
Pesobic Lake

Lincoln County, Wisconsin

Comprehensive Management Plan

March 2013



Sponsored by:

Pesobic Lake Association

WDNR Grant Program

LPL-1400-11 & LPL-1401-11

Pesobic Lake
Lincoln County, Wisconsin
Comprehensive Management Plan
March 2013

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

Funded by: Pesobic Lake Association
Wisconsin Dept. of Natural Resources
(LPL-1400-11 & LPL-1401-11)

Acknowledgements

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

Pesobic Lake Planning Committee

Scott Voight
Bill Morris
Ken Adams

Dale Kuck
Tom Fox
Joe Mertens

Mike Saeger
Steve Peterson

Wisconsin Dept. of Natural Resources

Jim Kreitlow
Kevin Gauthier

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- A. Public Participation Materials
- B. Stakeholder Survey Response Charts and Comments
- C. Water Quality Data
- D. Watershed Analysis WiLMS Results
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1.0 INTRODUCTION

Pesobic Lake, Lincoln County, is a 156-acre seepage lake with a maximum depth of 11 feet and a mean depth of six feet. This upper-mesotrophic/lower eutrophic lake has a relatively small watershed when compared to the size of the lake. Pesobic Lake contains 35 native plant species, of which large purple bladderwort is the most common plant. Reed canary grass, a wetland exotic plant species, was found along portions of the shoreline in 2011.

Field Survey Notes

Slightly stained water observed in 2011 during lake visits. Many species observed during plant studies, including snail-seed pondweed which is of special interest/concern in Wisconsin.



Photograph 1.0-1 Pesobic Lake, Lincoln County

Lake at a Glance - Pesobic Lake

Morphology	
Acreage	156
Maximum Depth (ft)	11
Mean Depth (ft)	6
Shoreline Complexity	1.9
Vegetation	
Curly-leaf Survey Date	June 21, 2011
Comprehensive Survey Date	July 13-14, 2011
Number of Native Species	35
Threatened/Special Concern Species	Snail-seed pondweed (<i>Potamogeton bicupulatus</i>)
Exotic Plant Species	Reed canary grass (<i>Phalaris arundinacea</i>)
Simpson's Diversity	0.81
Average Conservatism	7.9
Water Quality	
Trophic State	Upper mesotrophic/lower eutrophic
Limiting Nutrient	Phosphorus
Water Acidity (pH)	6.1 to 6.6
Sensitivity to Acid Rain	Moderately sensitive
Watershed to Lake Area Ratio	6:1

Pesobic Lake is located just north of the city of Merrill in Lincoln County. The Pesobic Lake Association (PLA) was founded in 1991 to oversee management activities on the lake. The PLA is a “*non-profit corporation dedicated to maintain, protect and enhance the quality of the lake and its surroundings for the collective interest of its members*”. In 2010, members of the lake association approached the Wisconsin Department of Natural Resources (WDNR) and Onterra staff with questions about creating a lake management plan for Pesobic Lake, and applying for financial assistance through the state to do so. The lake management planning project was funded by grants through the WDNR’s lake grant program in August 2010, with studies beginning the following year.

The PLA became interested in creating a lake management plan for two primary reasons. First, the group wanted to be better prepared to react if Pesobic Lake becomes established with an aquatic invasive species. The association understands that the WDNR can respond more quickly and accurately to address an invasive species establishment if the lake has management plan in place. Second, they understood the value in gaining a better understanding of the overall condition of the lake. The information obtained in this document helps to design and implement management strategies that guide current PLA plans and programs. Additionally, the understanding that has been achieved about the natural lake ecosystem will help to direct future management actions.

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. Materials used during the planning process can be found in Appendix A.

Kick-off Meeting

On June 27, 2011, a project kick-off meeting was held at the Park City Credit Union's Community Room to introduce the project to the general public. The meeting was announced through a mailing and personal contact by Pesobic Lake Association board members. The attendees observed a presentation given by Tim Hoyman, an aquatic ecologist with Onterra. Mr. Hoyman'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.

Planning Committee Meeting

On July 16, 2012, Dan Cibulka and Brenton Butterfield met with several members of the PLA Planning Committee to discuss the results of the studies that had been conducted on Pesobic Lake in 2011-2012. All project components, including stakeholder survey results, water quality analysis, watershed modeling, aquatic plant inventories and fisheries data integration were presented upon with initial conclusions following. Specific concerns, such as lowering water levels, aquatic invasive species, increasing watershed communities and presence of duck hunting on the lake were discussed.

Management Plan Review and Adoption Process

Prior to the July 16 planning meeting, the PLA Planning Committee was provided with the results sections of the study for them to review (Sections 3.1-3.4). Following discussion and then creation of the Implementation Plan, this portion of the document was sent to the PLA Planning Committee on September 26, 2012 for review. The entire document, in draft form, was submitted to the WDNR for comments on January 24, 2013 and was approved on March 22, 2013.

Riparian Property Owner Brochure

In lieu of a Wrap-Up meeting that would inform riparian property owners about the results of the project study, PLA planning committee members decided a more effective route to deliver this information would be in the form of a tri-fold brochure that summarized the projects findings.

This brochure was created in December 2012 by Onterra and provided to the PLA to distribute. The brochure is included within Appendix A.

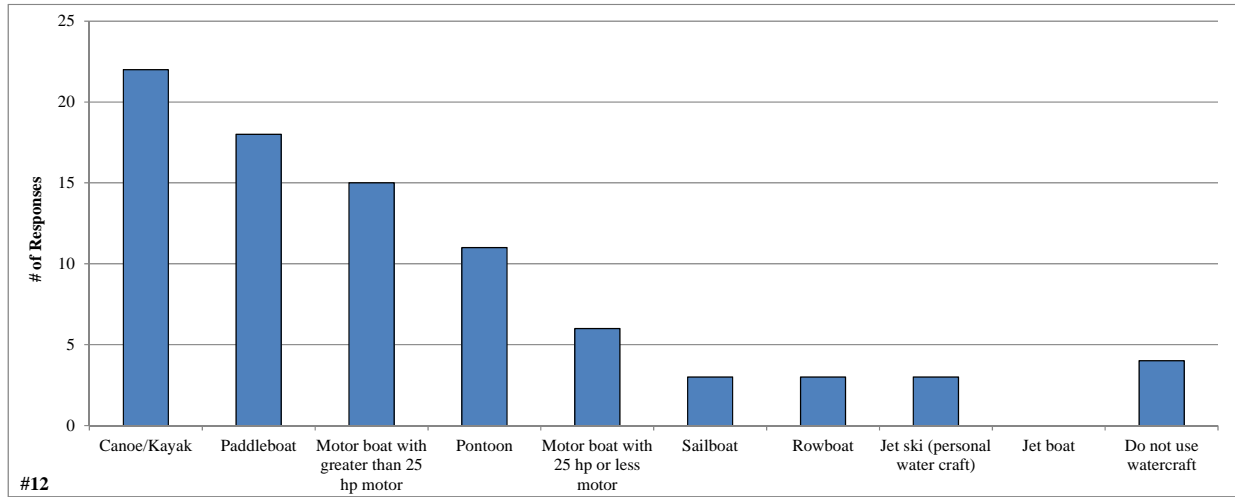
Stakeholder Survey

During March 2012, a seven-page, 29-question survey was mailed to 56 riparian property owners around Pesobic Lake. Seventy percent of the surveys were returned and those results were entered into a spreadsheet by members of the Pesobic Lake 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 and a general summary is discussed below.

Based upon the results of the Stakeholder Survey, much was learned about the people that use and care for Pesobic Lake. The majority of stakeholders (77%) are year-round residents, while 14% visit on weekends through the year and 6% live on the lake during the summer months only. Thirty-four percent of stakeholders have owned their property for over 25 years. As indicated within Questions #12 and #13 of the survey, the majority of respondents enjoy passive activities on this relatively small lake (Figure 2.0-1).

Issues pertaining to aquatic plant growth and water quality were ranked as concerns by survey respondents (Figure 2.0-2). Responses pertaining to water quality issues/perceptions are discussed within the Water Quality Section, while responses pertaining to aquatic plant issues are discussed within the Aquatic Plant Section. Additionally, other survey information is discussed throughout the management plan where appropriate.

Question 12: What types of watercraft do you currently use on the lake?



Question 13: Please rank up to three activities that are important reasons for owning your property on or near the lake.

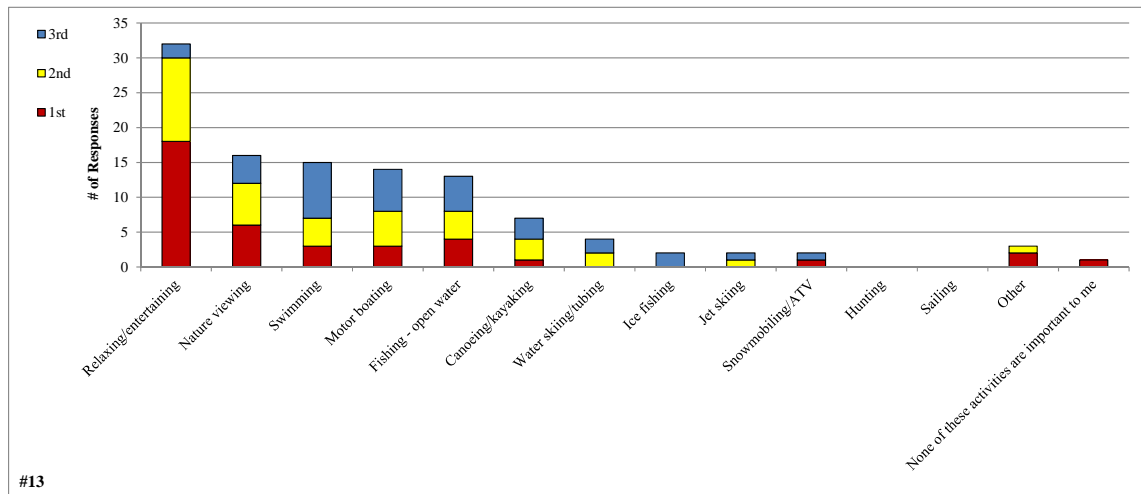
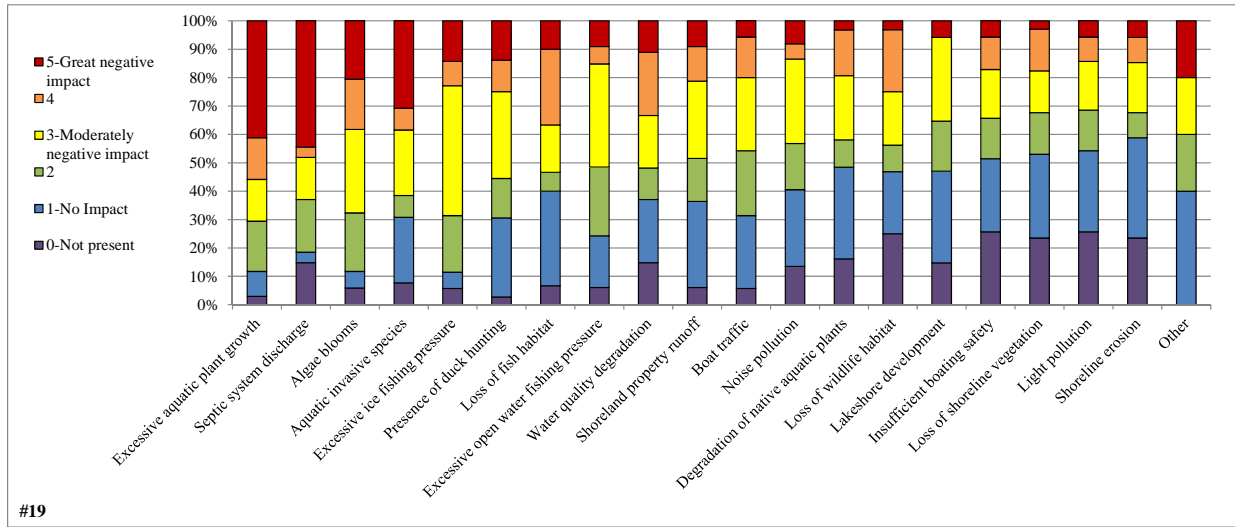


Figure 2.0-1. Select survey responses from the Pesobic Lake Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

Question 19: To what level do you believe these factors may be negatively impacting Pesobic Lake?



Question 20: Please rank your top three concerns regarding Pesobic Lake.

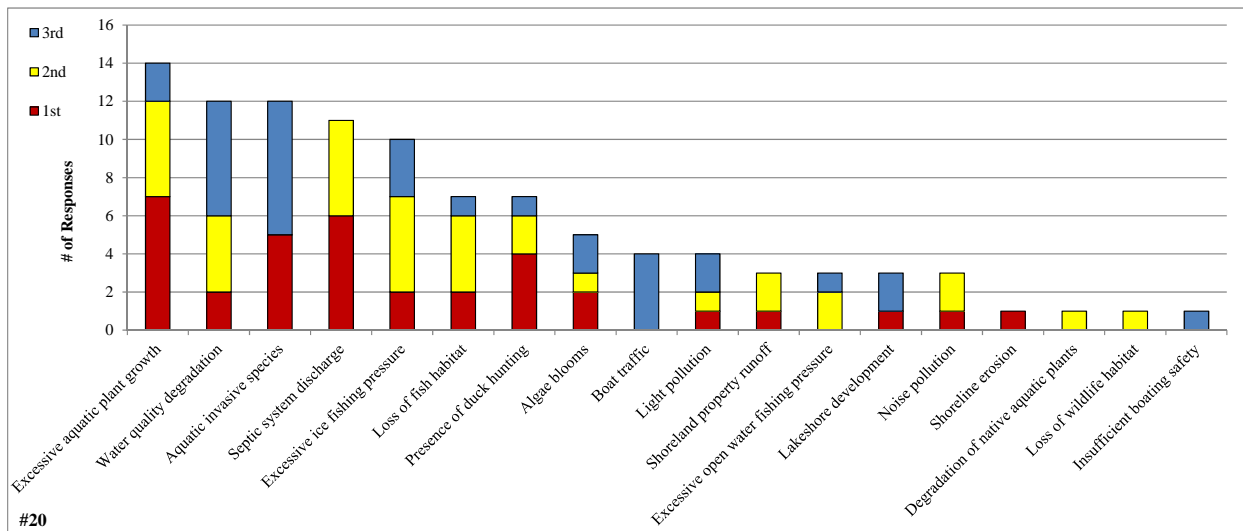


Figure 2.0-2. Select survey responses from the Pesobic Lake Stakeholder Survey, continued. Additional questions and response charts may be found in Appendix B.

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, water quality values that may be considered poor for one lake may be considered good for another because judging water quality is often subjective. However, focusing on specific aspects or parameters that are important to lake ecology, comparing those values to similar lakes within the same region and historical data from the study lake provides an excellent method to evaluate the quality of a lake's water.

Many types of analyses are available for assessing the condition of a particular lake's water quality. In this document, the water quality analysis focuses upon attributes that are directly related to the productivity of the lake. In other words, the water quality that impacts and controls the fishery, plant production, and even the aesthetics of the lake are related here. Specific forms of water quality 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.

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

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

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

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

Trophic State

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

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

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

Limiting Nutrient

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

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

considered nitrogen limited. Values between these ratios indicate a transitional limitation between nitrogen and phosphorus.

Temperature and Dissolved Oxygen Profiles

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.

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

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.

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.

Comparisons with Other Datasets

The WDNR publication *Implementation and Interpretation of Lakes Assessment Data for the Upper Midwest* (PUB-SS-1044 2008) is an excellent source of data for comparing water quality from a given lake to lakes with similar features and lakes within specific regions of Wisconsin. Water quality among lakes, even among lakes that are located in close proximity to one another, can vary due to natural factors such as depth, surface area, the size of its watershed and the composition of the watershed's land cover. For this reason, the water quality of Pesobic Lake will be compared to lakes in the state with similar physical characteristics. The WDNR groups Wisconsin's lakes into 6 classifications (Figure 3.1-1).

First, the lakes are classified into two main groups: shallow (mixed) or deep (stratified). Shallow lakes tend to mix throughout or periodically during the growing season and as a result, remain well-oxygenated. Further, shallow lakes often support aquatic plant growth across most or all of the lake bottom. Deep lakes tend to stratify during the growing season and have the potential to have low oxygen levels in the bottom layer of water (hypolimnion). Aquatic plants are usually restricted to the shallower areas around the perimeter of the lake (littoral zone). An equation developed by Lathrop and Lillie (1980), which incorporates the maximum depth of the lake and the lake's surface area, is used to predict whether the lake is considered a shallow (mixed) lake or a deep (stratified) lake. The lakes are further divided into classifications based on their hydrology and watershed size:

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

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

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

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

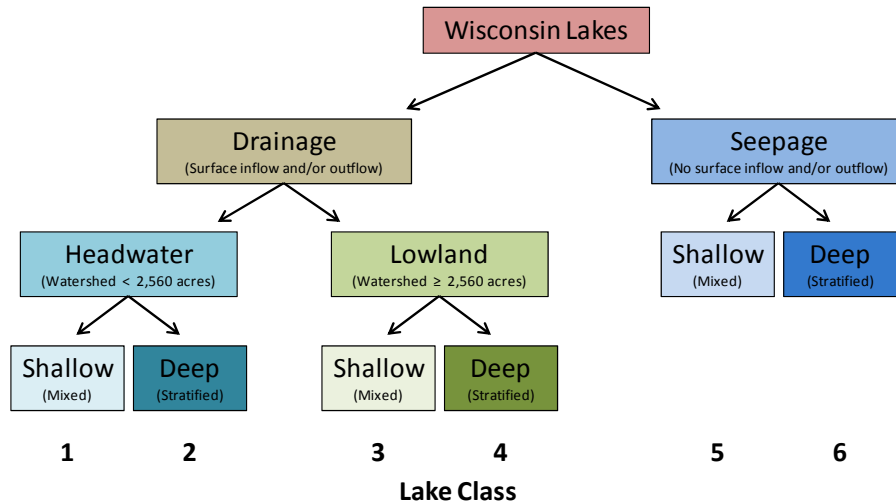


Figure 3.1-1. Wisconsin Lake Classifications. Pesobic Lake is classified as a shallow (mixed), seepage lake (Class 5). Adapted from WDNR PUB-SS-1044 2008.

Pesobic Lake does not possess a defined inlet and/or outlet and does not strongly stratify during the summer, designating it as a shallow seepage lake. The WDNR developed state-wide median values for total phosphorus, chlorophyll-*a*, and Secchi disk transparency for each of the six lake classifications. Though they did not sample sufficient lakes to create median values for each classification within each of the state’s ecoregions, they were able to create median values based on all of the lakes sampled within each ecoregion (Figure 3.1-2). Ecoregions are areas related by similar climate, physiography, hydrology, vegetation and wildlife potential. Comparing ecosystems in the same ecoregion is sounder than comparing systems within manmade boundaries such as counties, towns, or states. Pesobic Lake is within the North Central Hardwoods Forests ecoregion.

The Wisconsin 2010 Consolidated Assessment and Listing Methodology (WisCALM – WDNR 2009), created by the WDNR, is another useful tool in helping lake stakeholders understand the health of their lake compared to others within the state. Looking at pre-settlement diatom population compositions from sediment cores collected from numerous lakes around the state, they were able to infer a reference condition for each lake’s water quality prior to human development within their watersheds. Using these reference conditions and current water quality data, they were able to rank phosphorus, chlorophyll-*a*, and Secchi disk transparency values for each lake class into categories ranging from excellent to poor.



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

These data along with data corresponding to statewide natural lake medians, historic, current, and average data from Pesobic Lake are displayed in Figures 3.1-3 – 3.1-5. Please note that the data in these graphs represent concentrations taken only taken during the growing season (April-October) from Pesobic Lake. Since state and regional medians were calculated using summer (June, July, August) data, summer data for Pesobic Lake have also been displayed. Furthermore, the total 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.

Pesobic Lake Water Quality Analysis

Pesobic Lake Long-term Trends

In a survey distributed to Pesobic Lake riparian property owners during March of 2012, several questions were posed to lake stakeholders pertaining to the water quality of Pesobic Lake. Over half of respondents (53%) described the water quality of the lake to be *Good*, while 32% described it as *Fair* and 12% labeled the water quality as *Excellent* (Appendix B, Question #14). Most (29%) respondents indicated they felt the water quality had *remained the same* since they first visited the lake, while 37% felt it had improved and 21% felt it had degraded (Question #15). “Water quality degradation” was the second highest rated concern stakeholders had regarding Pesobic Lake (Question #20).

While the observations of riparian property owners are important to consider, it is also important to remember that perceptions of water quality are often quite subjective, varying much between individuals. Additionally, the condition of a lake’s water may fluctuate annually due to environmental factors and this difference is difficult to quantify without scientific data.

There has been a considerable amount of water quality data collected from Pesobic Lake over the past 20+ years. The majority of this data has been collected by Pesobic Lake volunteers through the Citizens Lake Monitoring Network (CLMN). These volunteers are enrolled in the advanced stage of this program, meaning that along with taking measurements of Secchi disk clarity, they are trained to collect samples that are read to detect total phosphorus and chlorophyll-*a*. Building the datasets of these three parameters is important, because it allows for the detection of trends which may point stakeholders towards an issue that is impacting Pesobic Lake.

Total phosphorus samples have been collected with some regularity since 1998. While some fluctuations exist due to environmental conditions, all annual summer average values fall within categories of *Good* or *Excellent* (Figure 3.1-3). A weighted average over all years lies within the *Good* category, and is only slightly higher than the median value for other shallow seepage lakes across the state, and lower than all lakes within the North Central Hardwood Forests (NCHF) Ecoregion.

Chlorophyll-*a* data has been collected in a manner consistent with the collection of total phosphorus data. Similarly, most of the annual summer averages fall within categories of *Good* and *Excellent* while a weighted average over the available time period ranks as *Good* (Figure 3.1-4). The weighted average is slightly higher than the median for similar lakes statewide but lower than all regional lakes.

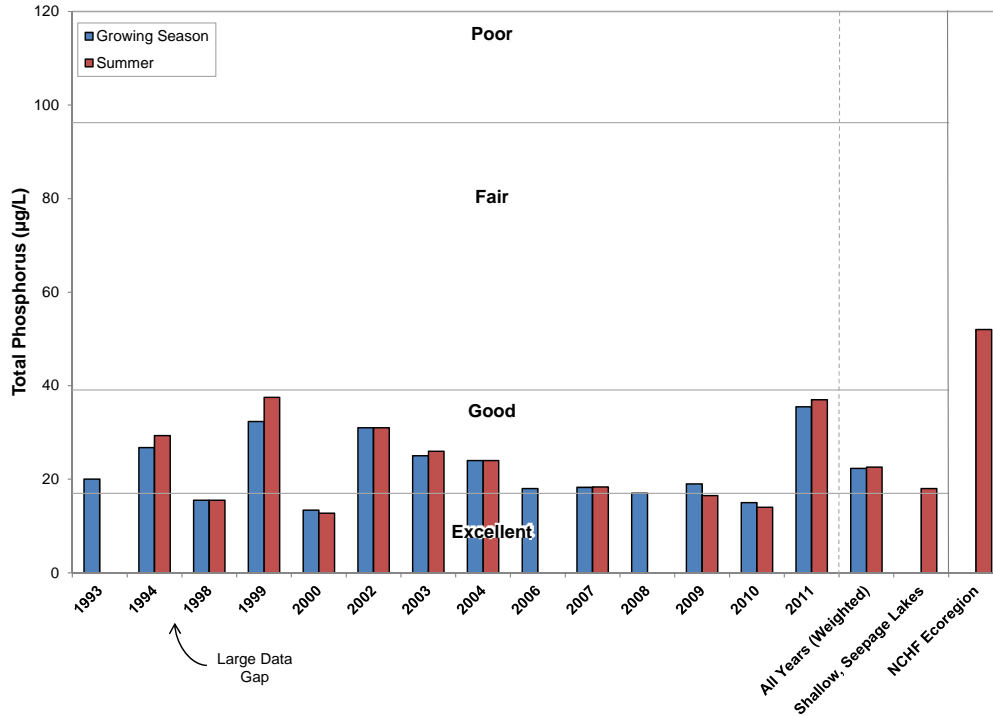


Figure 3.1-3. Pesobic Lake, state-wide class 5 lakes, and regional total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

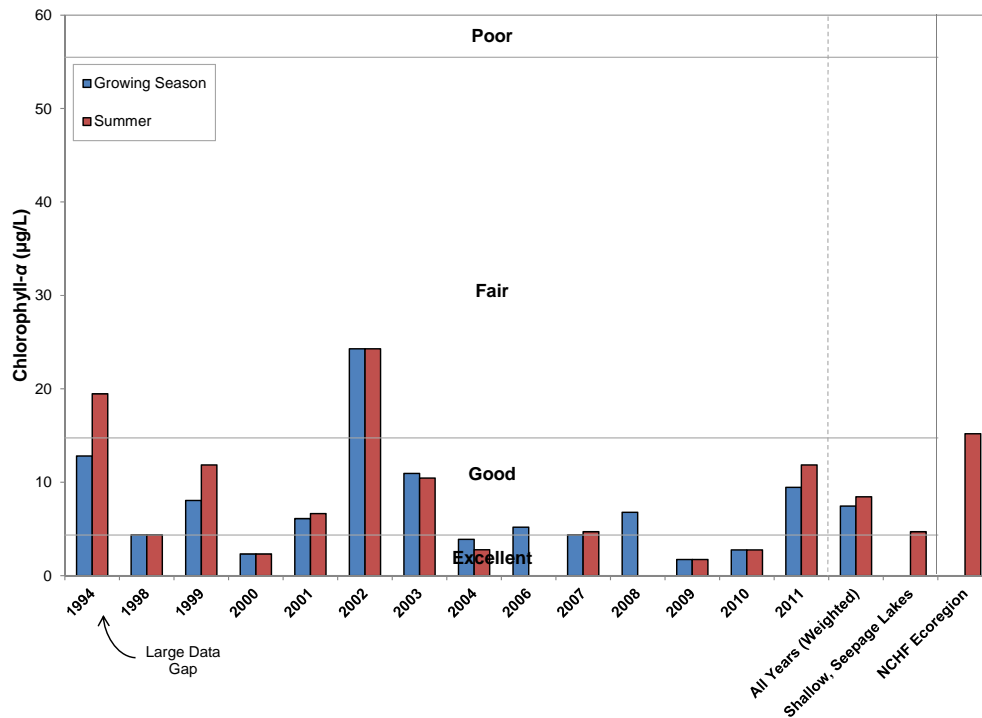


Figure 3.1-4. Pesobic Lake, state-wide class 5 lakes, and regional chlorophyll-a concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Besides a six-year gap between 2001 and 2008, Secchi disk clarity values have been collected with regularity since 1986. Incredibly inexpensive and easy to conduct, this measurement offers managers quite a bit of information about a lake's water clarity and should be continued on Pesobic Lake as long as possible. The available data suggests that the lake has *Good* water clarity; however, a weighted average over all years is a bit lower than the median value for other shallow, seepage lakes across the state and very similar to the median of all lakes within the NCHF Ecoregion (Figure 3.1-5).

Considerable variance exists within the Secchi disk clarity dataset. Some of these variances may be due to sampling timing and regularity; for example, in 2000 only one reading was taken in late August. Therefore, this data point may not be representative of the overall water quality in this calendar year. In 2011, total phosphorus and chlorophyll-*a* concentrations were slightly higher than in previous years, and this was coupled with a corresponding decrease in Secchi disk clarity. Due to the high amount of snowfall and spring rains that Wisconsin received, 2011 is thought to be a "wet" year compared to other years (such as 2010). A potential increase in water runoff to Pesobic Lake may have washed in more nutrients and dissolved substances than in previous years, increasing algal content and reducing clarity within the water column.

Secchi disk clarity is influenced by many factors, including plankton production and suspended sediments, which themselves vary due to several environmental conditions such as precipitation, sunlight, and nutrient availability. In a lake such as Pesobic Lake, a natural staining of the water plays a role in light penetration, and thus water clarity, as well. The darker waters of Pesobic Lake contain many organic acids that are washed into the lake from nearby wetlands. The acids are not harmful to humans or aquatic species; they are by-products of decomposing wetland plant material. As will be discussed in the Aquatic Vegetation Section, this natural staining reduces light penetration into the water column, which reduces visibility but also reduces the growing depth of aquatic vegetation within the lake.

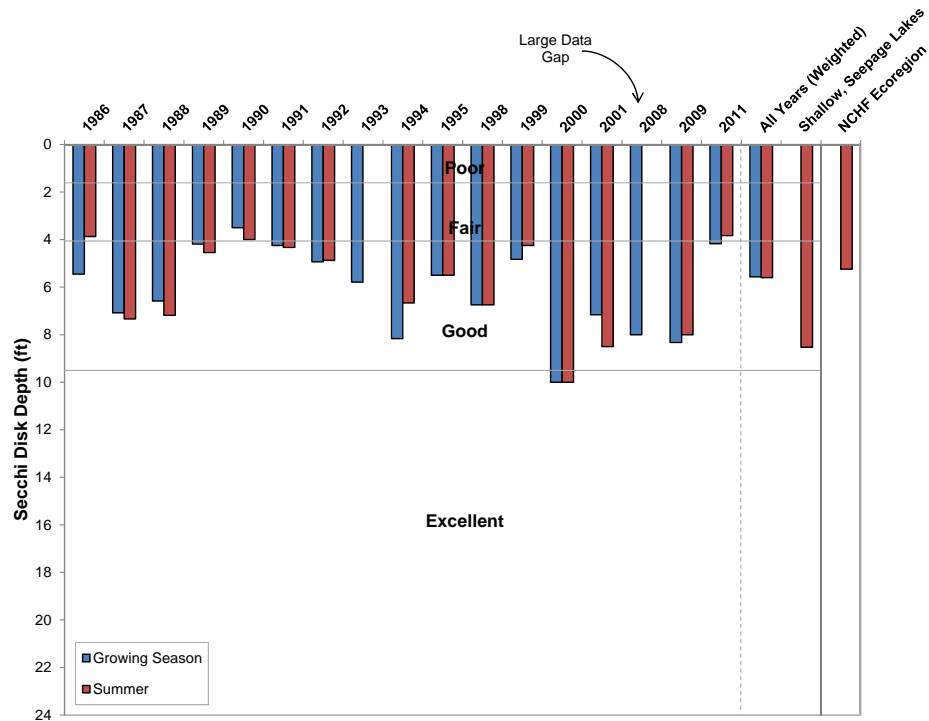


Figure 3.1-5. Pesobic Lake, state-wide class 5 lakes, and regional Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Limiting Plant Nutrient of Pesobic Lake

Using midsummer nitrogen and phosphorus concentrations from Pesobic Lake, a nitrogen:phosphorus ratio of 27:1 was calculated. This finding indicates that Pesobic Lake is indeed phosphorus limited as are the vast majority of Wisconsin lakes. In general, this means that cutting phosphorus inputs may limit plant growth within the lake.

Pesobic Lake Trophic State

Figure 3.1-6 contains the Trophic State Index (TSI) values for Pesobic Lake. The TSI values were calculated using total phosphorus and chlorophyll-*a* data; Secchi disk data was not used as water clarity in Pesobic Lake is influenced by factors other than free-floating algae, as discussed earlier. TSI values for Pesobic Lake vary from upper oligotrophic to eutrophic (Figure 3.1-6). However, the weighted average for years for which data are available indicates that Pesobic Lake is currently in an upper mesotrophic-lower eutrophic state.

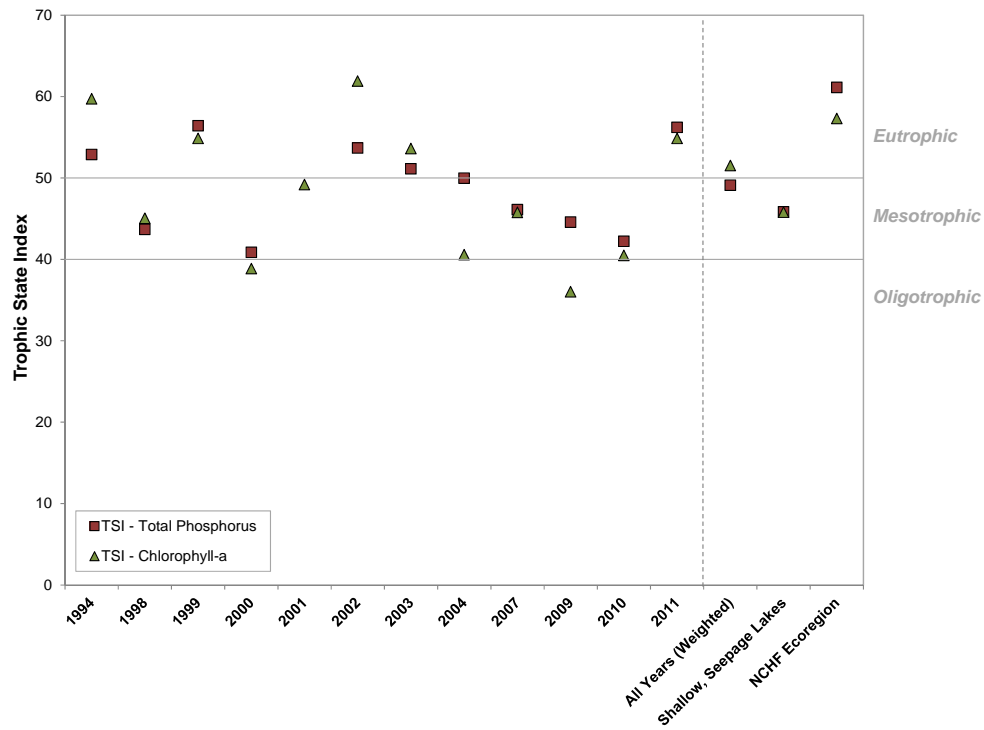


Figure 3.1-6. Pesobic Lake, state-wide class 5 lakes, and regional Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Dissolved Oxygen and Temperature in Pesobic Lake

Dissolved oxygen and temperature were measured during water quality sampling visits to Pesobic Lake by Onterra staff. Profiles depicting these data are displayed in Figure 3.1-7.

Small, relatively shallow lakes such as Pesobic Lake tend to not thermally stratify during the open water season. As pictured in April and November profiles, temperature and dissolved oxygen gradients are consistent throughout the water column. In deeper lakes, three distinct layers may develop in the summer months – a warmer upper layer (epilimnion), lower cold layer (hypolimnion) and a middle later of a temperature gradient (metalimnion – or commonly known as the thermocline). Wind energy during the summer months is able to distribute temperature and oxygen throughout the lake, so stratification of temperature layers does not develop.

In the winter months, ice cover does not allow wind to influence the lake. At this time, colder temperatures are located near the ice-covered surface and warmer, dense water moves to the bottom of the lake. Bacteria work to decompose organic matter near the bottom of the lake, which reduces oxygen. The bottom of the lake may become void of oxygen because of this, while oxygen also depletes to an extent in the upper portion of the water column. In March of 2012, dissolved oxygen concentration remained above 3.0 mg/L for the first four feet of the water column, enough to sustain warm-water species that are found in Wisconsin lakes.

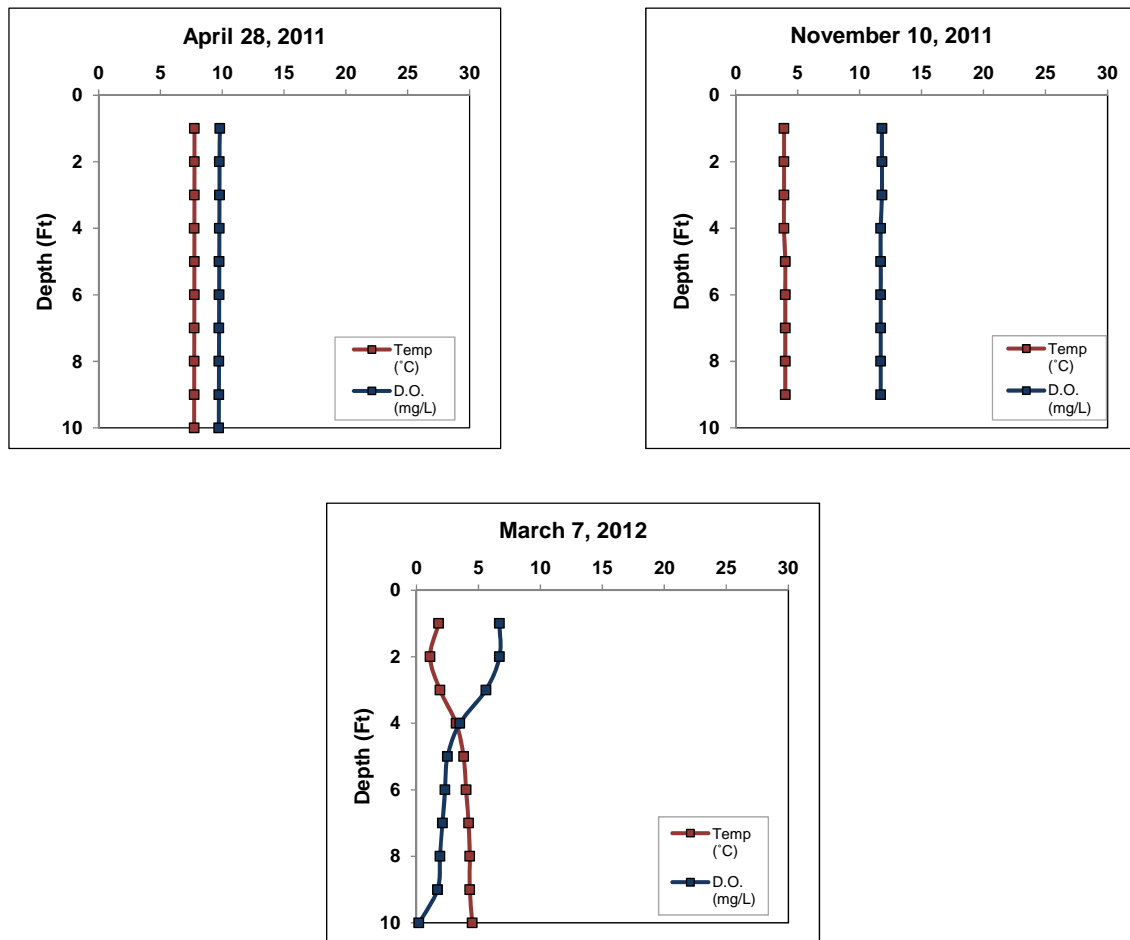


Figure 3.1-7. Pesobic Lake dissolved oxygen and temperature profiles.

Additional Water Quality Data Collected at Pesobic Lake

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

The pH scale ranges from 0 to 14 and indicates the concentration of hydrogen ions (H^+) within the lake's water and is an index of the lake's acidity. Water with a pH value of 7 has equal amounts of hydrogen ions and hydroxide ions (OH^-), and is considered to be neutral. Water with a pH of less than 7 has higher concentrations of hydrogen ions and is considered to be acidic, while values greater than 7 have lower hydrogen ion concentrations and are considered basic or alkaline. The pH scale is logarithmic; meaning that for every 1.0 pH unit the hydrogen ion concentration changes tenfold. The normal range for lake water pH in Wisconsin is about 5.2 to 8.4, though values lower than 5.2 can be observed in some acid bog lakes and higher than 8.4 in some marl lakes. In lakes with a pH of 6.5 and lower, the spawning of certain fish species such as walleye becomes inhibited (Shaw, 1985). The pH of the water in Pesobic Lake was found to be acidic with surface values ranging from 6.1 to 6.6.

Alkalinity is a lake's capacity to resist fluctuations in pH by neutralizing or buffering against inputs such as acid rain. The main compounds that contribute to a lake's alkalinity in Wisconsin are bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}), which neutralize hydrogen ions from acidic inputs. These compounds are present in a lake if the groundwater entering it comes into contact with minerals such as calcite ($CaCO_3$) and/or dolomite ($CaMgCO_3$). A lake's pH is primarily determined by the amount of alkalinity. Rainwater in northern Wisconsin is slightly acidic naturally due to dissolved carbon dioxide from the atmosphere with a pH of around 5.0. Consequently, lakes with low alkalinity have lower pH due to their inability to buffer against acid inputs. The alkalinity in Pesobic Lake was measured at 4.9 (mg/L as $CaCO_3$), indicating that the lake has a low capacity to resist fluctuations in pH and is moderately sensitive to acid rain.

Like associated pH and alkalinity, the concentration of calcium within a lake's water depends on the geology of the lake's watershed. Recently, the combination of calcium concentration and pH has been used to determine what lakes can support zebra mussel populations if they are introduced. The commonly accepted pH range for zebra mussels is 7.0 to 9.0, so Pesobic Lake's pH values fall slightly outside of this range. Lakes with calcium concentrations of less than 12 mg/L are considered to have very low susceptibility to zebra mussel establishment. The calcium concentration of Pesobic Lake was found to be 2.3 mg/L, falling well below the optimal range for zebra mussels.

Researchers at the University of Wisconsin - Madison have developed an AIS suitability model called smart prevention (Vander Zanden and Olden 2008). In regards to zebra mussels, this model relies on measured or estimated dissolved calcium concentration to indicate whether a given lake in Wisconsin is suitable, borderline suitable, or unsuitable for sustaining zebra mussels. Within this model, suitability was estimated for approximately 13,000 Wisconsin waterbodies and is displayed as an interactive mapping tool (www.aissmartprevention.wisc.edu). Based upon this analysis, Pesobic Lake was considered borderline suitable for mussel

establishment. Plankton tows were completed by Onterra staff during the summer of 2011 and these samples were processed by the WDNR for larval zebra mussels. Their analysis did not locate any larval zebra mussels.

Total suspended solids (TSS) are a measure of inorganic and organic particles suspended in the water, and include everything from algae to clay particles. High TSS creates low water clarity, and prevents light from penetrating into the water to support aquatic plant growth. TSS was measured in Pesobic Lake during two water quality sampling events, and the data indicate that TSS were undetectable during all of the sampling events.

3.2 Watershed Assessment

Watershed Modeling

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

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

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

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.

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 are entered into WiLMS along with the acreages of different types of land cover within the watershed to produce useful information about the lake ecosystem. This information includes an estimate of annual phosphorus load and the partitioning of those loads between the watershed's different land cover types and atmospheric fallout entering through the lake's water surface. WiLMS also calculates the lake's flushing rate and residence times using county-specific average precipitation/evaporation values or values entered by the user. Predictive models are also included within WiLMS that are valuable in validating modeled phosphorus loads to the lake in question and modeling alternate land cover scenarios within the watershed. Finally, if specific information is available, WiLMS will also estimate the significance of internal nutrient loading within a lake and the impact of shoreland septic systems.

Delineation of land cover types within Pesobic Lake's watershed indicates that the largest portion (32% or 352 acres) is comprised of wetlands (Figure 3.2-1 and Map 2). Forests are the second-largest land cover type covering approximately 268 acres (24% of the watershed), followed by rural residential areas (16% or 182 acres), the lake's surface itself (14% or 156 acres), pasture/grass (11% or 127 acres), and row crop agriculture (3% or 38 acres). Overall, the watershed is relatively small in size at 1,122 acres and yields a watershed to lake area ratio of 6:1.

WiLMS was utilized to estimate the annual phosphorus load to Pesobic Lake (model output in Appendix D). It is difficult to accurately model lakes with no tributary input (seepage lakes), as WiLMS is designed to model drainage systems with an inlet and an outlet most accurately. However, this modeling program may be used to give managers a general idea of the phosphorus load to a seepage lake. Additionally, in-field samples of the lake's water quality may be used to calibrate the model and ensure accuracy. Because water quality data is readily available through the efforts of Pesobic Lake volunteers and also through this project, these calibrations were able to be made.

The annual phosphorus load to Pesobic Lake is approximately 176 lbs (Figure 3.2-2). Because of the small watershed, which is also in relatively good condition, the greatest contributor of phosphorus to Pesobic Lake is actually the lake surface, which collects 42 lbs (24% of the total load) of phosphorus a year through atmospheric deposition. Row crops and pasture/grass areas, the smallest land cover types, deliver an estimated 33 lbs (19%) each, wetlands deliver 31 lbs (17%), and forests (12%) and rural residential areas (9%) export smaller portions of the annual load.

The estimated 176 lbs of phosphorus entering Pesobic Lake annually is believed to be overestimated by the model, as the predicted within-lake growing season phosphorus was significantly higher than what was actually measured within the lake. As discussed previously, it is difficult to model phosphorus delivery to a lake with no tributary inlet. In addition, the areas of row crops and pasture/grass are surrounded by or adjacent to wetlands and forests which intercept runoff from these areas and increase filtering and soil percolation. These factors are not anticipated in WiLMS and as a result, the modeling indicates a higher phosphorus load than actually occurs.

As previously mentioned, lakes that have a small watershed to lake area ratio are particularly vulnerable to changes that may occur within the watershed. A relatively small conversion of one land cover type to another may have significant impacts, likely not in the short-term, upon the lake. WiLMS was utilized to model a scenario in which 25% (67 acres) of the forested land present in the watershed was converted to row crop agriculture classification. This relatively small change in land management resulted in a 22% increase in the annual total phosphorus load to the lake. The shoreline of a lake is a critical zone in terms of protecting the health of a lake, but is often subject to modifications which increase the level of unnatural development. This particular area of the watershed is discussed further below.

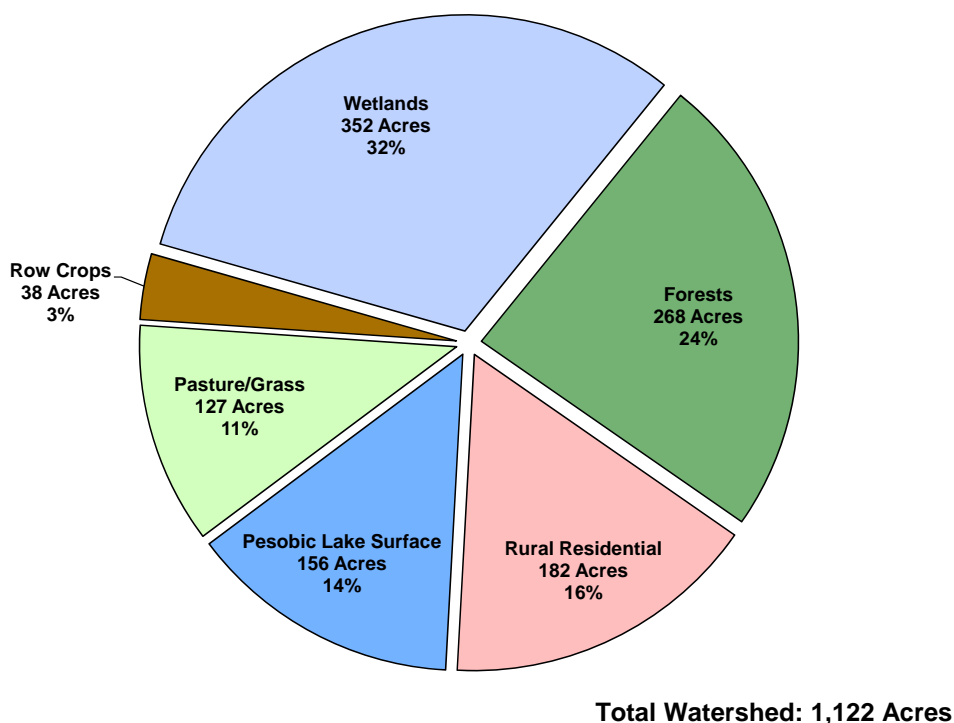
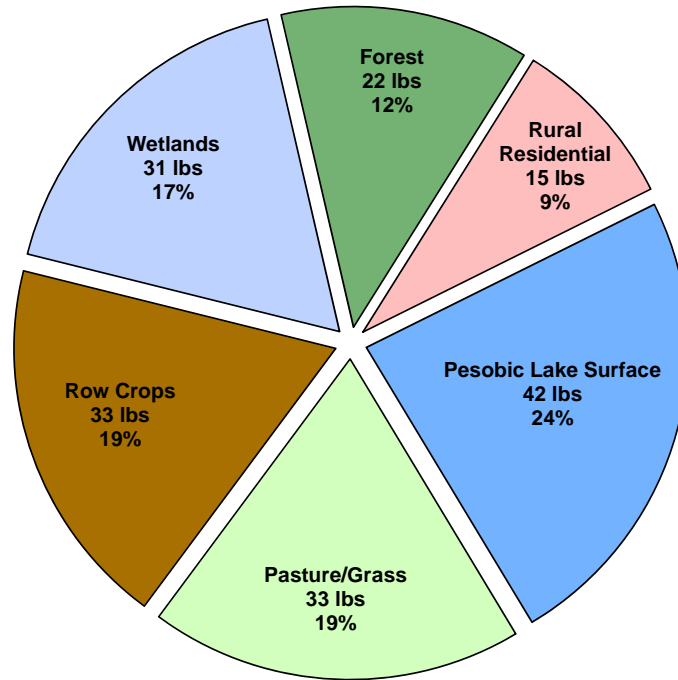


Figure 3.2-1. Pesobic Lake watershed land cover types in acres. Based upon National Land Cover Database (NLCD – Fry et. al 2011).



Total Loading: 176 lbs

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

3.3 Shoreland Condition

The Importance of a Lake's Shoreland Zone

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

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

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

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

Shoreland Zone Regulations

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

Wisconsin-NR 115: Wisconsin's Shoreland Protection Program

Wisconsin's shoreland zoning rule, NR 115, sets the minimum standards for shoreland development. First adopted in 1966, the code set a deadline for county adoption of January 1, 1968. By 1971, all counties in Wisconsin had adopted the code and were administering the shoreland ordinances it specified. Interestingly, in 2007 it was noted that many (27) counties had

recognized inadequacies within the 1968 ordinance and had actually adopted more strict shoreland ordinances. Passed in February of 2010, the final NR 115 allowed many standards to remain the same, such as lot sizes, shoreland setbacks and buffer sizes. However, several standards changed as a result of efforts to balance public rights to lake use with private property rights. The regulation sets minimum standards for the shoreland zone, and requires all counties in the state to adopt shoreland zoning ordinances of their own. County ordinances may be more restrictive than NR 115, but not less so. These policy regulations require each county to amend ordinances for vegetation removal on shorelands, impervious surface standards, nonconforming structures and establishing mitigation requirements for development. Minimum requirements for each of these categories are as follows (Note: counties must adopt these standards by February 2014, counties may not have these standards in place at this time):

- **Vegetation Removal:** For the first 35 feet of property (shoreland zone), no vegetation removal is permitted except for: sound forestry practices on larger pieces of land, access and viewing corridors (may not exceed the lesser of 30 percent of the shoreline frontage), invasive species removal, or damaged, diseased, or dying vegetation. Vegetation removed must be replaced by replanting in the same area (native species only)..
- **Impervious surface standards:** The amount of impervious surface is restricted to 15% of the total lot size, on lots that are within 300 feet of the ordinary high-water mark of the waterbody. A county may allow more than 15% impervious surface (but not more than 30%) on a lot provided that the county issues a permit and that an approved mitigation plan is implemented by the property owner.
- **Nonconforming structures:** Nonconforming structures are structures that were lawfully placed when constructed but do not comply with distance of water setback. Originally, structures within 75 ft of the shoreline had limitations on structural repair and expansion. New language in NR-115 allows construction projects on structures within 75 feet with the following caveats:
 - No expansion or complete reconstruction within 0-35 feet of shoreline
 - Re-construction may occur if no other build-able location exists within 35-75 feet, dependent on the county.
 - Construction may occur if mitigation measures are included either within the footprint or beyond 75 feet.
 - Vertical expansion cannot exceed 35 feet
- **Mitigation requirements:** New language in NR-115 specifies mitigation techniques that may be incorporated on a property to offset the impacts of impervious surface, replacement of nonconforming structure, or other development projects. Practices such as buffer restorations along the shoreland zone, rain gardens, removal of fire pits, and beaches all may be acceptable mitigation methods dependent on the county.
- Contact the county's regulations/zoning department for all minimum requirements.

Wisconsin Act 31

While not directly aimed at regulating shoreland practices, the State of Wisconsin passed Wisconsin Act 31 in 2009 in an effort to minimize watercraft impacts upon shorelines. This act

prohibits a person from operating a watercraft (other than personal watercraft) at a speed in excess of slow-no-wake speed within 100 feet of a pier, raft, buoyed area or the shoreline of a lake. Additionally, personal watercraft must abide by slow-no-wake speeds while within 200 feet of these same areas. Act 31 was put into place to reduce wave action upon the sensitive shoreland zone of a lake. The legislation does state that pickup and drop off areas marked with regulatory markers and that are open to personal watercraft operators and motorboats engaged in waterskiing/a similar activity may be exempt from this distance restriction. Additionally, a city, village, town, public inland lake protection and rehabilitation district or town sanitary district may provide an exemption from the 100 foot requirement or may substitute a lesser number of feet.

Shoreland Research

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

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

Shorelands provide much in terms of nutrient retention and mitigation, but also play an important role in wildlife habitat. Woodford and Meyer (2003) found that green frog density was negatively correlated with development density in Wisconsin lakes. As development increased, the habitat for green frogs decreased and thus populations became significantly lower. Common loons, a bird species notorious for its haunting call that echoes across Wisconsin lakes, are often associated more so with undeveloped lakes than developed lakes (Lindsay et al. 2002). And

studies on shoreland development and fish nests show that undeveloped shorelands are preferred as well. In a study conducted on three Minnesota lakes, researchers found that only 74 of 852 black crappie nests were found near shorelines that had any type of dwelling on it (Reed, 2001). The remaining nests were all located along undeveloped shoreland.

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



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

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

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 shoreland. Removal of native plants and dead, fallen timbers from shallow, near-shore areas for boating and swimming activities destroys habitat used by fish, mammals, birds, insects, and amphibians, while leaving bottom and shoreland sediments vulnerable to wave action caused by boating and wind (Jennings 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 depends on the size of the restoration area, the depth of buffer zone required to be restored, the existing plant density, the planting density required, the species planted, and the type of planting (e.g. seeds, bare-roots, plugs, live-stakes) being conducted. Other sites may require erosion control stabilization measures, which could be as simple as using erosion control blankets and plants and/or seeds or more extensive techniques such as geotextile bags (vegetated retaining walls), geogrids (vegetated soil lifts), or bio-logs (see above picture). Some of these erosion control techniques may reduce the need for rip-rap or seawalls which are sterile environments that do not allow for plant growth or natural shorelines. Questions about rip-rap or seawalls should be directed to the local Wisconsin DNR Water Resources Management Specialist. Other measures possibly required include protective measures used to guard newly planted area from wildlife predation, wave-action, and erosion, such as fencing, erosion control matting, and animal deterrent sprays. One of the most important aspects of planting is maintaining moisture levels. This is done by watering regularly for the first two years until plants establish themselves, using soil amendments (i.e., peat, compost) while planting, and using mulch to help retain moisture.

Most restoration work can be completed by the landowner themselves. To decrease costs further, bare-root form of trees and shrubs should be purchased in early spring. If additional assistance is needed, the lakefront property owner could contact an experienced landscaper. For properties with erosion issues, owners should contact their local county conservation office to discuss cost-share options.

In general, a restoration project with the characteristics described below would have an estimated materials and supplies cost of approximately \$1,400. The more native vegetation a site has, the lower the cost. Owner's should contact the county's regulations/zoning department for all minimum requirements. The single site used for the estimate indicated above has the following characteristics:

- Spring planting timeframe.
- 100' of shoreline.
- An upland buffer zone depth of 35'.
- An access and viewing corridor 30' x 35' free of planting (recreation area).
- Planting area of upland buffer zone 2- 35' x 35' areas
- Site is assumed to need little invasive species removal prior to restoration.
- Site has only turf grass (no existing trees or shrubs), a moderate slope, sandy-loam soils, and partial shade.
- Trees and shrubs planted at a density of 1 tree/100 sq ft and 2 shrubs/100 sq ft, therefore, 24 native trees and 48 native shrubs would need to be planted.
- Turf grass would be removed by hand.
- A native seed mix is used in bare areas of the upland buffer zone.
- An aquatic zone with shallow-water 2 - 5' x 35' areas.
- Plant spacing for the aquatic zone would be 3 feet.
- Each site would need 70' of erosion control fabric to protect plants and sediment near the shoreland (the remainder of the site would be mulched).
- Soil amendment (peat, compost) would be needed during planting.
- 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.

<i>Advantages</i>	<i>Disadvantages</i>
<ul style="list-style-type: none"> • 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 shoreland erosion. • Lower cost when compared to rip-rap and seawalls. • Restoration projects can be completed in phases to spread out costs. • Once native plants are established, they require less water, maintenance, no fertilizer; provide wildlife food and habitat, and natural aesthetics compared to ornamental (non-native) varieties. • Many educational and volunteer opportunities are available with each project. 	<ul style="list-style-type: none"> • 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.

Pesobic Lake Shoreland Zone Condition

Pesobic Lake's shoreland zone can be classified in terms of its degree of development. In general, more developed shorelands are more stressful on a lake ecosystem, while definite benefits occur from shorelands that are left in their natural state. Figure 3.3-1 displays a diagram of shoreland categories, from "Urbanized", meaning the shoreland zone is completely disturbed by human influence, to "Natural/Undeveloped", meaning the shoreland has been left in its original state.

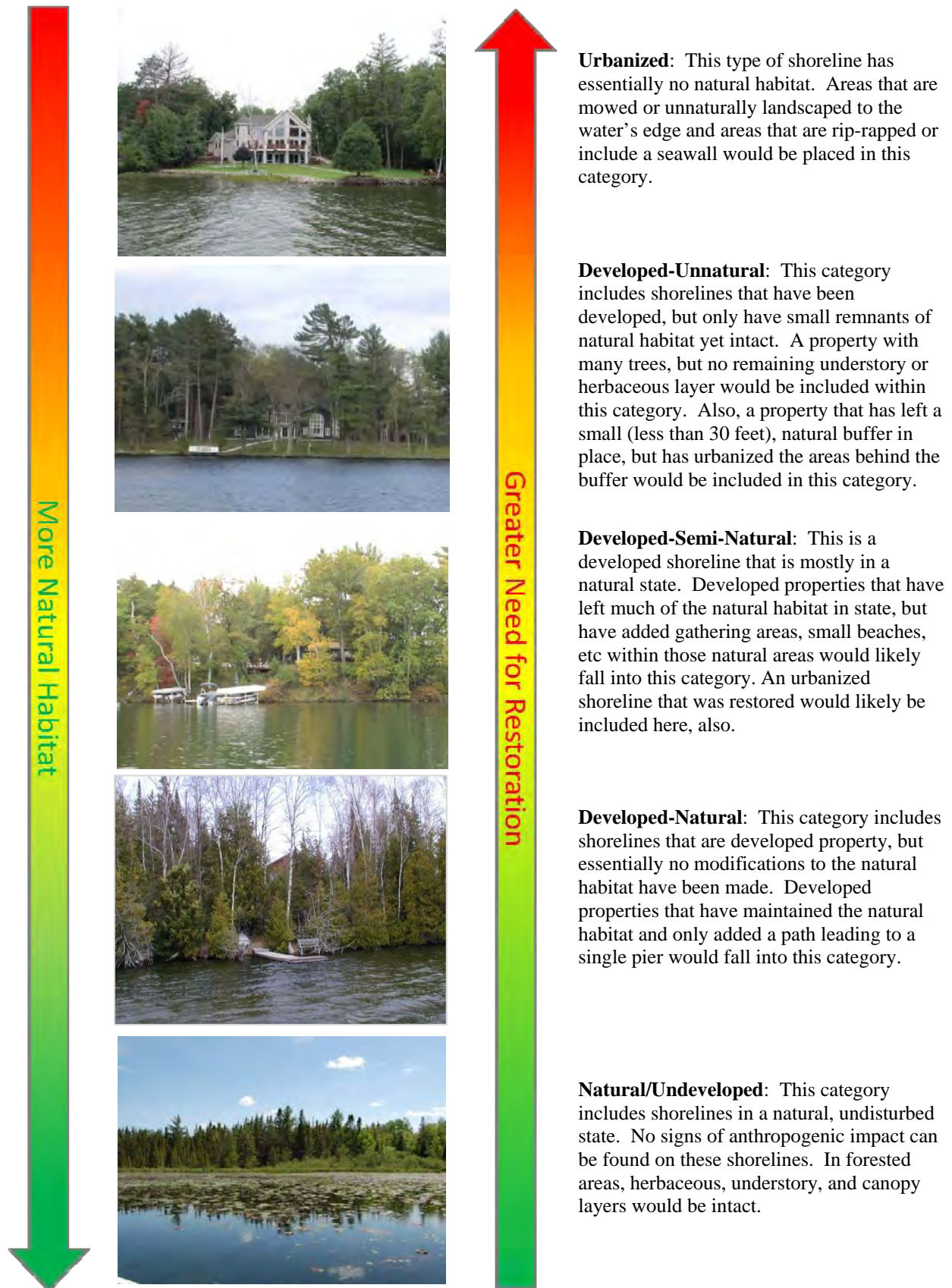


Figure 3.3-1. Shoreline assessment category descriptions.

On Pesobic Lake, the development stage of the entire shoreline was surveyed during the fall of 2011, using a GPS unit to map the shoreline. Onterra staff only considered the area of shoreland 35 feet inland from the water's edge, and did not assess the shoreline on a property-by-property basis. During the survey, Onterra staff examined the shoreline for signs of development and assigned areas of the shoreland one of the five descriptive categories in Figure 3.3-2.

Pesobic Lake has stretches of shoreland that fit all of the five shoreland assessment categories. In all, 0.9 miles of natural/undeveloped and developed-natural shoreline were observed during the survey (Figure 3.2-4). These shoreland types provide the most benefit to the lake and should be left in their natural state if at all possible. During the survey, 1.2 miles of urbanized and developed-unnatural shoreline were observed. If restoration of the Pesobic Lake shoreline is to occur, primary focus should be placed on these shoreland areas as they currently provide little benefit to, and actually may harm, the lake ecosystem. Map 3 displays the location of these shoreline lengths around the entire lake.

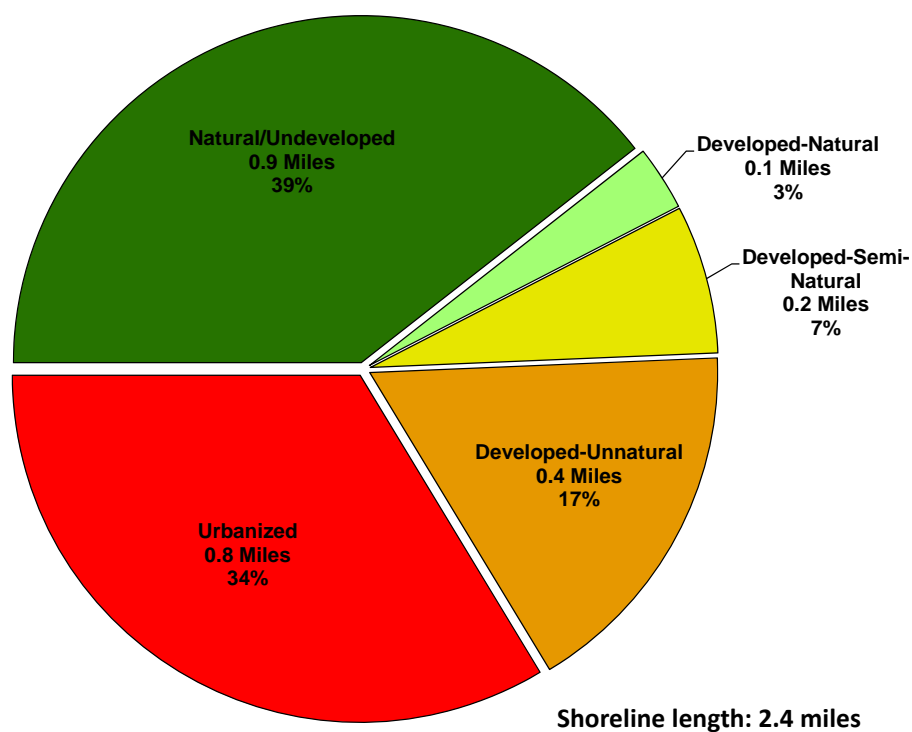


Figure 3.3-2. Pesobic Lake shoreland categories and total lengths. Based upon a fall 2011 survey. Locations of these categorized shorelands can be found on Map 3.

While producing a completely natural shoreline is ideal for a lake ecosystem, it is not always practical from a human's perspective. However, riparian property owners can take small steps in ensuring their property's impact upon the lake is minimal. Choosing an appropriate landscape position for lawns is one option to consider. Locating lawns on flat, unsloped areas or in areas that do not terminate at the lake's edge is one way to reduce the amount of runoff a lake receives from a developed site.

3.4 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 predation by predator fish, which could result in 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

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.

Important Note:

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

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 $\geq 50\%$ of the lake littoral area). Additionally, it is important to note that local permits and U.S. Army Corps of Engineers regulations may also apply. For more information on permit requirements, please contact the WDNR Regional Water Management Specialist or Aquatic Plant Management and Protection Specialist.

Manual Removal

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.

<i>Advantages</i>	<i>Disadvantages</i>
<ul style="list-style-type: none">• 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.	<ul style="list-style-type: none">• Labor intensive.• Impractical for larger areas or dense plant beds.• Subsequent treatments may be needed as plants recolonize and/or continue to grow.• Uprooting of plants stirs bottom sediments making it difficult to conduct action.• May disturb benthic organisms and fish-spawning areas.• Risk of spreading invasive species if fragments are not removed.

Bottom Screens

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

<i>Advantages</i>	<i>Disadvantages</i>
<ul style="list-style-type: none"> • 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. 	<ul style="list-style-type: none"> • 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
<ul style="list-style-type: none"> • 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. 	<ul style="list-style-type: none"> • May be cost prohibitive if pumping is required to lower water levels. • Has the potential to upset the lake ecosystem and have significant effects on fish and other aquatic wildlife. • Adjacent wetlands may be altered due to lower water levels. • Disrupts recreational, hydroelectric, irrigation and water supply uses. • May enhance the spread of certain undesirable species, like common reed (<i>Phragmites australis</i>) and reed canary grass (<i>Phalaris arundinacea</i>). • 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.



Cost

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

Advantages	Disadvantages
<ul style="list-style-type: none"> • 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. 	<ul style="list-style-type: none"> • Initial costs and maintenance are high if the lake organization intends to own and operate the equipment. • Multiple treatments are likely required. • Many small fish, amphibians and invertebrates may be harvested along with plants. • There is little or no reduction in plant density with harvesting. • Invasive and exotic species may spread because of plant fragmentation associated with harvester operation. • Bottom sediments may be re-suspended leading to increased turbidity and water column nutrient levels.

Herbicide Treatment

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



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

Applying herbicides in the aquatic environment requires special considerations compared with terrestrial applications. WDNR administrative code states that a permit is required if "you are standing in socks and they get wet." In these situations, the herbicide application needs to be

completed by an applicator licensed with the Wisconsin Department of Agriculture, Trade and Consumer Protection. All herbicide applications conducted under the ordinary high water mark require herbicides specifically labeled by the United States Environmental Protection Agency

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

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

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

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

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

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

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

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

Cost

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

<i>Advantages</i>	<i>Disadvantages</i>
<ul style="list-style-type: none">• Herbicides are easily applied in restricted areas, like around docks and boatlifts.• Herbicides can target large areas all at once.• If certain chemicals are applied at the correct dosages and at the right time of year, they can selectively control certain invasive species, such as Eurasian water-milfoil.• Some herbicides can be used effectively in spot treatments.• Most herbicides are designed to target plant physiology and in general, have low toxicological effects on non-plant organisms (e.g. mammals, insects)	<ul style="list-style-type: none">• All herbicide use carries some degree of human health and ecological risk due to toxicity.• 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 aquatic herbicides are nonselective.• Some herbicides have a combination of use restrictions that must be followed after their application.• Overuse of same herbicide may lead to plant resistance to that herbicide.

Biological Controls

There are many insects, fish and pathogens within the United States that are used as biological controls for aquatic macrophytes. For instance, the herbivorous grass carp has been used for years in many states to control aquatic plants with some success and some failures. However, it is illegal to possess grass carp within Wisconsin because their use can create problems worse than the plants that they were used to control. Other states have also used insects to battle invasive plants, such as water hyacinth weevils (*Neochetina spp.*) and hydrilla stem weevil (*Bagous spp.*) to control water hyacinth (*Eichhornia crassipes*) and hydrilla (*Hydrilla verticillata*), respectively. 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 has shown promise in reducing Eurasian water-milfoil stands in Wisconsin, Washington, Vermont, and other states. Research is currently being conducted to discover the best situations for the use of the insect in battling Eurasian water milfoil. Currently the milfoil weevil is not a WDNR grant-eligible method of controlling Eurasian water milfoil.

Cost

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

<i>Advantages</i>	<i>Disadvantages</i>
<ul style="list-style-type: none"> • Milfoil weevils occur naturally in Wisconsin. • Likely environmentally safe and little risk of unintended consequences. 	<ul style="list-style-type: none"> • 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 californiensis* 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 kiddie 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.

<i>Advantages</i>	<i>Disadvantages</i>
<ul style="list-style-type: none"> • Extremely inexpensive control method. • Once released, considerably less effort than other control methods is required. • Augmenting populations many lead to long-term control. 	<ul style="list-style-type: none"> • Although considered “safe,” reservations about introducing one non-native species to control another exist. • Long range studies have not been completed on this technique.

Analysis of Current Aquatic Plant Data

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

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

Primer on Data Analysis & Data Interpretation

Species List

The species list is simply a list of all of the 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 Pesobic Lake, 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 and Richness

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.

Simpson's diversity index is used to determine this diversity in a lake ecosystem. Simpson's diversity (1-D) is calculated as:

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

where:

n = the total number of instances of a particular species

N = the total number of instances of all species and

D is a value between 0 and 1

If a lake has a diversity index value of 0.90, it means that if two plants were randomly sampled from the lake there is a 90% probability that the two individuals would be of a different species. Between 2005 and 2009, WDNR Science Services conducted point-intercept surveys on 252 lakes within the state. In the absence of comparative data from Nichols (1999), the Simpson's Diversity Index values of the lakes within the WDNR Science Services dataset will be compared to Pesobic Lake. Comparisons will be displayed using boxplots that showing median values and upper/lower quartiles of lakes in the same ecoregion (Water Quality section, Figure 3.1-2) and in the state.

Box Plot or box-and-whisker diagram graphically shows data through five-number summaries: minimum, lower quartile, median, upper quartile, and maximum. Just as the median divides the data into upper and lower halves, quartiles further divide the data by calculating the median of each half of the dataset.

As previously stated, species diversity is not the same as species richness. One factor that influences species richness 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 Pesobic Lake will be compared to lakes in the same ecoregion and in the state (Figure 3.4-1).

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.

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. The floristic quality is calculated using the species richness and average conservatism value of the aquatic plant species that were solely encountered on the lake during the point-intercept survey and does not include incidental species or those encountered during other aquatic plant surveys.

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 3.4-1). 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.

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.

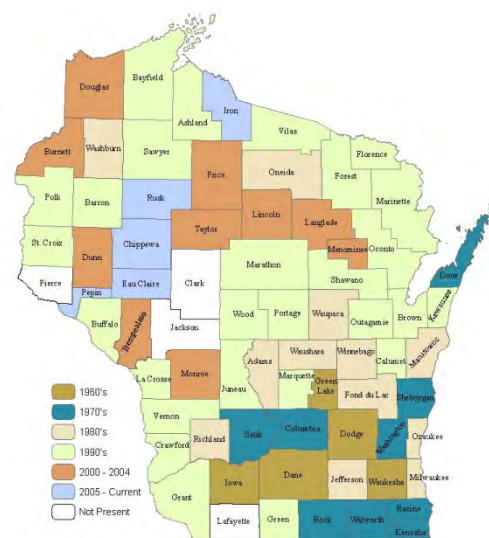


Figure 3.4-1. Spread of Eurasian water milfoil within WI counties. WDNr Data 2011 mapped by Onterra.

Aquatic Plant Survey Results

As mentioned above, numerous plant surveys were completed as a part of this project. On June 21, 2011, a survey was completed on Pesobic Lake that focused upon locating any potential occurrences of the non-native curly-leaf pondweed. This meander-based survey of the *littoral zone* did not locate any occurrences of this invasive plant. It is believed that this aquatic invasive species is currently not present in Pesobic Lake or it exists at an undetectable level.

The whole-lake aquatic plant point-intercept and community mapping surveys were conducted on Pesobic Lake on July 13 and 14, 2011 by Onterra (Appendix E). During these surveys, a total of 35 aquatic plant species were located, one of which, reed canary grass, is considered to be a non-native, invasive species (Table 3.4-1). Reed canary grass and its occurrence on the shores of Pesobic Lake will be discussed in detail at the end of this section. One species located, snail-seed pondweed (*Potamogeton bicupulatus*) is listed as species of special concern by the Wisconsin Natural Heritage Inventory (NHI) Program because of its rarity and vulnerability to environmental degradation.

As determined from the point-intercept survey, the majority of the sediment within Pesobic Lake is comprised of fine organic sediments or muck (91%), while sand and rock comprise the remaining 7% and 2%, respectively (Figure 3.4-2). Map 4 illustrates that the majority of sandy and rocky areas were encountered in the shallow, southern portion of the lake.

Approximately 80% of the 251 point-intercept locations sampled within the maximum depth of plant growth (9 feet), or the littoral zone, contained aquatic vegetation. Map 5 shows that the majority of the lake is capable of supporting aquatic plant growth. As was discussed in the Water Quality Section, Pesobic Lake's water is stained with dissolved organic compounds. These compounds reduce sunlight penetration and limit the depth to which aquatic plants can grow. However, Pesobic Lake is relatively shallow and thus can support plant growth throughout most of the lake.

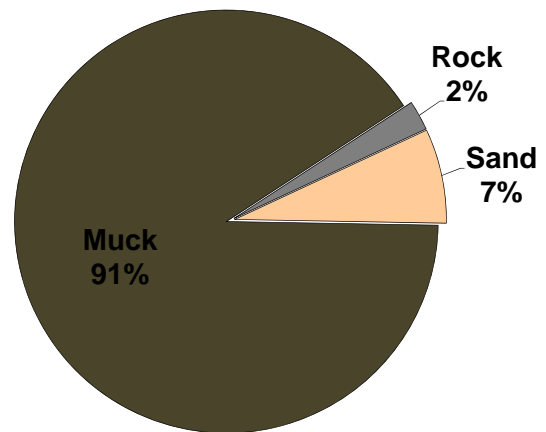


Figure 3.4-2. Pesobic Lake proportion of substrate types within littoral areas. Created using data from July 2011 aquatic plant point-intercept survey.

Figure 3.4-3 displays the frequency of occurrence of aquatic vegetation across littoral depths, and shows that 100% of the point-intercept locations between 1 and 5 feet contained aquatic vegetation. This figure also shows that the aquatic plant species within the lake inhabit different areas based upon water depth. For example, needle spikerush was most frequently encountered in about 1 foot of water, while arrowhead rosettes were most abundant in 5 to 6 feet of water.

Table 3.4-1. Aquatic plant species located in Pesobic Lake during July 2011 surveys.

Life Form	Scientific Name	Common Name	Coefficient of Conservatism (c)	2011 (Onterra)
Emergent	<i>Calla palustris</i>	Water arum	9	I
	<i>Carex crinita</i>	Fringed sedge	6	I
	<i>Carex rostrata</i>	Beaked sedge	10	I
	<i>Decodon verticillatus</i>	Water-willow	7	I
	<i>Dulichium arundinaceum</i>	Three-way sedge	9	I
	<i>Eleocharis palustris</i>	Creeping spikerush	6	X
	<i>Glyceria borealis</i>	Northern manna grass	8	I
	<i>Glyceria canadensis</i>	Rattlesnake grass	7	I
	<i>Iris versicolor</i>	Northern blue flag	5	I
	<i>Juncus effusus</i>	Soft rush	4	I
	<i>Phalaris arundinacea</i>	Reed canary grass	Exotic	I
	<i>Sagittaria latifolia</i>	Common arrowhead	3	I
	<i>Sagittaria rigida</i>	Stiff arrowhead	8	I
	<i>Schoenoplectus tabernaemontani</i>	Softstem bulrush	4	I
	<i>Zizania palustris</i>	Northern wild rice	8	I
FL	<i>Brasenia schreberi</i>	Watershield	7	X
	<i>Nuphar variegata</i>	Spatterdock	6	I
FL/E	<i>Sparganium americanum</i>	Eastern bur-reed	8	I
	<i>Sparganium fluctuans</i>	Floating-leaf bur-reed	10	X
	<i>Sparganium natans</i>	Little bur-reed	9	I
Submergent	<i>Chara spp.</i>	Muskgrasses	7	X
	<i>Elatine minima</i>	Waterwort	9	X
	<i>Elodea nuttallii</i>	Slender waterweed	7	X
	<i>Isoetes spp.</i>	Quillwort species	N/A	X
	<i>Myriophyllum farwellii</i>	Farwell's water milfoil	9	X
	<i>Myriophyllum tenellum</i>	Dwarf water milfoil	10	X
	<i>Najas gracillima</i>	Northern naiad	7	X
	<i>Nitella spp.</i>	Stoneworts	7	X
	<i>Potamogeton bicupulatus</i> *	Snail-seed pondweed	9	X
	<i>Potamogeton epihydrus</i>	Ribbon-leaf pondweed	8	X
	<i>Utricularia purpurea</i>	Large purple bladderwort	9	X
<i>Utricularia vulgaris</i>	Common bladderwort	7	X	
S/E	<i>Eleocharis acicularis</i>	Needle spikerush	5	X
	<i>Hypericum boreale</i>	Northern St. John's-wort	6	I
	<i>Juncus pelocarpus</i>	Brown-fruited rush	8	X
	<i>Sagittaria cristata</i> (Rosette)	Crested arrowhead	9	X

FL = Floating Leaf; FL/E = Floating Leaf and Emergent; S/E = Submergent and Emergent

X = Located on rake during point-intercept survey; I = Incidental Species

* Listed as a species of 'special concern' in Wisconsin

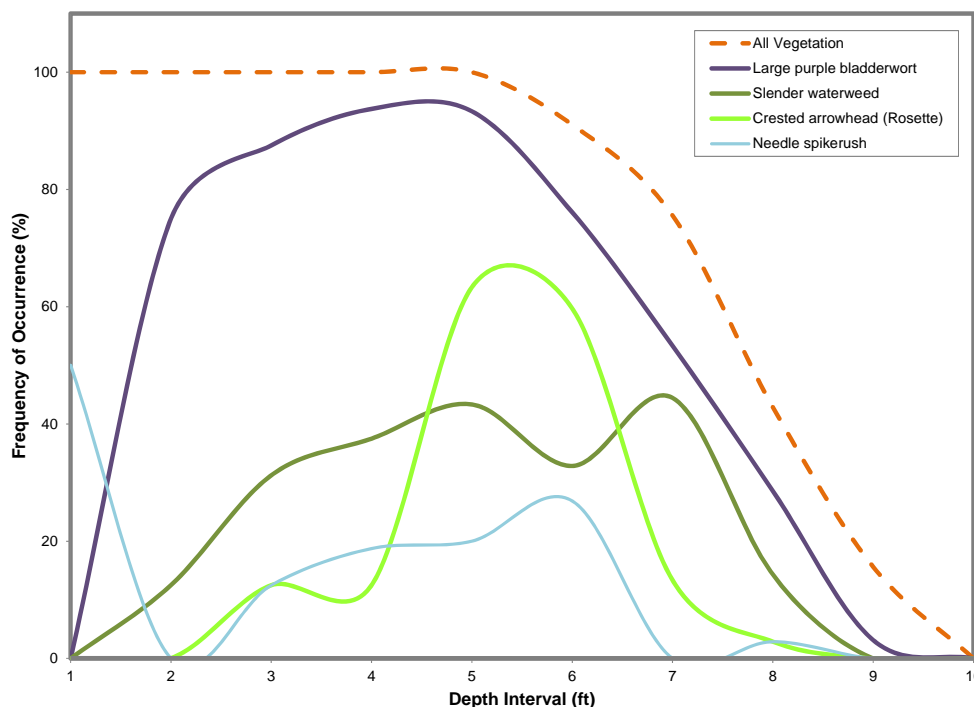


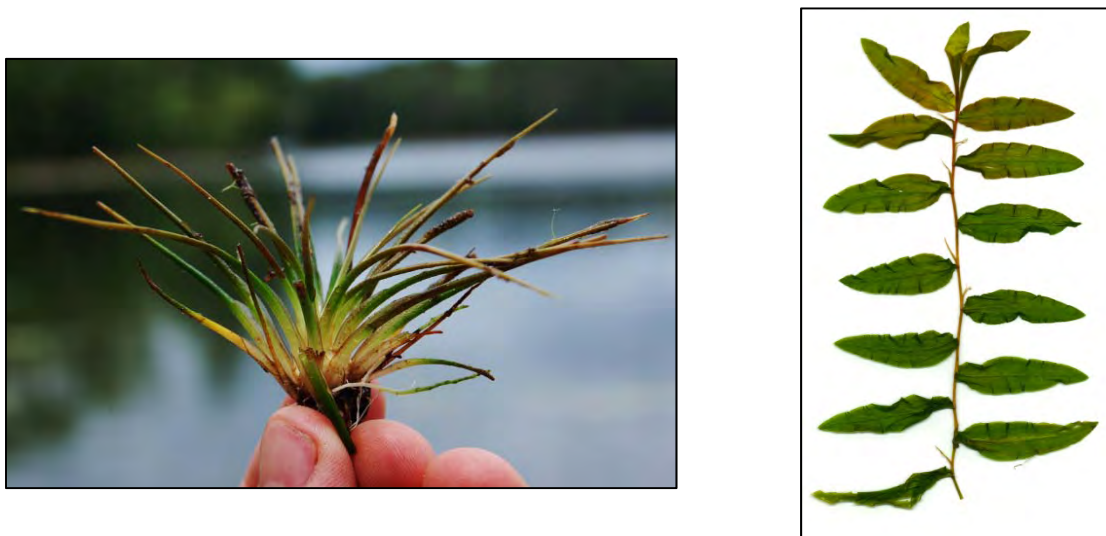
Figure 3.4-3. Frequency of occurrence at littoral depths for select Pesobic Lake plant species. Note: Lines smoothed to ease visualization. Created using data from July 2011 aquatic plant point-intercept survey.

Submersed aquatic plants can be grouped into one of two general categories based upon their morphological growth form and habitat preferences. These two groups include species of the *isoetid* growth form and those of the *elodeid* growth form. Plants of the isoetid growth form are small, slow-growing, inconspicuous submerged plants (Photo 3.4-1). These species often have evergreen, succulent-like leaves and are usually found growing in sandy/rocky soils within near-shore areas of a lake (Boston and Adams 1987, Vestergaard and Sand-Jensen 2000).

In contrast, aquatic plant species of the elodeid growth form have leaves on tall, erect stems which grow up into the water column, and are the plants that lake users are likely familiar with (Photo 3.4-1). It is important to note that these two groups are based solely on morphology and not on species' relationships; for example, dwarf-water milfoil (*Myriophyllum tenellum*) is classified as an isoetid, while all of the other milfoil species in Wisconsin such as northern water milfoil (*Myriophyllum sibiricum*) are classified as elodeids.

Alkalinity, as it relates to the amount of bicarbonate within the water, is the primary water chemistry factor for determining a lake's aquatic plant community composition in terms of isoetid versus elodeid growth forms (Vestergaard and Sand-Jensen 2000). Most aquatic plant species of the elodeid growth form cannot inhabit lakes with little or no alkalinity because their carbon demand for photosynthesis cannot be met solely from the dissolved carbon dioxide within the water and must be supplemented from bicarbonate. On the other hand, aquatic plant species of the isoetid growth form can thrive in lakes with little or no alkalinity because they have the ability to derive carbon dioxide directly from the sediment, and many also have a form of photosynthesis to maximize carbon storage. While isoetids are able to grow in lakes with higher

alkalinity, their short stature makes them poor competitors for space and light against the taller elodeid species. Thus, isoetids are most prevalent in lakes with little to no alkalinity where they can avoid competition from elodeids. However, in lakes with low to moderate alkalinity levels like Pesobic Lake, isoetids can grow and exist among a scattered canopy of the taller elodeids.



Photograph 3.4-1. Quillwort (*Isoetes*) species of the isoetid growth form (left), and a pondweed (*Potamogeton*) species of the elodeid growth form (right).

The vast majority of aquatic plant species in Wisconsin are of the elodeid growth form, so lakes with higher alkalinity levels generally have a higher number of aquatic plant species, or higher species richness. As was discussed in the Water Quality Section, Pesobic Lake has very low alkalinity and thus a relatively low amount of submersed aquatic plant species. Only those species adapted to survive in carbon-limited environments will be able to live within the lake. The submersed species located in Pesobic Lake are indicative of a carbon-limited system. While Pesobic Lake has adequate amounts of phosphorus and nitrogen, the low carbon availability limits the aquatic plant community in terms of species composition and biomass.

Of the 18 aquatic plant species located during the point-intercept survey, large purple bladderwort was the most frequently encountered species with a littoral occurrence of nearly 60% (Figure 3.4-4). Large purple bladderwort is well adapted for life in a nutrient-limited environment. As its name suggests, it possesses small, sac-like bladders which it uses to capture and digest zooplankton prey. This species produces a beautiful, purple, snapdragon-like flower above the water's surface. Another species of bladderwort, common bladderwort, was also located in Pesobic Lake in 2011.

Slender naiad was the second-most frequently encountered aquatic plant species during the 2011 point-intercept survey (Figure 3.4-4). This species is one of three native naiad species present in Wisconsin. It differs from the other two species by having very fine, thread-like leaves. These leaves help to maximize surface area and uptake of carbon dioxide within the water. Slender naiad is only found growing in low alkaline, soft water lakes, and is more sensitive to environmental pollution than many other aquatic plant species (Wentz and Stucky 1971).

The third-most frequently encountered aquatic plant species in 2011 was crested arrowhead. Unlike most of the arrowhead species in Wisconsin which are emergent, near-shore plants, crested arrowhead is most often found in a submersed, small rosette form. As mentioned previously, crested arrowhead was most abundant between 5 and 6 feet of water in Pesobic Lake.

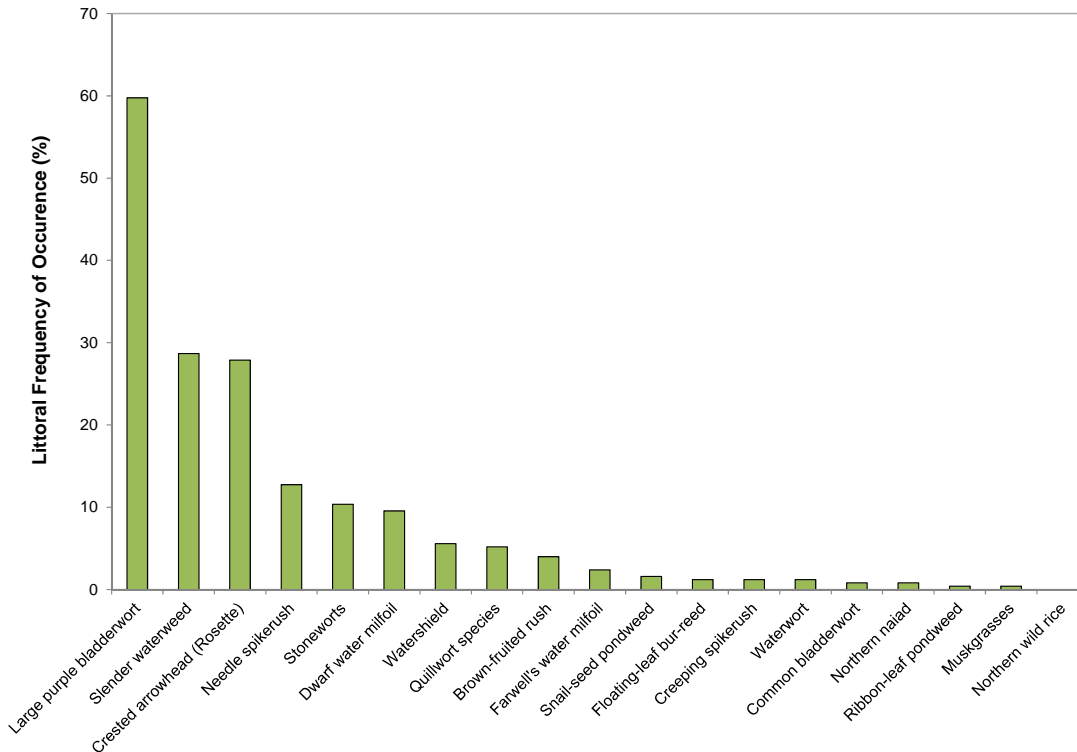


Figure 3.4-4. Pesobic Lake aquatic plant littoral frequency of occurrence. Created using data from July 2011 aquatic plant point-intercept survey.

As discussed in the primer section, the calculations used for the Floristic Quality Index (FQI) for a lake's aquatic plant community are based on the aquatic plant species that were solely encountered on the rake during the point-intercept survey and does not include incidental species. For example, while a total of 35 native aquatic plant species were located in Pesobic Lake during the 2011 surveys, 18 were encountered on the rake during the point-intercept survey. The native species encountered on the rake and their conservatism values were used to calculate the FQI of Pesobic Lake's aquatic plant community (equation shown below).

The species that are present in Pesobic Lake are indicative of very high-quality conditions. Data collected from the aquatic plant surveys show that the average conservatism value (7.9) is well above the North Central Hardwood Forests ecoregion and Wisconsin State medians (Figure 3.4-5), indicating that the majority of the plant species found in Pesobic Lake are considered sensitive to environmental disturbance and their presence signifies excellent environmental conditions.

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

Figure 3.4-5 compares the FQI components from Pesobic Lake calculated from the 2011 point-intercept survey to median values of lakes within the North Central Hardwood Forests Ecoregion in Wisconsin. As displayed, the native species richness and average conservatism values for Pesobic Lake exceed median values for both the ecoregion and the state. Combining Pesobic Lake's native species richness and average conservatism values yields an exceptionally high FQI value of 33.4, greatly exceeding the ecoregion and state medians (Figure 3.4-5). This analysis indicates that the aquatic plant community of Pesobic Lake is of higher quality than the majority of lakes within the North Central Hardwood Forests Ecoregion and the entire state of Wisconsin.

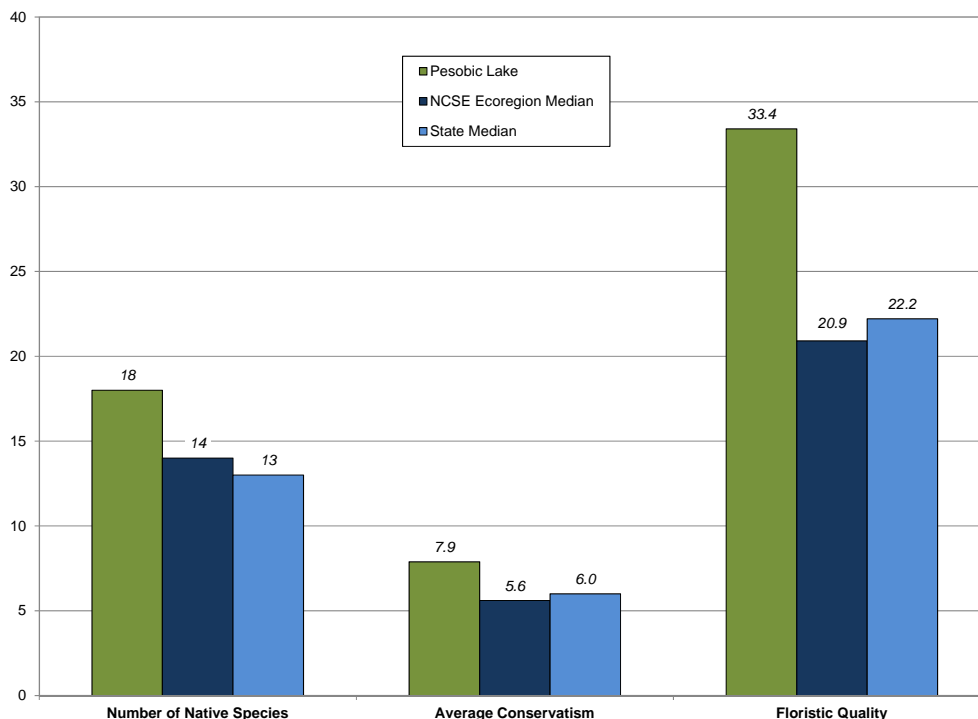


Figure 3.4-5. Pesobic Lake Floristic Quality Assessment. Created using data from July 2011 aquatic plant point-intercept survey. Analysis following Nichols (1999).

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

While a method for characterizing diversity values of fair, poor, etc. does not exist, lakes within the same ecoregion may be compared to provide an idea of how Pesobic Lake's diversity value ranks. Using data obtained from WDNR Science Services, quartiles were calculated for 71 lakes within the NCHF Ecoregion (Figure 3.4-6). Using the data collected from the 2011 point-intercept survey, Pesobic Lake's aquatic plant community was shown to have relatively low species diversity with a Simpson's diversity value of 0.81. This diversity value falls within the lower quartiles for lakes in both the NCHF ecoregion and within the entire state (Figure 3.4-6).

This value indicates that if two individual aquatic plants were randomly sampled from Pesobic Lake, there would be an 81% probability that they would be of different species.

The littoral frequency of occurrence analysis allows for an understanding of how often each of the plant species is located during the point-intercept survey. Because each sampling location may contain numerous plant species, relative frequency of occurrence is one tool to evaluate how often each plant species is found in relation to all other species found (composition of population). For instance, while large purple bladderwort was located at approximately 60% of the littoral sampling locations in Pesobic Lake, its relative frequency of occurrence was 34%. Explained another way, if 100 plants were randomly sampled from Pesobic Lake, 34 of them would be large purple bladderwort. Figure 3.4-7 displays the relative frequency of occurrence of aquatic plant species within Pesobic Lake, and shows the majority (67%) of the lake's plant community is comprised of only three species; this yields a low species diversity value.

Because Pesobic Lake's aquatic plant community is not exceptionally diverse does not mean that it is not a high-quality community. As discussed earlier, the carbon-limited environment of Pesobic Lake allows only those species that are specially adapted to thrive there, and creates a very unique aquatic plant community. The majority of the aquatic plant species present in Pesobic Lake are indicative of a very high-quality lake.

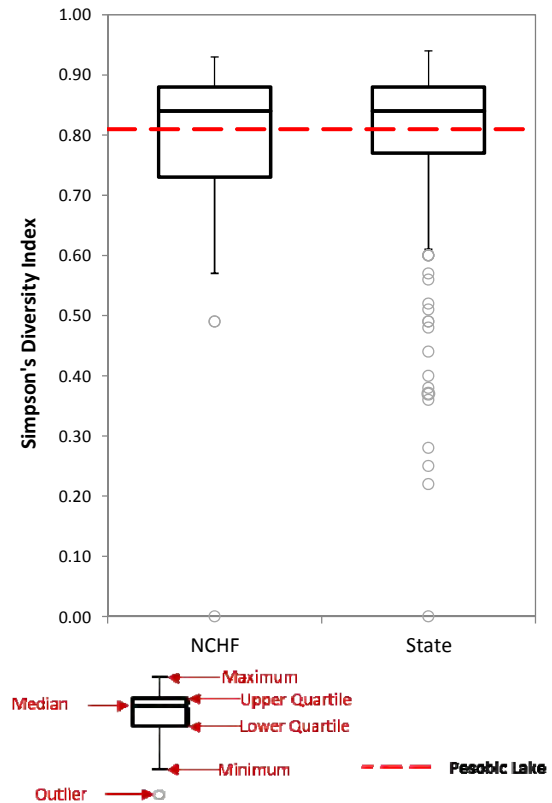


Figure 3.4-6. Pesobic Lake species diversity index. Created using data from 2011 aquatic plant point-intercept survey.

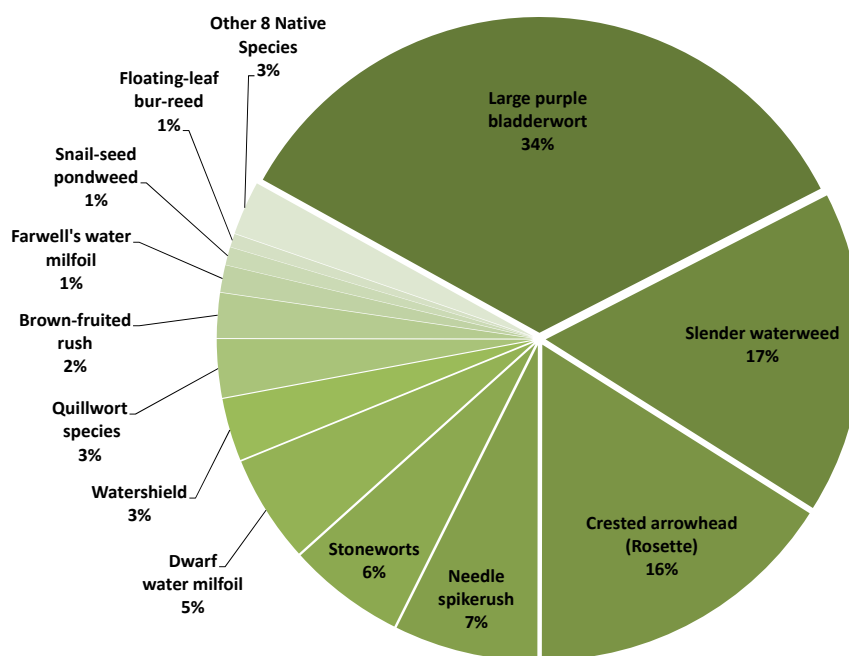


Figure 3.4-7 Pesobic Lake relative plant littoral frequency of occurrence. Created using data from July 2011 aquatic plant point-intercept survey.

The quality of Pesobic Lake's aquatic plant community is also indicated by the high incidence of emergent and floating-leaf plant communities that occur in the lakes. The 2011 community map (Map 6) indicates that approximately 11.9 acres (7.6%) of the 156-acre lake contain these types of plant communities (Table 3.4-2). Twenty floating-leaf and emergent species were located in Pesobic Lake (Table 3.4-1). These plant communities provide valuable fish and wildlife habitat important to the ecosystem of the lake. These areas are particularly important during times of fluctuating water levels, since structural habitat of fallen trees and other forms of coarse-woody debris can become quite sparse along the shores of receding water lines.

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 Pesobic Lake. This is important, because these communities are often negatively affected by recreational use and shoreland development. Radomski and Goeman (2001) found a 66% reduction in vegetation coverage on developed shorelines when compared to undeveloped shorelines in Minnesota Lakes. Furthermore, they also found a significant reduction in abundance and size of northern pike (*Esox lucius*), bluegill (*Lepomis macrochirus*), and pumpkinseed (*Lepomis gibbosus*) associated with these developed shorelines.

Table 3.4-2. Pesobic Lake acres of floating-leaf and emergent plant communities. Created from the July 2011 community mapping survey.

Aquatic Plant Community	Acres
Emergent	2.6
Floating-leaf	7.7
Mixed Emergent & Floating-leaf	1.6
Total	11.9

Non-native Aquatic Plants in Pesobic Lake

Reed Canary Grass

Reed canary grass (*Phalaris arundinacea*) is a large, coarse perennial grass that can reach three to six feet in height. Often difficult to distinguish from native grasses, this species forms dense, highly productive stands that vigorously outcompete native species. Unlike native grasses, few wildlife species utilize the grass as a food source, and the stems grow too densely to provide cover for small mammals and waterfowl. It grows best in moist soils such as wetlands, marshes, stream banks and lake shorelines.

Reed canary grass is difficult to eradicate; at the time of this writing there is no commonly accepted control method. This plant is quite resilient to herbicide applications. Small, discrete patches have been covered by black plastic to reduce growth for an entire season. However, the species must be monitored because rhizomes may spread out beyond the plastic.

At this time, populations are not excessive on Pesobic Lake's shorelines, though it is recommended that continued monitoring of reed canary grass takes place. During the 2011 community mapping survey, Onterra ecologists mapped occurrences of reed canary grass (Map 6) along the lake's shoreline. Similar studies conducted in the future may show if populations have increased or not..

3.5 Fisheries Data Integration

Fishery management is an important aspect in the comprehensive management of a lake ecosystem; therefore, a brief summary of available data is included here as 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 Pesobic Lake. The goal of this section is to provide an incomplete overview of some of the data that exists, particularly in regards to specific issues (e.g. spear fishery, fish stocking, angling regulations, etc) that were brought forth by the PLA stakeholders within the stakeholder survey and other planning activities. Although current fish data were not collected, the following information was compiled based upon data available from the WDNR and the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) (WDNR 2011 & GLIFWC 2012A and 2012B).

Pesobic Lake Fishery

Pesobic Lake Fish Species and Fishing Activity

Based on data collected from the stakeholder survey (Appendix B), fishing was the fifth-highest ranked important or enjoyable activity on Pesobic Lake (Question #13). Approximately 88% of these same respondents believed that the quality of fishing on the lake was either good or fair (Question #10); and approximately 40% believe that the quality of fishing has remained the same since they have obtained their property (Question #11).

Table 3.5-1 shows the popular game fish that are present in the system. When examining the fishery of a lake, it is important to remember what “drives” that fishery, or what is responsible for determining its mass and composition. The gamefish in Pesobic Lake are supported by an underlying food chain. At the bottom of this food chain are the elements that fuel algae and plant growth – nutrients such as phosphorus and nitrogen, and sunlight. The next tier in the food chain belongs to zooplankton, which are tiny crustaceans that feed upon algae and plants, and insects. Smaller fish called planktivores feed upon zooplankton and insects, and in turn become food for larger fish species. The species at the top of the food chain are called piscivores, and are the larger gamefish that are often sought after by anglers, such as bass and walleye.

Table 3.5-1. Gamefish present in Pesobic Lake with corresponding biological information (Becker, 1983).

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

A concept called energy flow describes how the biomass of piscivores is determined within a lake. Because algae and plant matter are generally small in energy content, it takes an incredible amount of this food type to support a sufficient biomass of zooplankton and insects. In turn, it takes a large biomass of zooplankton and insects to support planktivorous fish species. And finally, there must be a large planktivorous fish community to support a modest piscivorous fish community. Studies have shown that in natural ecosystems, it is largely the amount of primary productivity (algae and plant matter) that drives the rest of the producers and consumers in the aquatic food chain. This relationship is illustrated in Figure 3.5-1.

As discussed in the Water Quality section, Pesobic Lake is an upper mesotrophic-lower eutrophic system, meaning it has moderate nutrient content and thus moderate primary productivity. Simply put, this means Pesobic Lake should be able to support sizable populations of predatory fish (piscivores) because the supporting food chain is relatively robust.

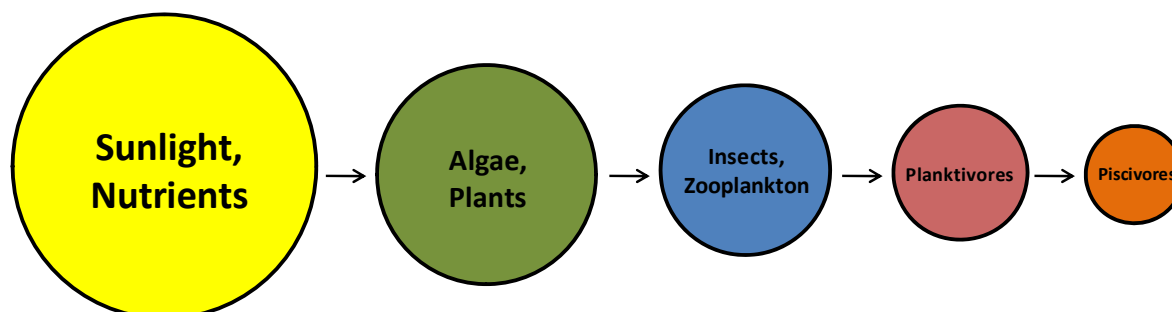


Figure 3.5-1. Aquatic food chain. Adapted from Carpenter et. al 1985.

Native American Spear Harvest on Wisconsin Lakes

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 3.5-1). Pesobic Lake falls within the ceded territory based on the Treaty of 1837. 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

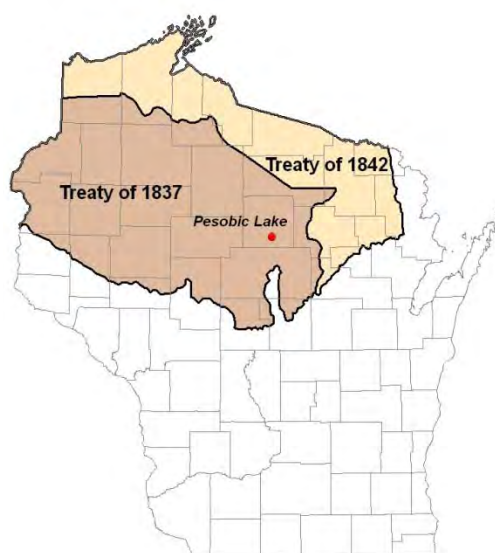


Figure 3.5-2. Location of Pesobic Lake within the Native American Ceded Territory (GLIFWC 2012A). This map was digitized by Onterra; therefore it is a representation and not legally binding.

lightly speared. The tribes have historically selected a percentage which allows for a 2-3 daily bag limit for hook-and-line anglers (USDI 2007).

Native American spearers are able to harvest muskellunge, walleye, northern pike, and bass during the open water season. The spear harvest is monitored through a nightly permit system and a complete monitoring of the harvest (GLIFWC 2012B). 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.

Records indicate that nearby tribes have historically not declared a spear harvest quota on Pesobic Lake. It is possible that spearing efforts have been concentrated on other larger lakes in the region, which would potentially have a higher estimated safe harvest for both walleye and muskellunge.

Because Pesobic Lake is located within ceded territory, special fisheries regulations may occur, specifically in terms of walleye. An adjusted walleye bag limit pamphlet is distributed each year by the WDNR which explains the more restrictive bag or length limits that may pertain to Pesobic Lake. In 2011, no restrictive bag limits were set for Pesobic Lake, meaning the statewide bag limit of five fish in a day exists for this waterbody. There is no minimum length limit on walleye, but only one fish over 14" is allowed.

Pesobic Lake is in the northern half of both the muskellunge and northern pike management zone and the largemouth and smallmouth bass management zone. Muskellunge must be 34" to be harvested, with a daily bag limit of one fish, while no minimum length limit exists for northern pike and only five pike may be kept in a single day. For bass species, a catch and release season runs from the first Saturday in May to the third Saturday in June. Following this catch and release season, five fish may be kept daily, and a minimum length limit of 14" exists. Statewide regulations apply for all other fish species.

Pesobic Lake Fish Stocking and Management

To assist in meeting fisheries management goals, the WDNR may stock fish in a waterbody that were raised in nearby permitted 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.

Currently, Pesobic Lake is stocked every other year with small fingerling walleye (Table 3.5-2). According to WDNR regional fisheries biologist Dave Seibel, A WDNR survey conducted in 2003 found a fishable population of walleyes within the lake. These stocking efforts aim to bolster the current population. During the 2003 survey, walleye density was estimated to be about 151 fish, or roughly 1.0 fish per acre. Mr. Seibel stated that Pesobic Lake is being

managed by the WDNR for a mixed fishery, which includes largemouth bass, walleye, panfish, northern pike and crappies.

Table 3.5-2. Walleye stocking data available from the WDNR from 1972 to 2010 (WDNR 2011).

Year	Age Class	# Stocked	Avg. Length (inches)
1974	Fry	300,000	-
1976	Fry	300,000	-
1981	Fingerling	7,200	3
1984	Fingerling	7,200	3
1986	Fingerling	7,200	3
1988	Fingerling	7,200	2
1989	Fingerling	7,220	3
1992	Fingerling	4,060	3
1994	Fingerling	3,616	2.8
1996	Fingerling	392	4.3
2000	Small Fingerling	15,652	1.9
2002	Small Fingerling	14,600	1.7
2004	Small Fingerling	14,600	1.3
2006	Small Fingerling	5,110	1.4
2008	Small Fingerling	4,378	1.7
2010	Small Fingerling	5,445	1.4

Pesobic Lake Substrate Type

According to the point-intercept survey conducted by Onterra, 91% of the substrate sampled in the littoral zone on Pesobic Lake was muck, with the remaining 9% being split between sand (7%) and rock (2%) (Map 4). 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. This organic material suspends the eggs above the substrate, so the eggs are not buried in sediment and suffocate as a result. 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.

4.0 SUMMARY AND CONCLUSIONS

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

- 1) Collect baseline data to increase the general understanding of the Pesobic Lake ecosystem.
- 2) Collect detailed information regarding invasive plant species within the lake, should any exist.
- 3) Collect sociological information from Pesobic Lake stakeholders regarding their use of the lake and their thoughts pertaining to the past and current condition of the lake and its management.

The three objectives were fulfilled during the project and have led to a good understanding of the Pesobic Lake ecosystem, the folks that care about the lakes, and what needs to be completed to protect and enhance them.

Overall, the studies conducted on Pesobic Lake indicate that the lake is in good health. Phosphorus, the nutrient of concern in most Wisconsin lakes, is not found in excess within the lake, as determined by over a decade worth of monitoring. An analysis within the Water Quality Section indicates that concentrations are *Good*, and comparable to similar lakes across the state. Many lakes across the state suffer from excessive phosphorus content; the results vary but include nuisance conditions of aquatic plants as well as algae blooms that cover the surface of the lake like a blanket. The algae content of the lake (as monitored through chlorophyll-*a* abundance) is only slightly higher than the median for similar lakes across the state and all regional lakes, and ranks as *Good* overall. The clarity of the lake, while ranking as *Good* as well, can be influenced in some years by environmental conditions such as precipitation amount, which may flush naturally occurring acids from nearby wetlands into the lake.

A lake's water quality and quantity is often a reflection of the surrounding drainage basin, or watershed. Thus is the case for Pesobic Lake. Seepage lakes, such as Pesobic, often have small watersheds and no inlet or outlet streams. Therefore, their water levels are often reflective of the groundwater table; because of this, they are particularly susceptible to drought conditions. On the positive side, seepage lakes often have better water quality because of the limited nutrient input from surrounding land. Modeling of the Pesobic Lake watershed indicates that a minimal phosphorus load enters the lake on an annual basis. This is largely because of the advantageous land cover types that are within the lake, the small watershed, and the lack of an inlet stream. The immediate shoreline, however, is one area of slight concern regarding the lake's watershed. Studies conducted in 2011 determined that over half of the shoreline (51%) consists of urbanized or developed-unnatural areas. Past and present research has indicated that the immediate shoreline provides many ecological services due to its being located at the interface between the aquatic and terrestrial environment. In regards to protecting Pesobic Lake, conserving the existing natural shoreline and restoring areas of disturbed shoreline may be one of the best options at this time.

The aquatic plant community of Pesobic Lake is unique, with a total of 35 native species being found within the lake, one of which is listed as a species of Special Concern in Wisconsin because of its rarity and vulnerability to environmental degradation. Certain species thrive in slightly acidic, low alkalinity waters such as what is found in Pesobic Lake. As discussed within

the Aquatic Plant Section, this is partially why isoetid (small, turf-like) species and bladderworts are present while the large-leaf pondweed (musky cabbage) and coontail that is found in other lakes nearby is not found in Pesobic Lake.

In addition to water chemistry, water level changes may impact the distribution and abundance of aquatic plant species as well. Watershield, a floating-leaf plant with a shield or football shaped leaf, was found along the shorelines of Pesobic Lake in several areas (see the Community Map – Map 6). This plant is adapted to grow under fluctuating water levels. With water levels fluctuating on Pesobic Lake in the past decade or so, the residents around Pesobic Lake have indicated that the extents of watershield growth have increased over time. Because intensive management of native aquatic plants can be detrimental to the plant community and open niche areas for invasive plant residence, these techniques are highly discouraged by the WDNR's Aquatic Plant Management Strategy for the Northern Region (attached as Appendix F). The best applicable way for residents to achieve access to the open water areas of the lake is through manual removal of the plants. Native plant manual removal is governed through Chapter NR 109, which is attached within Appendix F as well. Essentially, this regulation provides for a 30 ft removal zone, extending directly out from a use area such as a dock or swim area. Floating debris that results from removal must be removed from the lake, and where wild rice may be present, a permit is required from the local WDNR aquatic plant management coordinator. Monitoring of the extents of watershield communities within the lake would be a good way for the PLA to document colonial expansion or retraction.

Another positive aspect of the aquatic plant community is that currently, the only invasive plant found within Pesobic Lake is reed canary grass, a common wetland invasive plant that was found on the lake's shorelines in several areas. This plant is not currently troubling the ecosystem, though its presence should be monitored in the future to look determine if its spatial distribution or density has changed. In the meantime, efforts to spread knowledge about Eurasian water milfoil and curly-leaf pondweed, two aquatic invasive plants that have continued to threaten the ecological integrity of Wisconsin's lakes, should be continued. Members of the PLA have adopted a strategy to continue to monitor the lake for these species, as they realize that discovering an early infestation is crucial for keeping the occurrence of these species under control.

Pesobic Lake is a public resource that many individuals with many different interests utilize. It provides for an outstanding recreational facility that anglers, boaters, swimmers, waterfowl hunters, connoisseurs of nature and others can enjoy. It is important that all those who participate in management and recreation on the lake realize that this resource needs to be maintained and managed for diverse enjoyment. However, perhaps more importantly, this lake needs to be maintained for its ecological integrity as well. The Implementation Plan that follows is the result of conversations between PLA lake stakeholders, Onterra staff, and WDNR specialists on ways that the PLA may maintain this unique resource while enjoying its natural beauty at the same time.

5.0 IMPLEMENTATION PLAN

The Implementation Plan presented below was created through the collaborative efforts of the PLA Planning Committee and ecologist/planners from Onterra. It represents the path the PLA will follow in order to meet their lake management goals. The goals detailed within the plan are realistic and based upon the findings of the studies completed in conjunction with this planning project and the needs of the Pesobic Lake stakeholders as portrayed by the members of the Planning Committee, the returned stakeholder surveys, and numerous communications between Planning Committee members and the lake stakeholders. The Implementation Plan is a living document in that it will be under constant review and adjustment depending on the condition of the lake, the availability of funds, level of volunteer involvement, and the needs of the stakeholders.

Management Goal 1: Increase Pesobic 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 Pesobic Lake.

Timeframe: Begin summer 2013

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 public safety. An Education Committee will be created to promote lake protection through a variety of educational efforts.

One of the first projects the Education Committee will undertake is a newsletter to be distributed to PLA members and non-members who own property on the lake. Communication amongst these stakeholders is important 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 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. During this lake management planning project, the Pesobic Lake Planning Committee discussed the possibility of constructing a kiosk at the public landing. This kiosk would serve as an easy way to disseminate information to all Pesobic Lake users – those who live on the lake and those who do not. Funding opportunities through a state sponsored small-scale grant may be applicable for this task.

Example Educational Topics:

- Aquatic invasive species monitoring updates
- Boating safety and ordinances (slow-no-wake zones and hours)
- Catch and release fishing
- Littering (particularly on ice and near public landing)
- Noise, air, and light pollution
- Shoreland restoration and protection
- Septic system maintenance
- Fishing regulations
- Waterfowl hunting regulations
- Specific topics brought forth in other management actions

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 PLA Board will identify a base level of annual financial support for educational activities to be undertaken by the Education Committee.

Management Goal 2: Maintain Current Water Quality Conditions

Management Action: Continue collecting water quality data on Pesobic Lake as a part of the WDNR Citizens Lake Monitoring Network.

Timeframe: Continuation of current efforts

Facilitator: Scott Voigt

Description: Monitoring water quality is an important aspect of every lake management planning activity. Collection of water quality data at regular intervals aids in the management of the lake by building a database that can be used for long-term trend analysis. 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. Currently monitoring of water quality is conducted by Scott Voigt through the program's advanced protocol. Using this methodology, information is collected regarding the clarity of the water, as well as the phosphorus content and algae abundance within the lake. The volunteer monitoring of the water quality is a large commitment and new volunteers may be needed in the future as the volunteer's level of commitment changes. It is also important to have others involved if a temporary substitute is needed to collect samples while the normal volunteer is unavailable. It is the responsibility of this action's facilitator to coordinate new volunteers as needed. Note: as a part of this program, the data collected are automatically added to the WDNR database and available through their Surface Water Integrated Monitoring System (SWIMS) by the volunteer.

Action Steps: See description above.

Management Goal 3: Prevent Aquatic Invasive Species Introductions to Pesobic Lake

Management Action: Coordinate annual volunteer monitoring for Aquatic Invasive Species.

Timeframe: Summer 2013

Facilitator: Planning Committee

Description: In lakes without Eurasian water milfoil and other aquatic invasive species, early detection of pioneer colonies commonly leads to successful control and in cases of very small infestations, possibly even eradication. One way in which lake residents can spot early infestations of AIS is through conducting “Lake Sweeps” on their lake. During a lake sweep, volunteers monitor the entire area of the system in which plants grow (littoral zone) annually in search of non-native plant species. This program uses an “adopt-a-shoreline” approach where volunteers are responsible for surveying specified areas of the system.

In order for accurate data to be collected during these sweeps, volunteers must be able to identify non-native species such as Eurasian water milfoil and curly-leaf pondweed. Distinguishing these plants from native look-a-likes is very important. Additionally, the collection of suspected plants is important. A specimen of the plant would need to be collected for verification, and, if possible, GPS coordinates should be collected.

Action Steps:

1. Volunteers from the PLA update their skills by attending a training session conducted by WDNR/UW-Extension through the AIS Coordinator for Lincoln County (John Preuss – 715-369-9886) and the Lincoln County Conservationist (Diane Hanson – 715-536-0363).
2. Trained volunteers recruit and train additional association members as needed.
3. Complete lake surveys following protocols established by Lincoln County AIS staff.
4. Report results to Lincoln County AIS staff and PLA.

6.0 METHODS

Lake Water Quality

Baseline water quality conditions were studied to assist in identifying potential water quality problems in Pesobic Lake (e.g., elevated phosphorus levels, anaerobic conditions, etc.). Water quality was monitored at the deepest point on the lake that would most accurately depict the conditions of the lake (Map 1). Samples were collected using WDNR Citizen Lake Monitoring Network (CLMN) protocols which occurred once in spring and three times during the summer. In addition to the samples collected by PLA members, professional water quality samples were collected at subsurface (S) and near bottom (B) depths once in spring, winter, and fall. Although PLA members collected a spring total phosphorus sample, professionals also collected a near bottom sample to coincide with the bottom total phosphorus sample. Winter dissolved oxygen was determined with a calibrated probe and all samples were collected with a 3-liter Van Dorn bottle. Secchi disk transparency was also included during each visit.

All samples that required laboratory analysis were processed through the Wisconsin State Laboratory of Hygiene (SLOH). The parameters measured, sample collection timing, and designated collector are contained in the table below.

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

◆ indicates samples collected as a part of the Citizen Lake Monitoring Network.

● indicates samples collected by volunteers under proposed project.

■ indicates samples collected by consultant under proposed project.

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

Watershed Analysis

The watershed analysis began with an accurate delineation of Pesobic Lake'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 National Land Cover Database (NLCD – Fry et. al 2011) 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)

Aquatic Vegetation

Curly-leaf Pondweed Survey

Surveys of curly-leaf pondweed were completed on Pesobic Lake during a June 21, 2012 field visit, 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

Comprehensive surveys of aquatic macrophytes were conducted on Pesobic Lake to characterize the existing communities within the lake and include inventories of emergent, submergent, and floating-leaved aquatic plants within them. The point-intercept method as described in the Wisconsin Department of Natural Resource document, Recommended Baseline Monitoring of Aquatic Plants in Wisconsin: Sampling Design, Field and Laboratory Procedures, Data Entry, and Analysis, and Applications (WDNR PUB-SS-1068 2010) was used to complete this study on July 13 and 14, 2012. A point spacing of 47 meters was used resulting in approximately 265 points.

Community Mapping

During the species inventory work, the aquatic vegetation community types within Pesobic Lake (emergent and floating-leaved vegetation) were mapped 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.

Representatives of all plant species located during the point-intercept and community mapping survey were collected and vouchered by the University of Wisconsin – Steven's Point Herbarium. A set of samples was also provided to the PLA.

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