clumps of plants
- Dominant colony
- 2009 Final Treatment Area (150 lbs/acre)

Map 3
Lac Vieux Desert
Vilas County, Wisconsin
& Gogebic, Michigan
2009 Final EWM Treatment Areas



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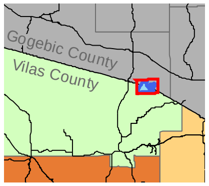
Sources:
Roads & Hydro: WDNR, MDNR
Map date: December 7, 2010



Extent of large map shown in red.

Legend

Point-intercept Survey Results

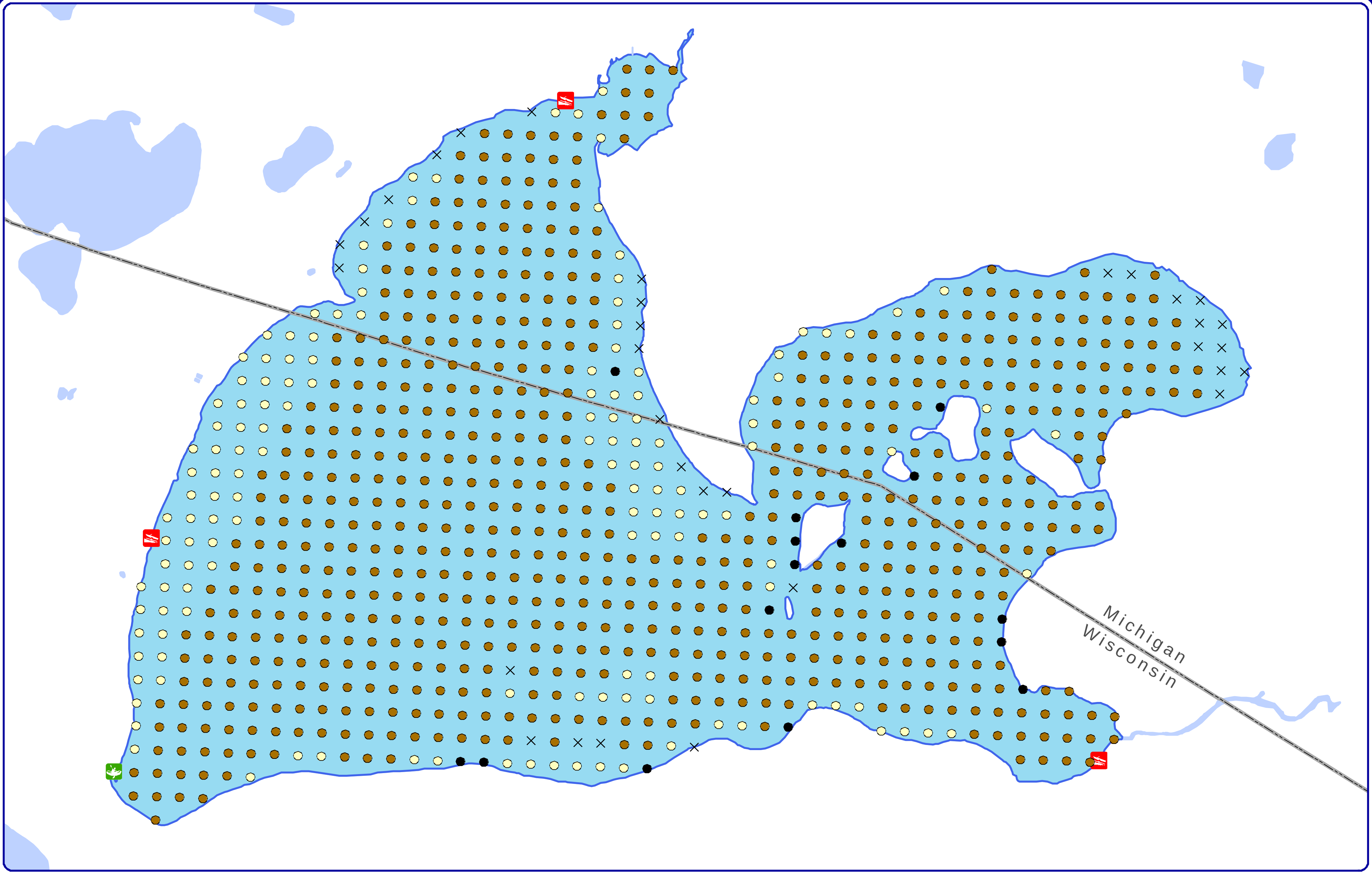
- Too Deep, Unreachable, or No Data
- Rake fullness = 1
- Rake fullness = 2
- Rake fullness = 3
- Floating-leaf and Emergent Plant Community

Map 4

Lac Vieux Desert Lake

Vilas County, Wisconsin
& Gogebic, Michigan

Point-intercept Survey Rake Fullness Results



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Miles

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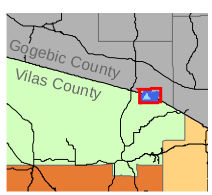
Sources:
Roads & Hydro: WDNR, MDNR
Map date: October 24, 2008



Extent of large map shown in red.

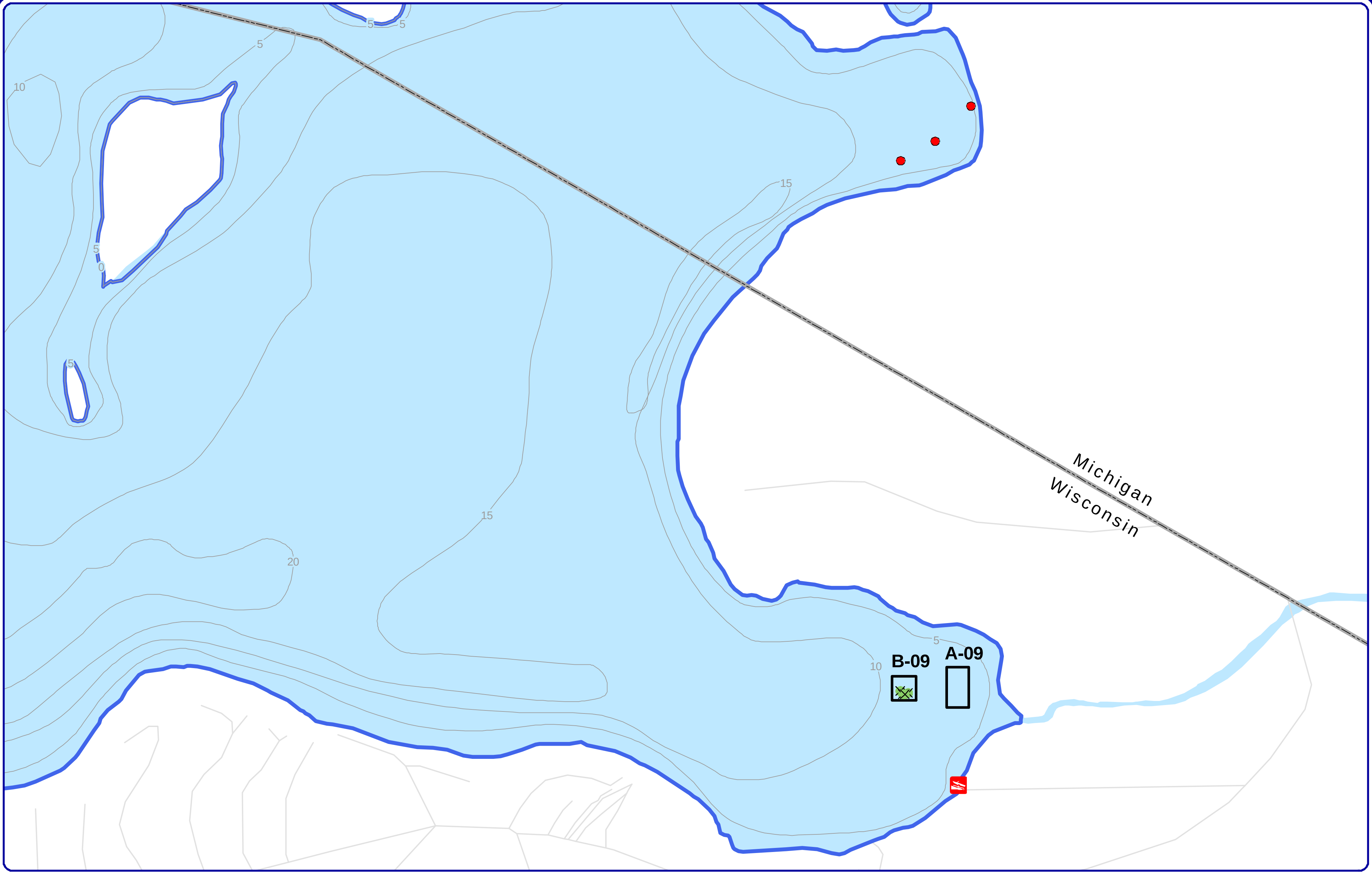
Legend

Point-intercept Survey Results

- × Too Deep, Unreachable, or No Data
- Sand
- Muck
- Rock

Map 5
Lac Vieux Desert Lake
Vilas County, Wisconsin
& Gogebic, Michigan

Point-intercept Survey Sediment Types



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250
Feet

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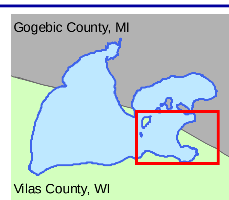
Sources:
Roads & Hydro: WDNR
Aquatic Plants: Onterra 2010-2011, USFS 2011
Bathymetry: WDNR - Digitized by Onterra
Map date: October 5, 2011
File Name: Map6_LVD_2010-11_EWMLocations.mxd



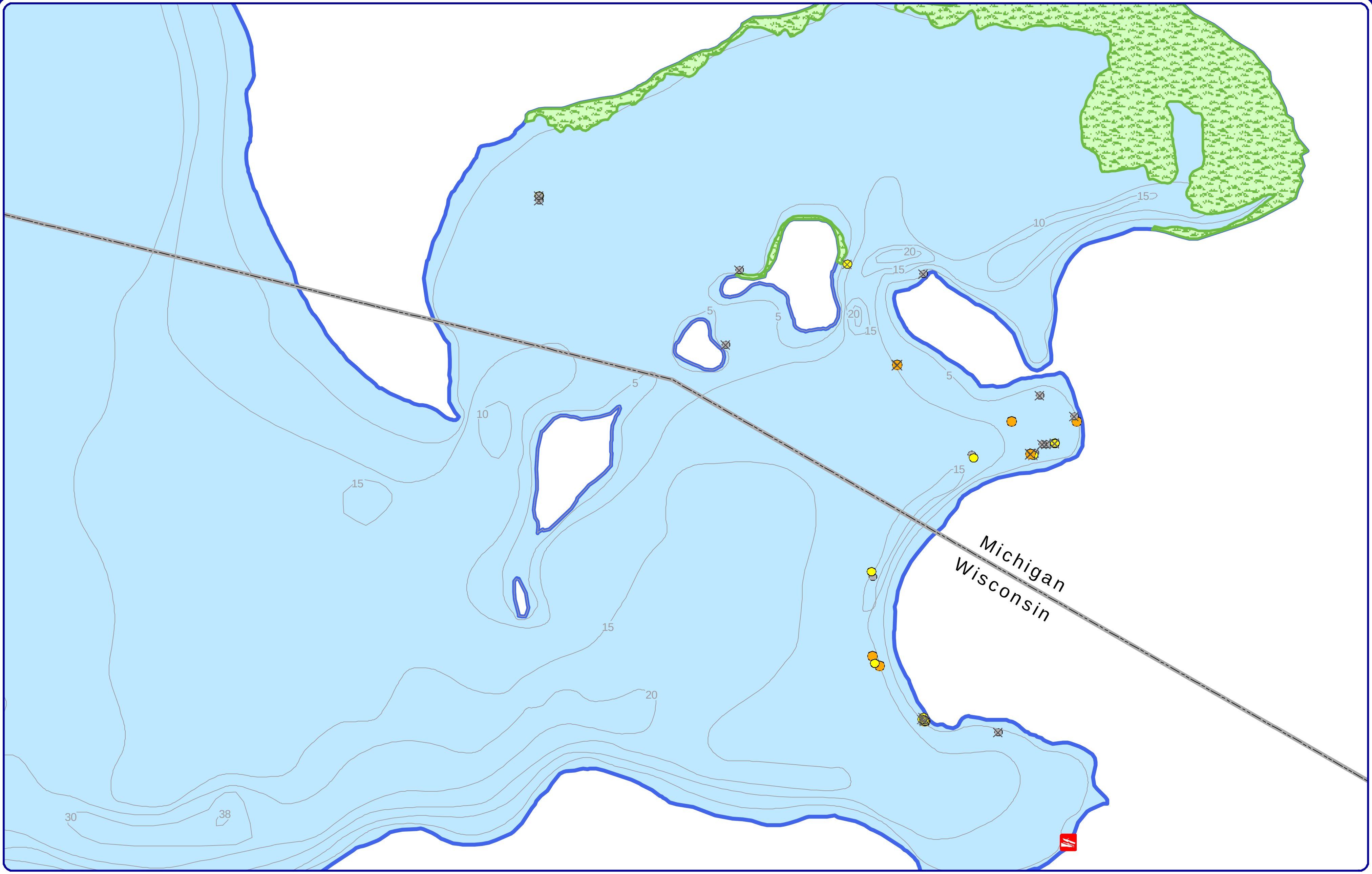
Extent of large map shown in red.

Legend

- 2010 EWM Hand Removed *(Onterra)*
- 2009 Final Treatment Area
- 2011 EWM Locations *(ISCCW)*

Map 6
Lac Vieux Desert
Vilas County, Wisconsin
& Gogebic, Michigan

2010-2011 EWM Survey Results



1,700

Feet

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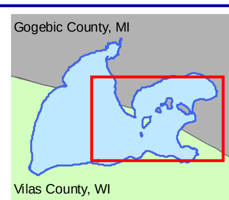
Sources:
Roads & Hydro: WDNR
EWM Survey: USFS, 2012; ISCCW, 2012; GLIFWC, 2012
Emergent Plants: Onterra, 2009
Bathymetry: WDNR - Digitized by Onterra
Map date: September 12, 2012



Extent of large map shown in red.

Legend

EWM Location
- Single or Few
- Clumps of Plants
- Small Plant Colony

Emergent Plant Colony Containing Wid Rice

EWM Hand-Removal Efforts Applied

Map 7
Lac Vieux Desert Lake
Vilas County, Wisconsin
& Gogebic, Michigan

2012 EWM Survey Results