CalMan Lakes

Calumet/Manitowoc County, Wisconsin

Watershed Management Planning Project

Phase I Report

May 2015

Sponsored by:

Calumet County Land and Water Conservation Department
WDNR Grant Program

LPL-1521-13

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Onterra, LLC
Lake Management Planning

CalMan Lakes

Calumet and Manitowoc Counties, Wisconsin

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Funded by: Calumet County Land and Water Conservation Department
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Acknowledgements

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

CalMan Lakes Planning Committee

The Planning Committee was responsible for much of the volunteer coordination and oversight that occurred with this project.

Calumet County Staff	**Manitowoc County Staff**	**Volunteers**
Danielle Santry	Jerry Halverson	Bob Sengbush
Anthony Reali	Mike Wendt	
Diane Schauer		

Organization

Brillion Conservation Club
Long Lake Advancement Association

Wisconsin Dept. of Natural Resources

Mary Gansberg	Steve Hogler	Paul Garrison
Scott Van Egeren	Adam Nickel	

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1.0 INTRODUCTION

The CalMan Lakes consist of four lakes located along the Calumet-Manitowoc County border in northeastern Wisconsin (Map 1). The project sponsor, the Calumet County Land and Water Conservation Department (CCLWCD), began developing an action plan to document ecological health issues on the lakes with two small-scale lake management planning grants through the Wisconsin Department of Natural Resources (WDNR) in 2011. The resulting CalMan Lakes Organizational Project report (2012) included watershed land use inventories, private on-site wastewater treatment system (POWTS) inventories, lake monitoring group data to document water quality impairments, and an action plan to organize future efforts towards improving the lakes. Most notably, this report listed application for, and development of, a CalMan Lakes Plan through the WDNR Lake Management Planning Grant Program.

Field Survey Notes

All lakes surrounded by beautiful rolling farmlands. Inlet/outlet streams observed flowing in spring months, but had mostly dried during summer. Numerous AIS observed on lakes during 2013 surveys. Deceased fish observed on Boot Lake during spring 2013 field visit.

Photo 1.0-1. Calumet County and Onterra staff, Long Lake, 2013.

Lake at a Glance - The CalMan Lakes

		Round Lake	Boot Lake	Long Lake	Becker Lake
Morphology	Acreage	11.8	11.0	129.0	37.0
	Max. Depth (ft)	55.0	15.0	38.0	51.0
	Volume (acre-ft)	246.4	87.5	1,508.8	572.2
	Mean Depth (ft)	20.9	8.0	11.7	15.5
	Direct Watershed Size (acres)	45	232	474	348
Plants	Comprehensive Survey Date*	2013	2014	2012	2013
	Number of Native Species	9	n/a	8	7
	Non-Native Plant Species	2	1	4	4
Water Quality	Trophic State	Eutrophic			
	Limiting Nutrient	Phosphorus			
	pH	Range from 7.2 - 8.4			
	Sensitivity to Acid Rain	Non-sensitive			
	Watershed to Lake Area Ratio	33:1			

*Point-intercept surveys completed by the Wisconsin Department of Natural Resources.

In addition to the actions documented within the CalMan Lakes Organizational Project report, local volunteers have collaborated with WDNR, Manitowoc and Calumet Counties, and other organizations to partake in activities aimed at monitoring the condition of these lakes. In 2009, 2012, and 2013, volunteers monitored watercraft at the public access points at Becker and Round Lakes as part of the state's Clean Boats Clean Waters (CBCW) Program, which is intended to reduce the transport of aquatic invasive species between waterbodies. A greater presence of CBCW volunteers can be seen at the Long Lake public access, where in 2013 volunteers spent 75 hours inspecting 208 watercraft and educating 506 people on aquatic invasive species related issues.

WDNR staff and citizen volunteers have collected water quality data on several of the CalMan Lakes. Long Lake is included within the WDNR's Long-term Trends water quality monitoring program. Becker Lake has a volunteer collecting water quality data through the Citizen Lake Monitoring Network (CLMN). The lakes are impaired largely by nutrients, which have resulted in late-summer algal blooms as well as dissolved oxygen depletion. Several accounts of winter fish kill have been documented on Becker and Round Lake. The poor water quality has impacted Becker and Round Lakes so much that in a 2012 correspondence, regional fisheries biologist Steve Hogler wrote:

The success or failure of restocking efforts in both Becker and Round Lakes will depend on improving the water quality of each lake. If additional low oxygen events occur during succeeding winters, fish stocking will not restore a desirable mix of self-reproducing fish back into the lakes. To achieve long term stability of a desirable mix of fish species, long term improvements in water quality will be necessary. To improve water quality in these lakes, changes in the watershed that reduce sediment and phosphorus runoff into the lake will be required. Additional management actions may be required even with decreases of external phosphorus levels to ensure long term stability of the lake and its fish community.

Along with preventing the spread of aquatic invasive species, it is the long-term objective of the CCLWCD to create a comprehensive management plan for the four lakes described below, as well as their surrounding watershed. This management planning project will be completed in a series of phases, with initial studies beginning in 2013-2014 and more specific studies following. Developing a management plan for these lakes over the course of several phases would allow for financial savings to be realized in project costs while creating a manageable project that would allow for sufficient attention to be applied to each lake's needs. The staff at the CCLWCD played a critical role in the management planning process between collecting data in the field, co-facilitating public forums, contacting local landowners, and reviewing reports as they were produced. The collaboration between the WDNR, county staff, local stakeholders, and private consultants were crucial to the project's success.

CalMan Lakes Description and Designated Use

Section 101(a)(2) of the Clean Water Act specifies that waterbodies be assigned one or several "uses". Designated uses are essentially definitions of the water quality standards for any given lake, river, stream segment, etc. They may be thought of as water quality goals, management objectives, or functions that are supported by a level of water quality. They are of course necessary for water quality goal establishment, but also in communicating these goals to the public. Examples of common designated uses include protection of aquatic life, recreation, domestic water supply, livestock irrigation and navigation. Designated uses for Wisconsin waterbodies are determined by the WDNR, and include categories of Fish and Aquatic Life, Recreation, Public Health and Welfare, and Wildlife. The designated use for each CalMan Lake, along with a brief description of the waterbody, is included below. Historic accounts for Calumet County lakes were obtained from Fassbender, 1971. Long Lake historic text obtained from the Surface Water Inventory of Wisconsin, 1968.

Round Lake Designated Use: Fish and Aquatic Life

Round Lake is a deep seepage lake. It's depth of 55 feet makes it the deepest lake in Calumet County. In 1959, the lake was chemically treated to remove rough warm-water species of fish and subsequent stocking of bluegill, largemouth bass and rainbow trout followed. The lake is known to host a variety of waterfowl during migration seasons. The lake has suffered in recent decades from agricultural runoff and subsequent algal blooms. Public access is available through a boat launch and roadside parking. Fassbender (1971) noted that "Round Lake is the most valuable water from a recreational and ecological viewpoint in Calumet County and as such should be subjected to every effort to protect and enhance its natural attributes."

Boot Lake Designated Use: Fish and Aquatic Life

Boot Lake is a deep seepage lake that is the shallowest of the four CalMan Lakes, at 15 feet. During high water periods, Boot Lake drains to Long Lake. As with Round Lake, Boot Lake was treated in 1965 to remove undesirable fish species. Northern pike, largemouth bass, bluegill and brook trout were introduced. It is likely that brook trout are no longer present in the lake, with perch and bullhead being reintroduced. In 1971, the lake was described as having frequent heavy algae blooms, with winterkill occurring often as well. The Brillion Conservation Club owns property on the north-northeast shoreland, which is otherwise surrounded by private land.

Long Lake Designated Use: Fish and Aquatic Life

Long Lake is considered a deep seepage lake due to its maximum depth of 38 feet and the intermittent inlet from a northern wetland complex and intermittent outlet to Becker Lake. The lake has a walleye, northern pike and panfish fishery. Major use problems include frequent algae blooms, stunted panfish, and a reported substantial carp population. Public access is ample with a county-owned launching ramp, large parking lot and picnic area.

Becker Lake Designated Use: Fish and Aquatic Life

The furthest "downstream" of the four CalMan Lakes, Becker Lake has an intermittent inlet from Long Lake and an intermittent outlet heading towards Grass Lake. It is technically classified as a deep seepage lake. Becker Lake is quite deep, with a maximum depth of 51 feet and a mean depth of 15 feet. The lake is documented to experience frequent algae blooms in the summer months, with a fish community structure that is evident of numerous winterkill events. Carp are abundant within the lake. Public access is available from a county-owned launching ramp.

Within this report, water quality standards and goals for the CalMan Lakes will be referenced to those set forth for the Fish and Aquatic Life category. If the water quality in the lakes do not allow it to meet their designated use, then it does not meet Wisconsin's water quality standards and the waterbody is considered "impaired". The waterbody is then placed on the "303(d)" list, commonly known as the "impaired waters list". In 2010, Long Lake was included on the 303(d) list for impairment due to excessive total phosphorus, which resulted in impairments, including eutrophication, degraded biological community and excessive algal growth.

Watershed Planning Process

The CalMan Watershed Planning Project began as a multi-phased, science-based collaborative approach that is consistent the outline suggested in the United States Environmental Protection Agency's (USEPA's) "Handbook for Developing Watershed Plans to Restore and Protect Our Waters" (USEPA, 2008). Specifically, the handbook outlines nine key elements that are critical for achieving improvements in water quality (Figure 1.0-1).

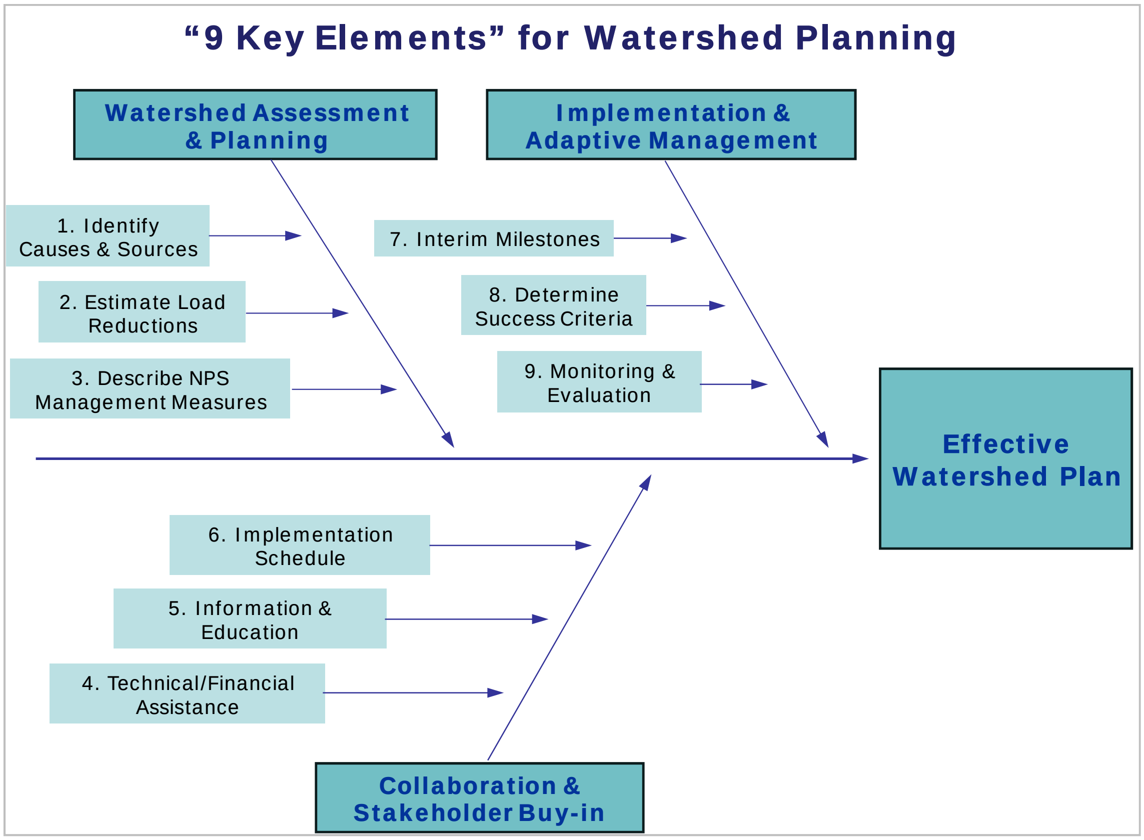

Figure 1.0-1. USEPA nine key elements for watershed planning. Adapted from USEPA 2008.

Phase I of the CalMan Lakes Watershed Planning Project began with an assessment of the pollutants, namely nutrients, which were believed to be impacting the lakes. Phase II studies will continue these studies with strategic monitoring of tributary streams that drain the small watershed into the CalMan Lakes. During this same time, efforts will be made to pinpoint critical areas in each sub watershed and estimate potential pollutant reductions through nonpoint source management efforts.

Note: This section will be completed as Phase III and Phase IV studies are completed.

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 numerous watershed stakeholders, volunteer activities in the watershed and various other educational initiatives.

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

Project Planning Process

Kick-off Meeting

On August 22, 2013, Onterra ecologists Dan Cibulka and Tim Hoyman met with Calumet County staff, Brillion Conservation Club and other watershed stakeholders to introduce the project and its components. The meeting was announced through a mailing and personal contact by Calumet County staff and Brillion Conservation Club members. The attendees observed a presentation given by Mr. Cibulka, which 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 and the various scientific components. The presentation was followed by a question and answer session.

Watershed Planning Meetings

The first of several watershed planning meetings was held on May 19, 2014. The meeting was attended by Calumet County and Manitowoc County conservation staff, as well as WDNR lakes coordinator Mary Gansberg and Onterra ecologists Dan Cibulka and Tim Hoyman. During this meeting, a presentation was delivered by Mr. Cibulka which included results of the in-lake studies and watershed assessments that had taken place in 2013. Following the presentation, the group discussed approach that would be taken in the following phase of the project.

Management Plan Review and Adoption Process

Prior to the Phase I watershed planning meeting, Section 3.0 of this document was sent to the meeting attendees for review. Comments from the meeting were integrated into an official Phase I Report, which was reviewed by CCLWCD staff in fall of 2014. During their September monthly meeting, Danielle Santry presented an outline of the report to the Brillion Conservation Club and addressed their questions on future studies the project would undertake.

An official Phase I draft report was presented to the WDNR in early November of 2014, with comments being addressed by Onterra staff later that month.

During a Long Lake Advancement Association meeting on December 6, 2014, Danielle Santry presented an update on the CalMan Watershed Plan, including a review of the Phase I report along with steps on 2015-2016 studies on the lakes. The LLAA was then given the opportunity to ask questions and provide commentary on the report. During a December 16, 2014 County Board meeting, the Calumet County Board of Supervisors voted unanimously (21 ayes, 0 nays, 0 absent) to adopt the Phase I CalMan Lakes Watershed Plan. During this time t report was also presented to the Manitowoc County Soil and Water Conservation Department to keep these stakeholders involved in the process as well as solicite.

In late December of 2014, the Phase I report was presented to a WDNR technical review team which included experts on various aspects of lake ecology and management. The review team provided feedback on the report on December 29, 2014. A conference call was held with Onterra staff, Calumet County staff and the WDNR technical team on January 9, 2015 to discuss the review in finer detail, including specifics on methodology of 2015-2016 scientific investigations . After the follow-up conversations stemming from this call, a final draft of the Phase I CalMan Lakes Watershed Management Plan was sent to the WDNR in January of 2015.

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 the CalMan Lakes is compared to other lakes in the state with similar characteristics as well as to lakes within the northern region (Appendix B). 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 CalMan Lakes' 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 epiliminion is the top layer of water which is the warmest water in the summer months and the coolest water in the winter months. The hypolimnion is the bottom layer and contains the coolest water in the summer months and the warmest water in the winter months. The metalimnion, often called the thermocline, is the middle layer containing the steepest temperature gradient.

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. days at a time).

Candidate Lakes

- Lakes with hypolimnetic total phosphorus concentrations consistently 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, several possibilities exist; 1) shoreland septic systems, 2) internal phosphorus cycling, 3) shoreland runoff, sediment resuspension, or 4) high nutrient groundwater input.

If the lake is considered a candidate for internal loading, modeling procedures are used to estimate that load.

Comparisons with Other Datasets

The WDNR document *Wisconsin 2014 Consolidated Assessment and Listing Methodology* (WDNR 2013) 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 the CalMan Lakes will be compared to lakes in the state with similar physical characteristics. The WDNR groups Wisconsin's lakes into ten natural communities (Figure 3.1-1).

First, the lakes are classified into three main groups: (1) lakes and reservoirs less than 10 acres, (2) lakes and reservoirs greater than or equal to 10 acres, and (3) a classification that addresses special waterbody circumstances. The last two categories have several sub-categories that provide attention to lakes that may be shallow, deep, play host to cold water fish species or have unique hydrologic patterns. Overall, the divisions categorize lakes based upon their size, stratification characteristics, hydrology. 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.

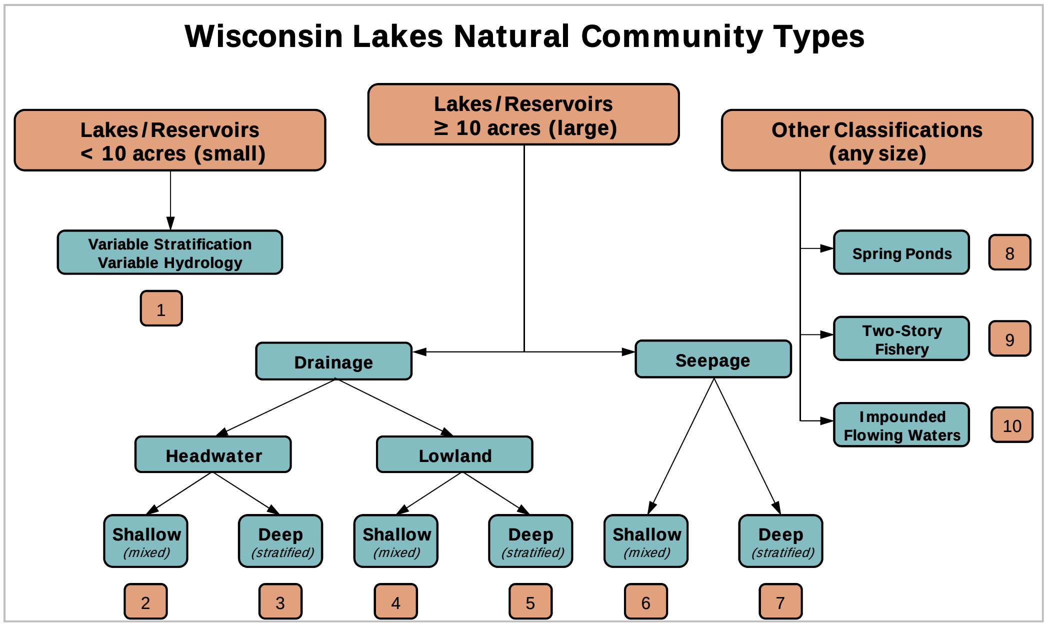

Figure 3.1-1. Wisconsin Lake Natural Communities. Adapted from WDNR 2013.

Garrison, et. al (2008) developed state-wide median values for total phosphorus, chlorophyll-*a*, and Secchi disk transparency for six of the lake classifications. Though they did not sample sufficient lakes to create median values for each classification within each of the state's ecoregions, they were able to create median values based on all of the lakes sampled within each ecoregion (Figure 3.1-2). Ecoregions are areas related by similar climate, physiography, hydrology, vegetation and wildlife potential. Comparing ecosystems in the same ecoregion is sounder than comparing systems within manmade boundaries such as counties, towns, or states. The CalMan Lakes are within the Southeastern Wisconsin Till Plains ecoregion.

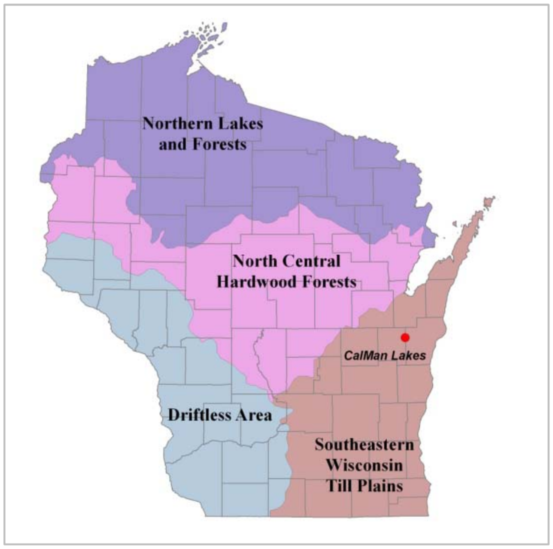

Figure 3.1-2. Location of the CalMan Lakes within the ecoregions of Wisconsin. After Nichols 1999.

The Wisconsin 2014 Consolidated Assessment and Listing Methodology document also helps stakeholders understand the health of their lake compared to other lakes within the state. Looking at pre-settlement diatom population compositions from sediment cores collected from numerous lakes around the state, they were able to infer a reference condition for each lake's water quality prior to human development within their watersheds. Using these reference conditions and current water quality data, the assessors were able to rank phosphorus, chlorophyll-*a*, and Secchi disk transparency values for each lake class into categories ranging from excellent to poor.

CalMan Lakes Water Quality Analysis

CalMan Lakes Nutrient Content and Clarity

The amount of historical water quality data existing on the CalMan Lakes varies by lake. Volunteers have been monitoring Long Lake and Becker Lake through the WDNR's Citizens Lake Monitoring Network (CLMN), collecting nutrient samples or Secchi disk clarity data several times each summer. Long Lake is also a part of the WDNR's Long Term Trend Monitoring Program, which has included water quality and aquatic plant sampling over the course of several years. Round and Boot Lakes do not have active CLMN volunteers and because of this, there are few historical data to compare against the data that were collected as a part of this project. The importance of consistent, reliable data cannot be stressed enough; just as a person continuously monitors their weight or other health parameters, the water quality of a lake should be monitored in order to understand the system better and make sounder management decisions.

Calumet County and Onterra staff collected water quality samples and monitored Secchi disk clarity on each CalMan lake during the course of this project. Monitoring occurred during the spring, summer, fall of 2013 and the following winter in 2014. Additionally, historical data was researched and is presented within this section as appropriate. Unless otherwise indicated, parameters represent samples collected from the sub-surface of each lake.

Phosphorus

WisCALM procedures for 303(d) listings of waterbodies include two years of data collection. Additionally, these samples must be taken between June 1 and September 15 to represent the time of the year in which nutrient impacts would be shown the most. Therefore, some of the phosphorus data in this section will be presented in a fashion compatible with WisCALM guidelines, while comparisons consistent with Garrison et. al (2008) are made elsewhere.

Total phosphorus values were collected from the sub-surface and near bottom areas of each CalMan Lake in 2013 as well as in other years. Figure 3.1-3 displays the summer sub-surface total phosphorus averages. In 2013, all lakes were found to have concentrations higher than 60 μg/L, which is the threshold for impairment in deep seepage lakes with a Fish and Aquatic Life Use designation. Average and median values also exceed this threshold. The impairment was particularly notable in Boot Lake, where all summer values but one exceeded 100 μg/L in 2013.
In looking at the 2013 data alone, all CalMan Lakes had average summer total phosphorus concentrations that were much greater than the median values of other deep seepage lakes in the state and all lakes in the Southern Wisconsin Till Plains ecoregion (Figure 3.1-4).

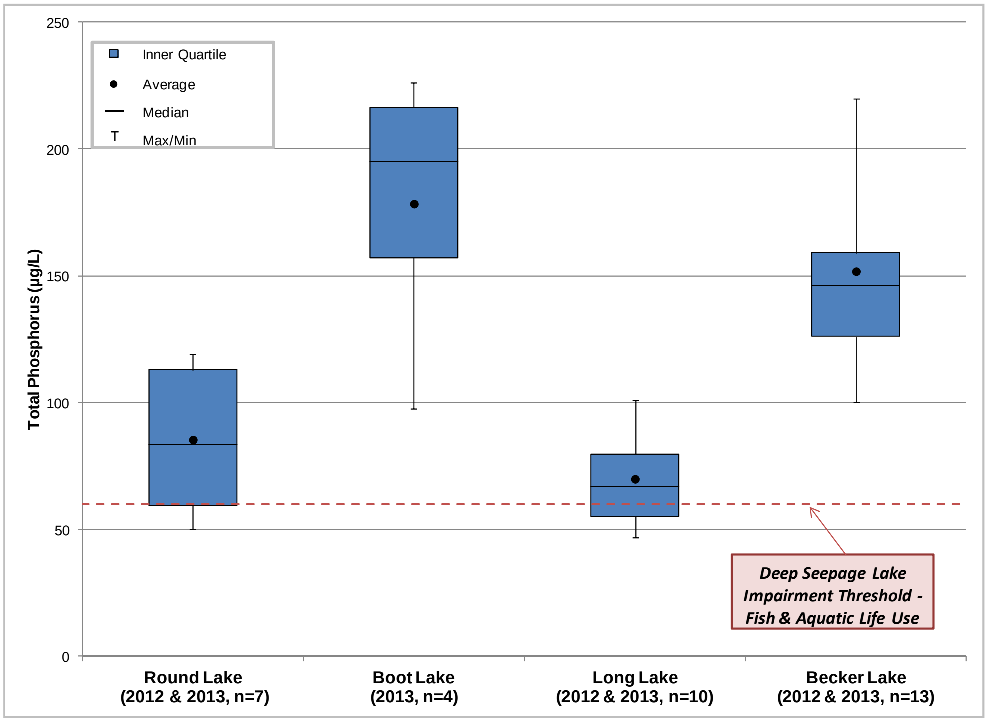

Figure 3.1-3. CalMan Lakes surface phosphorus concentrations. Values calculated with summer month surface sample data and methodology from WDNR 2013.

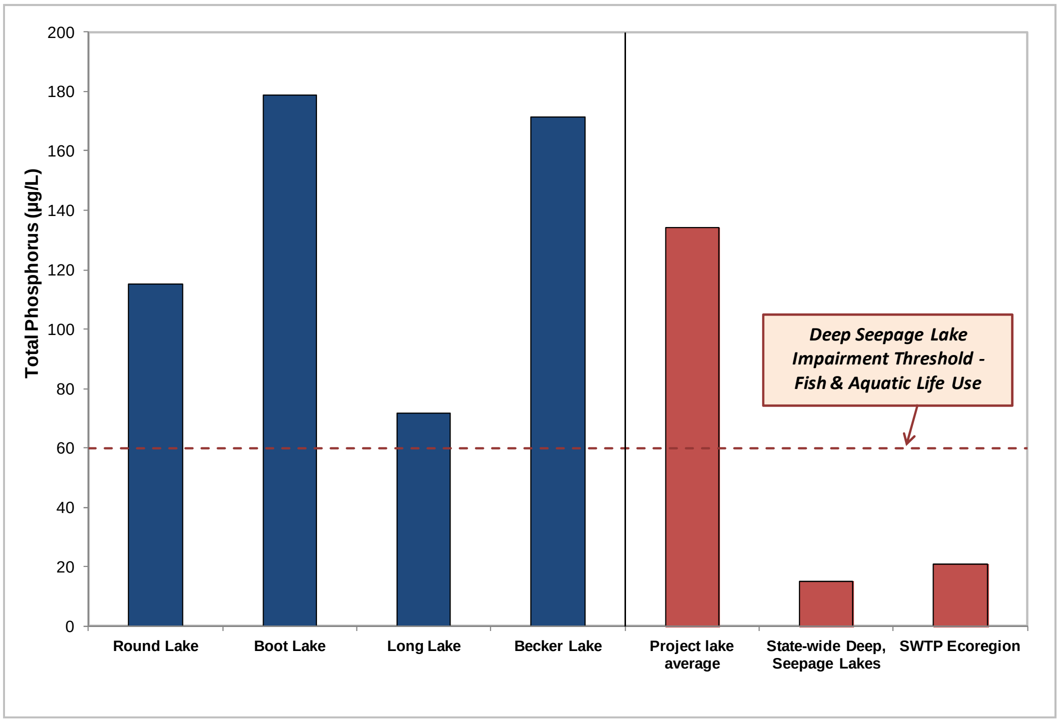

Figure 3.1-4. CalMan Lakes 2013 surface phosphorus concentrations and comparables. Comparables include statewide deep seepage lakes and Southern Wisconsin Till Plains ecoregion median values. Values calculated with summer month surface sample data and methodology from WDNR 2013.

As mentioned earlier, during 2013 and 2014water quality sampling trips total phosphorus samples were collected from the near-bottom waters of each CalMan Lake. Figure 3.1-4 displays that even though surface concentrations of phosphorus were high, very often as much as 10-20 times larger in the hypolimnion. This is an indication of sediment phosphorus release under anoxic conditions.

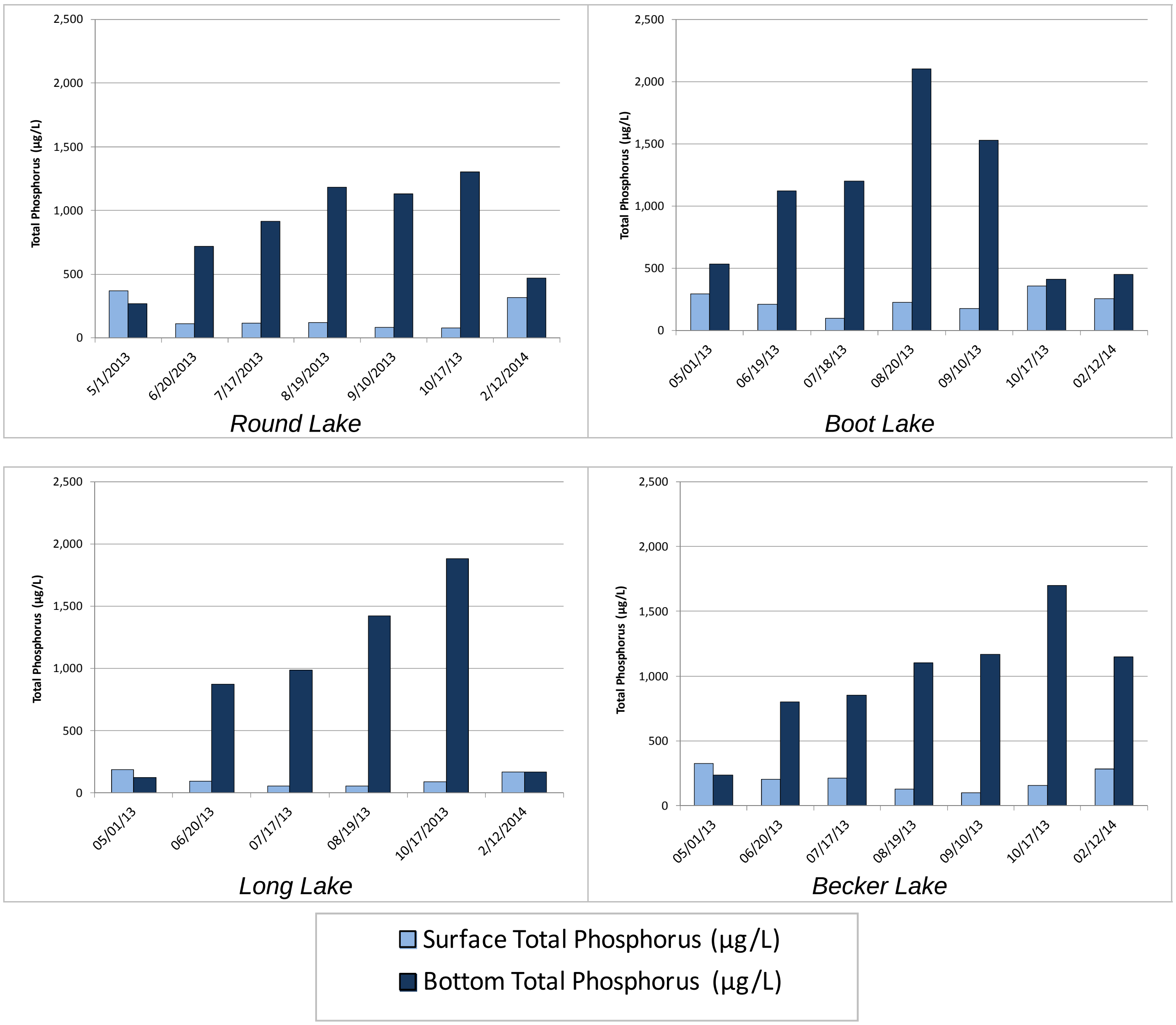

Figure 3.1-5 CalMan Lakes surface-bottom total phosphorus comparisons, 2013-2014.

Chlorophyll-*a*

As phosphorus concentrations are highly related to algae and chlorophyll-*a* concentrations, it is not unexpected to see considerable algae concentrations in the CalMan Lakes. As with phosphorus concentrations, chlorophyll-*a* concentrations can be quite variable in the CalMan Lakes (Figure 3.1-6 and Figure 3.1-7). The majority of recently collected concentrations are high; most were recorded above the threshold of impairment for deep seepage lakes.

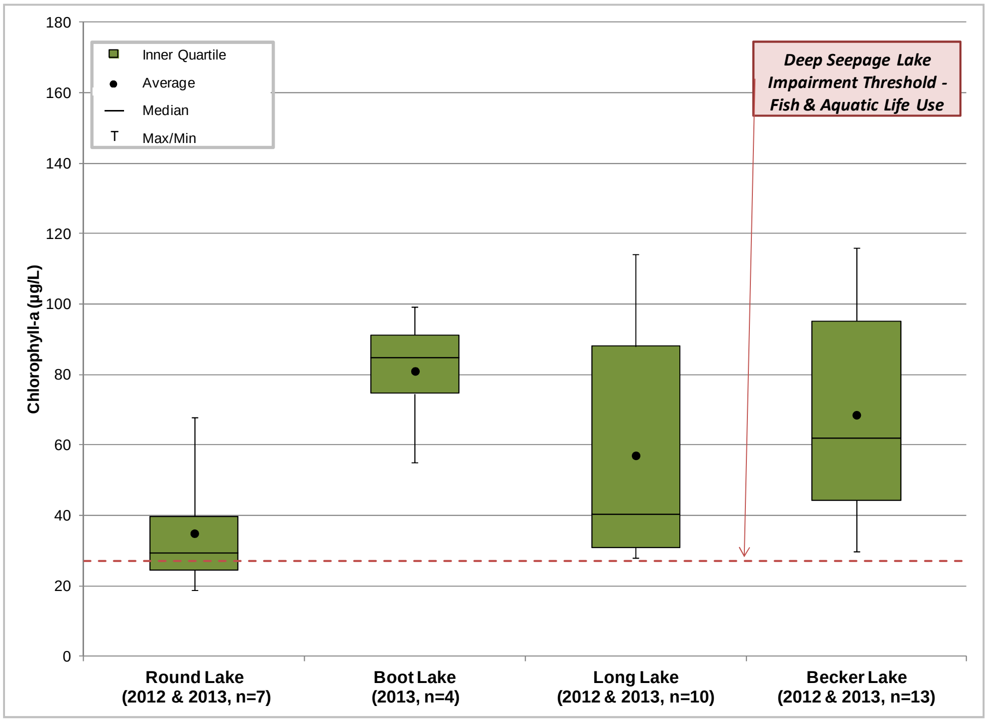

Figure 3.1-6. CalMan Lakes surface chlorophyll-*a* concentrations. Values calculated with summer month surface sample data and methodology from WDNR 2013.

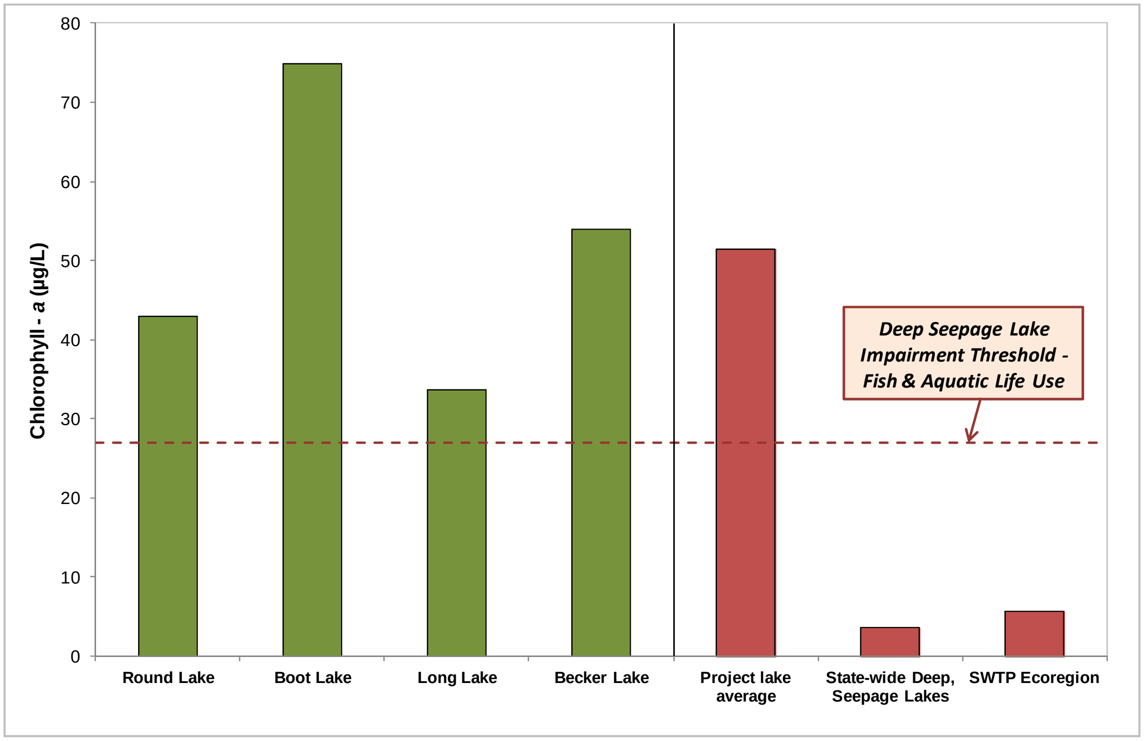

Figure 3.1-7. CalMan Lakes 2013 surface chlorophyll-*a* concentrations and comparables. Comparables include statewide deep seepage lakes and Southern Wisconsin Till Plains ecoregion median values. Values calculated with summer month surface sample data and methodology from WDNR 2013.

Water Clarity

Average summer Secchi disk clarity ranged from 0.7 feet deep to 3.5 feet deep in the CalMan Lakes in 2013 (Figure 3.1-8). The water clarity of a lake is heavily influenced by many characteristics. These include dissolved substances as well as non-dissolved substances. For example, water clarity is influenced by algal concentration; the more algae in the water column, the less visibility there is. This is an example of a non-dissolved substance that alters water clarity. Suspended sediments are another example. Dissolved organic substances may reduce the clarity by changing the color of the water in a lake.

"True color" measures the dissolved materials in water. Water samples collected in April of 2012 were measured for this parameter, and were found range between 30 and 60 Platinum-cobalt units (Pt-co units, or PCU) in the CalMan Lakes. Lillie and Mason (1983) categorized lakes with 0-40 PCU as having "low" color, 40-100 PCU as "medium" color, and >100 PCU as high color. In other words, the higher a PCU value is, the more a lake's water clarity may be impacted.

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. Total suspended solids were measured in the CalMan Lakes near the surface and near the bottom in spring, fall, and winter. Average total suspended solids values ranged between 8 mg/L in Round Lake and 23 mg/L in Boot Lake in 2013. While these values are somewhat low, it is likely that turbidity from TSS is quite high for short periods during high runoff events.

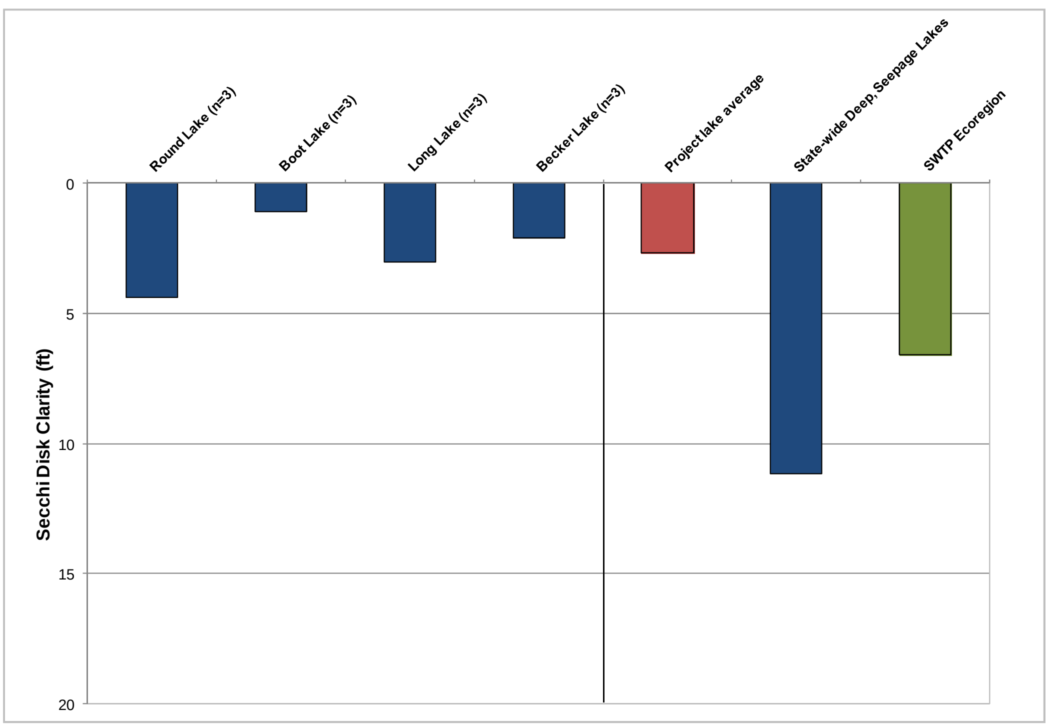

Figure 3.1-8. CalMan Lakes summer 2013 Secchi disk means. Comparables include statewide deep seepage lakes and Southern Wisconsin Till Plains ecoregion median values. Values calculated with summer month surface sample data and methodology using WDNR 2013.

Limiting Plant Nutrient of the CalMan Lakes

Using average nitrogen and phosphorus concentrations from all lakes included in the CalMan Lakes study, a nitrogen:phosphorus ratio was calculated for each lake (Table 3.1-1). In Boot and Long Lakes, the ratio weighed heavily in favor of nitrogen, meaning that phosphorus is clearly the limiting nutrient. Round Lake and Becker Lakes had ratios still in favor of nitrogen, but were closer to the ratio managers consider to be transitional between phosphorus and nitrogen limitation (10-15:1). This finding indicates that CalMan Lakes are indeed phosphorus limited as are the vast majority of Wisconsin lakes. In general, this means that cutting phosphorus inputs may limit algae and plant growth within the lakes.

Table 3.1-1. CalMan Lakes nitrogen:phosphorus ratios. Ratios calculated from sub-surface samples taken in summer from each lake.

Lake Name	N:P Ratio
Round Lake	24:1
Boot Lake	45:1
Long Lake	42:1
Becker Lake	19:1

Nitrogen

Nitrogen is a nutrient that occurs in lakes in several forms, all of which may be quantified separately and are linked through multiple chemical and physical properties. Nitrate (NO^{3}-), ammonia (NH^{4}+) and nitrite (NO^{2}-) are all nitrogen-based compounds that may be converted from one form to the other under a number of processes. Typically in lake systems, nitrogen is reported as total nitrogen, which is the sum of all nitrogen forms. Currently, Wisconsin has adopted water quality standards for some nitrogen compounds in groundwater and drinking water sources, but a standard for surface recreational waters has yet to be determined. NR 140 of Wisconsin’s Administrative Code states an enforcement standard of 10 mg/L for nitrate (expressed as N) for groundwater. This is the same threshold for drinking water, as defined by NR 809. For nitrite, 1 mg/L is the maximum contaminant level for drinking water. These standards have been developed based upon the risk of methernoglobenernia (blue-baby syndrome) in infants. US Fish and Wildlife Service guidance suggests that nitrate levels not exceed 3,000 mg/L for lakes with trout or warm water fish species (Piper et. al, 1982). Livestock risk to excessive nitrates does not typically occur until this compound reaches 20+ mg/L. Aquatic life is not impacted by nitrate except for at extremely high concentrations (Chern et. al, 1999).

Figure 3.1-9 displays July 2013 surface water total nitrogen values in the CalMan Lakes. For reference, the units in Figure 3.1-9 are in units of µg/L, or parts per billion (ppb). 1,000 µg/L is equal to 1.0 mg/L.

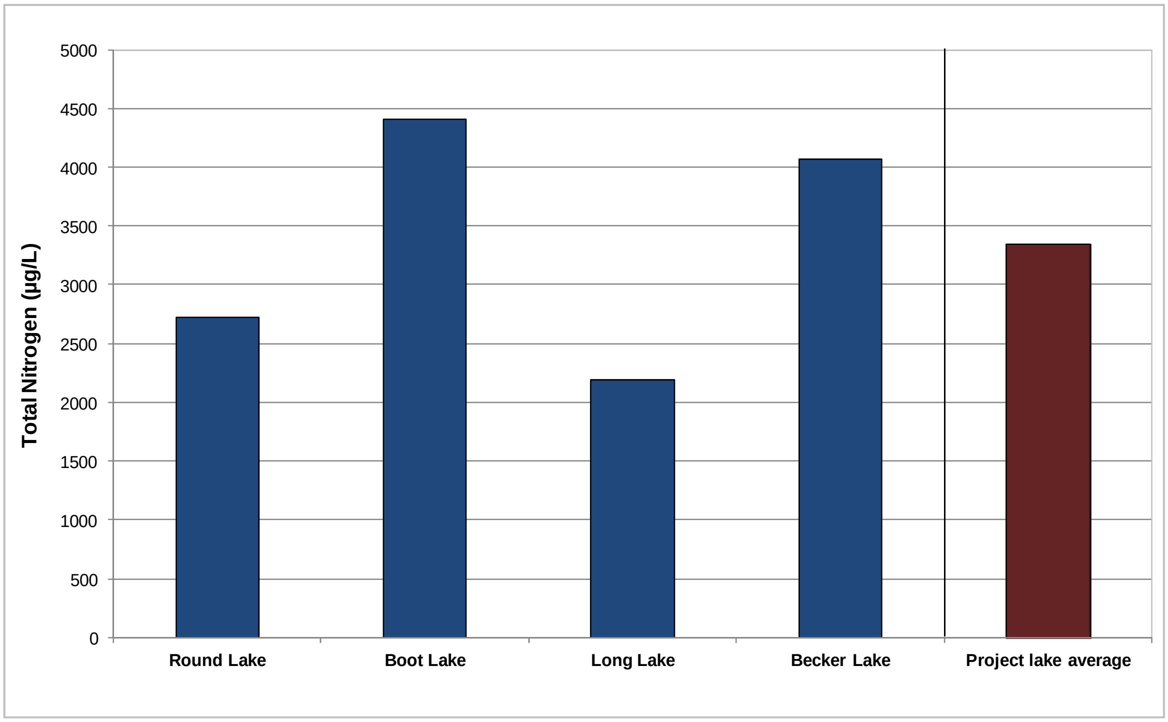

Figure 3.1-9. Mid summer nitrogen values from the CalMan Lakes. Values calculated with 2013 summer surface sample data and methodology from WDNR 2013.

CalMan Lakes Trophic State

Figure 3.1-10 contain the Trophic State Index (TSI) values for the CalMan Lakes. The TSI values calculated with Secchi disk, chlorophyll-*a*, and total phosphorus values range in values spanning from upper mesotrophic to lower eutrophic. In general, the best values to use in judging a lake's trophic state are the biological parameters. The CalMan Lakes may be classified as upper eutrophic, with Boot and Becker Lakes extending in a higher, hyper-eutrophic category. As previously mentioned, eutrophic lakes are characterized by having abundant nutrients, algae and aquatic plants, low visibility, and often soft sediments. Eutrophic lakes at the upper end of the classification often experience excessive algae or aquatic plant growth and may see winter fish kills.

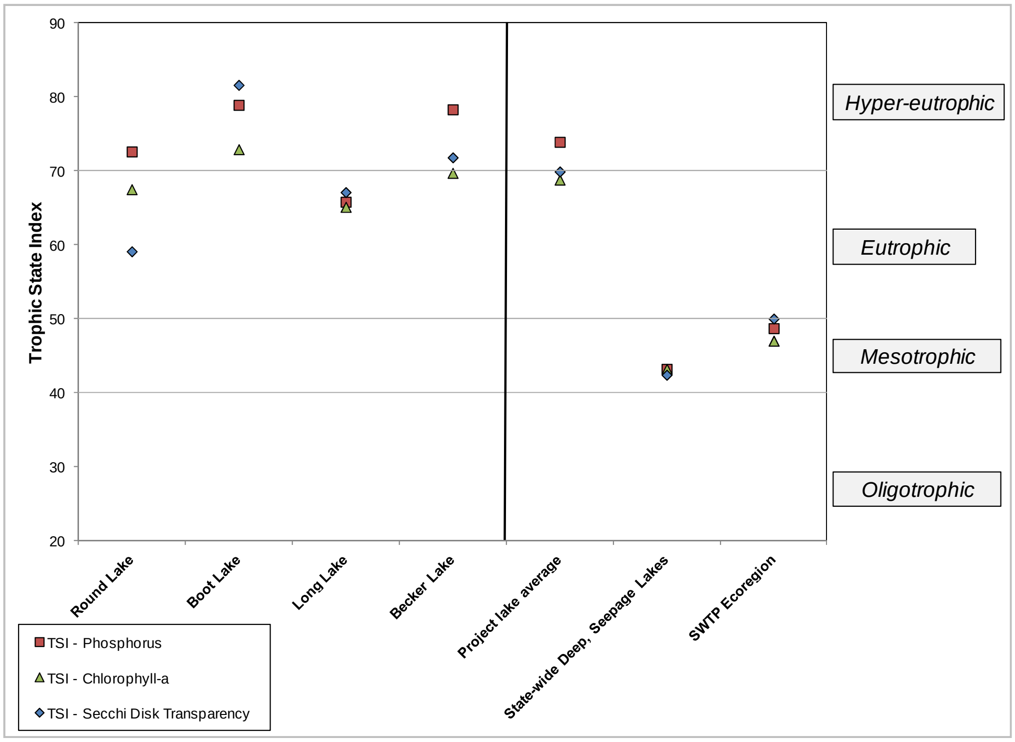

Figure 3.1-10. CalMan Lakes and comparable lakes Trophic State Index values. Comparables include statewide deep seepage lakes and Southern Wisconsin Till Plains ecoregion median values. Values calculated with summer month surface sample data and methodology from WDNR 2013.

Dissolved Oxygen & Temperature

Dissolved oxygen and temperature were measured during water quality sampling visits to the CalMan Lakes by Calumet County and Onterra staff. Profiles depicting these data are displayed in Figure 3.1-11 and 3.1-12.

During the spring (typically April-May), the water column within deep seepage lakes may be thoroughly or partially mixed, with similar temperatures and dissolved oxygen being present from the surface to the bottom of the lake. This same relationship is often seen in the fall as winds increase and air/surface water temperatures cool. During the summer months, deep seepage lakes typically undergo thermal stratification. While the hypolimnetic waters remain cool/cold, the epilimnetic waters warm as the sun's rays hit them and air temperatures increase. A gradient of oxygen often occurs during this time as well. Oxygen is typically higher in the epilimnion, where oxygen exchange occurs with the atmosphere and contribution of oxygen from aquatic plants also occurs. Near the bottom of the lake, these sources of oxygen are not present. Additionally, bacteria feed upon organic material and in the process use any available oxygen and convert it to carbon dioxide. Sometimes, strong summer winds may mix the water column, replenishing oxygen and warmer water to the hypolimnion. However this only occurs when the force of the wind is able to overcome the depth and density differences of the lake.

During the winter months, lakes become inversely stratified when temperatures near the ice at the surface are the coldest and the denser, warmer water sinks to the bottom. Oxygen may become depleted during this time as well. With the aquatic plants in the lake not present, no oxygen is contributed to the lake from this source, though some algae species may photosynthesize to a minimal extent under the ice. And since the lake is frozen over, oxygen from the atmosphere is not able to diffuse into the lake water this way. It is during the late winter that oxygen depletion may occur to the point at which fish kills are possible. Some fisheries biologists believe that sport fish can usually handle low dissolved oxygen levels under the ice, even for weeks at a time. Fish may sustain levels as low as 1.0 mg/L for 2-3 weeks. As indicated in Figure 3.1-11, much of the water column in Round, Boot and Becker Lakes was at or near 0 mg/L for oxygen content in mid-February of 2014. With ice finally leaving the lakes in early to mid April of 2014, it is possible that winter fish kill may have occurred.

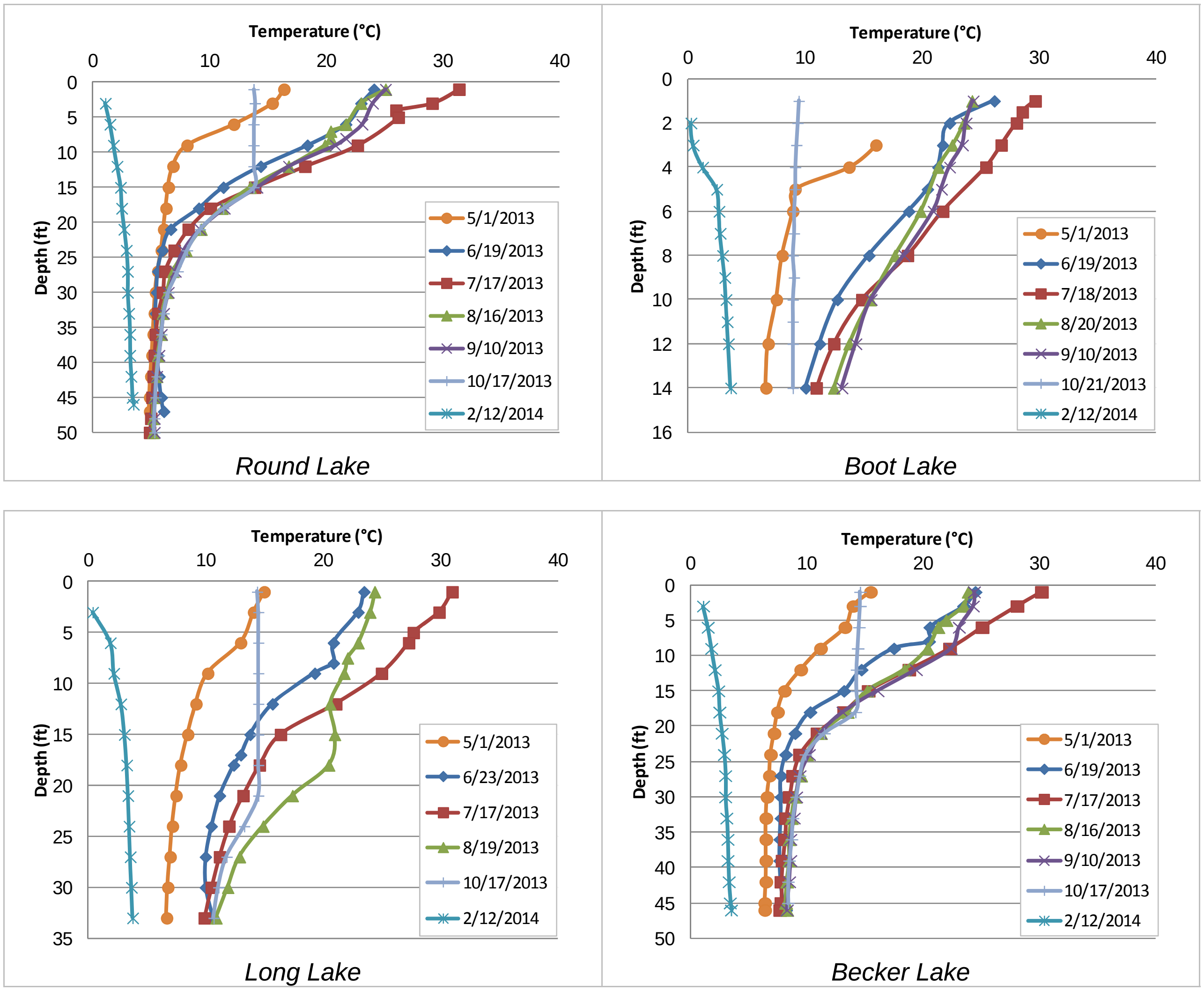

Figure 3.1-11. CalMan Lakes temperature profiles, 2013-2014.

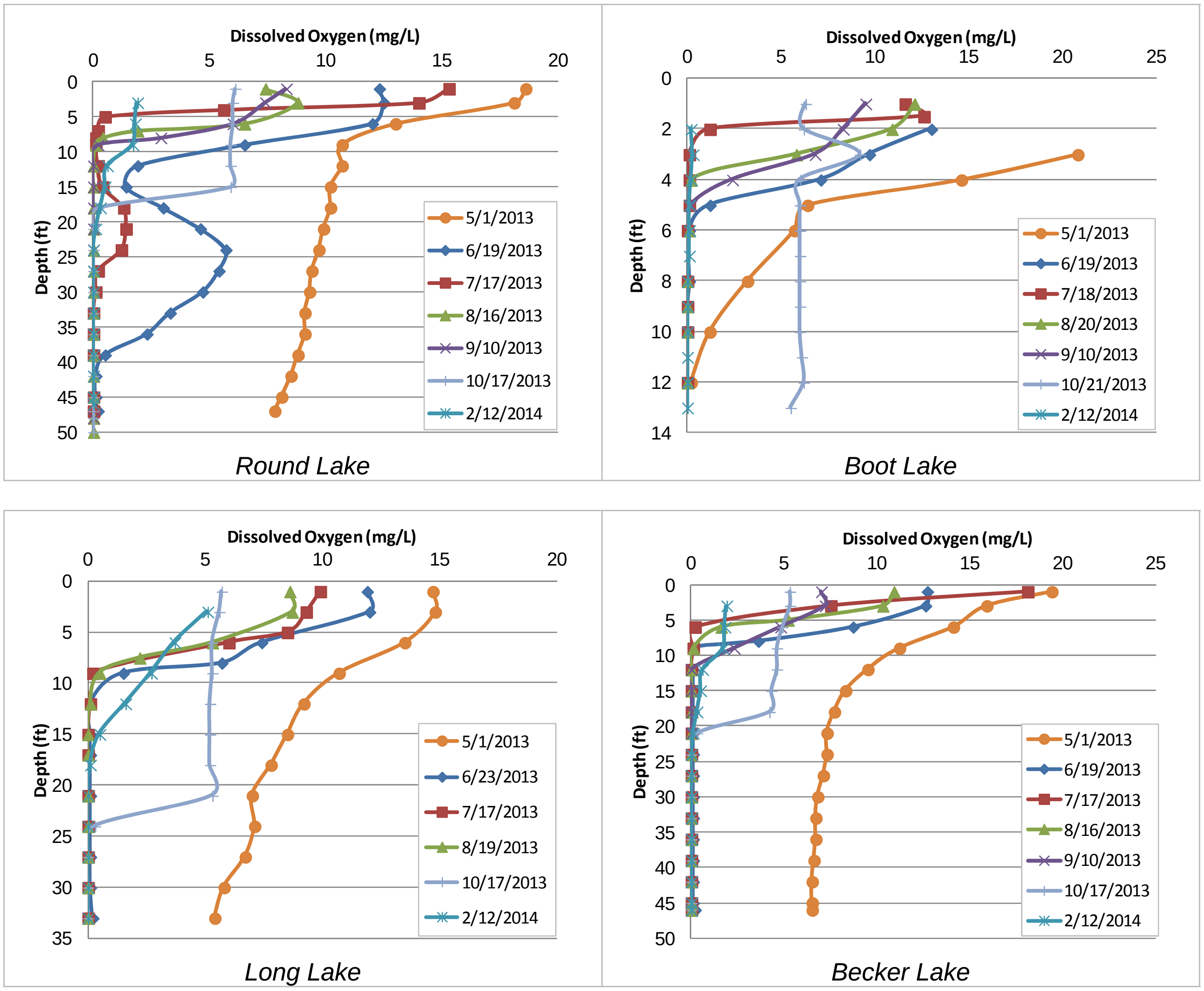

Figure 3.1-12. CalMan Lakes dissolved oxygen profiles, 2013-2014.

pH and Alkalinity

The water quality information discussed above 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 the CalMan Lake's water quality and are recommended as a part of the WDNR Long-Term Lake Trends monitoring protocol. These parameters include; pH, alkalinity, and calcium.

The pH scale ranges from 0 to 14.0 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 7.0 has equal amounts of hydrogen ions and hydroxide ions (OH^-), and is considered to be neutral. Water with a pH of less than 7.0 has higher concentrations of hydrogen ions and is considered to be acidic, while values greater than 7.0 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 and Nimphius, 1985). The variability in pH between lakes is most likely attributable to a number of environmental factors, with the chief determiner being geology near the lake and within its surface and underground watersheds. On a smaller scale within a lake or between similar lakes, photosynthesis by plants can impact pH because the process uses dissolved carbon dioxide, which acts as a carbonic acid in water. Carbon dioxide removal through photosynthesis reduces the acidity of lake water, and so pH increases. Between Round, Long and Becker Lakes, there is little variability in pH as the values lie around 9.0. Boot Lake's pH was found to be closer to neutral at 7.1 (Figure 3.1-13). The values seen within the CalMan Lakes are normal for Wisconsin lakes.

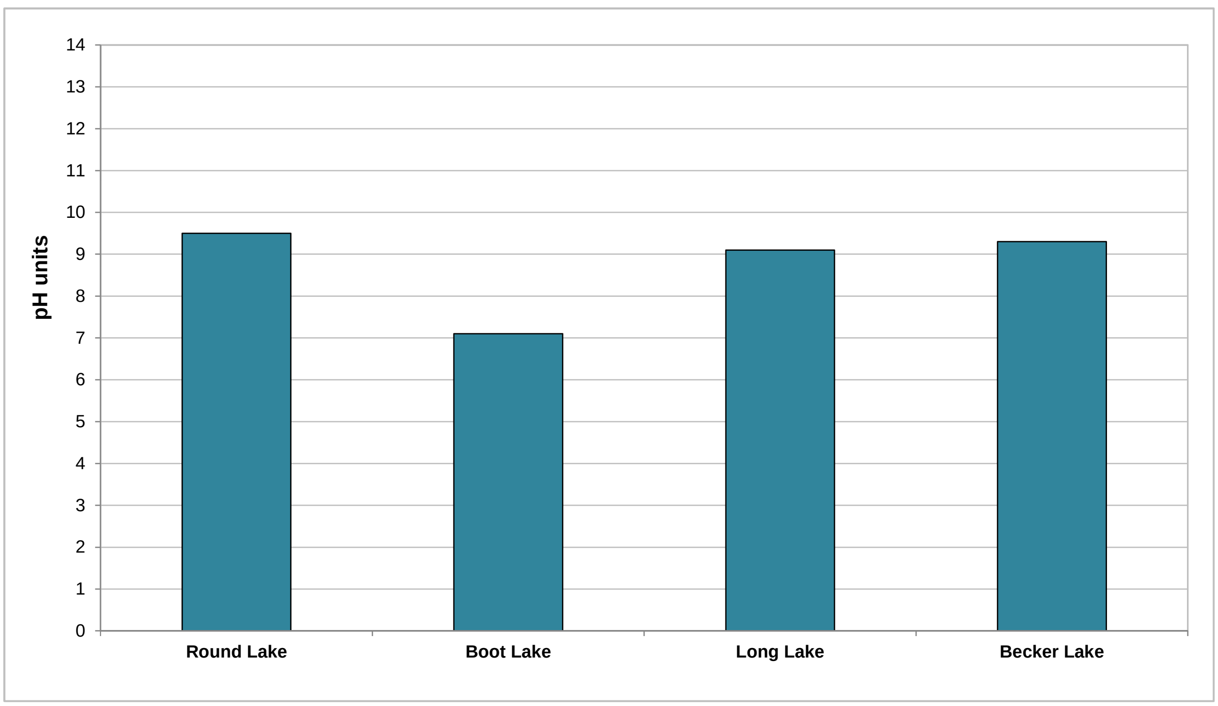

Figure 3.1-13. CalMan Lakes pH values. Data collected from summer month surface samples.

Alkalinity is a lake's capacity to resist fluctuations in pH by neutralizing or buffering acidic inputs such as acid rain. The main compounds that contribute to a lake's alkalinity in Wisconsin are bicarbonate (HCO_3^-) and carbonate (CO_3^-), which neutralize hydrogen ions from acidic inputs. These compounds are present in a lake if the groundwater entering it comes into contact with minerals such as calcite ($CaCO_3$) and/or dolomite ($CaMgCO_3$). A lake's pH is primarily determined by the amount of alkalinity it contains. 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. Alkalinity values are quite similar between the CalMan Lakes and are at values expected for lakes in this region, which are located above rock groupings that are relatively high in calcium carbonate. (Figure 3.1-14). Alkalinity determines the sensitivity of a lake to acid rain. Values between 2.0 and 10.0 mg/L as $CaCO_3$ are considered to be moderately sensitive to acid rain, while lakes with values of 10.0 to 25.0 mg/L as $CaCO_3$ are generally considered to have low sensitivity, and lakes above 25.0 mg/L as $CaCO_3$ are non-sensitive.

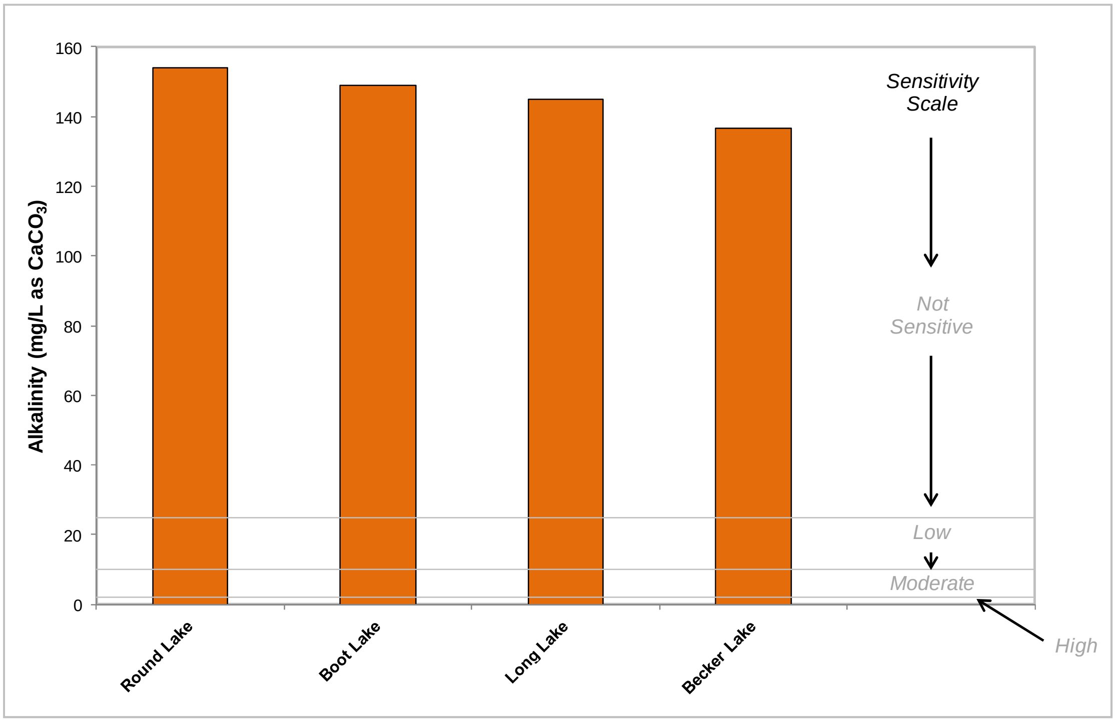

Figure 3.1-14. CalMan Lakes alkalinity values and acid rain sensitivity ranges. Data collected from summer surface samples.

Tributary Stream Monitoring

Tributary stream monitoring will be conducted during Phase II and Phase III of the project.

3.2 Watershed Assessment

Watershed Characteristics

As illustrated through this section, a lake's watershed has great influence over the water chemistry, hydrologic properties, and overall ecology of the waterbody. Various characteristics of the watershed may determine the quantity of nutrients, sediments, inorganic pollutants and water that reach a lake. Additionally, aspects of the watershed determine how fast (e.g. flow rate) these components reach a lake's waters. Aspects of a watershed that are important for any study include soil type, slope of the land, land cover type. The materials presented below are the result of studies completed by Onterra staff as well as CCLWCD staff, while a CCLWCD report on additional watershed parameters is included within Appendix D.

Private Onsite Wastewater Treatment Systems

Improperly maintained or faulty septic systems may impact both the health of individuals using the lake and also the water quality of a lake. A properly operating system will remove most disease-causing pathogens, but may not remove or treat nutrients such as phosphorus or nitrogen entirely. Besides the obvious health concerns, leaky septic systems may contribute nutrients to a lake, which can promote algae and aquatic plant growth.

The Wisconsin Department of Commerce oversees private onsite wastewater treatment systems (POWTS) through Chapter SPS 383 (formerly Chapter Comm 83). Although there are an estimated 772,000 private septic systems located in the state of Wisconsin, the exact number and location of these systems was largely unknown for some time. Recent legislation has prompted counties to develop a comprehensive inventory of their septic systems. As of January 2013, it is currently believed that 83% of the estimated number of systems have been inventoried.

In Manitowoc and Calumet County, all pre-1980 POWTS within the county must be inspected by a licensed professional and reported back to the county on a POWTS Inventory Inspection Report form. This report form is reviewed by staff and sorted into different categories depending upon the status of each system. Report forms that identify a properly functioning POWTS are scanned and attached to a parcel in a tax/parcel database and are entered into a three year POWTS maintenance tracking software program. The POWTS Inventory Inspection Report form documents the type of system (mound, conventional, holding tank, privy, etc), the condition of that system (failing or functioning), and a location of each system component if known.

If a system is deemed functioning, it is added to the county's maintenance program and the owner is required to have the system inspected by a licensed professional every 3 years and the septic tank pumped. If the system is a holding tank, the system is placed on a pumping schedule that reflects the size of the holding tank and the number of rooms in the dwelling unit. If the system is failing, it is ordered to be replaced. The county does assist low income individuals in seeking financial assistance from the state to offset the costs of installing a replacement system. Due to income limitations and the type of existing system, not all property owners or systems qualify for grant money.

Creating an inventory of POWTS throughout the state of Wisconsin is important, but maintaining these systems so that they operate correctly is critical. The enacted legislation has developed rules that establish a maintenance program for private sewage systems, and even encourages failing system replacement and rehabilitation through a funding program called the Wisconsin Fund. A condition for a county to participate in this program is that the county must adopt and implement a maintenance program, and must do so by the state-wide deadline of October 1, 2015. Because each program is governed on a county basis, your local health or zoning and planning department will be able to inform you on the maintenance program and funding opportunities in your county.

It is generally recommended that POWTS are pumped or inspected every three years for proper functioning. Between inspections, there are several ways to determine if your septic system may require maintenance:

- Sewage has backed up in your drains, toilets or basement
- Drains begin to run slower than normal
- Wet areas or bright green grass appear over the drain field
- A dense colony of aquatic plants or algae appears near your shoreland
- Bacteria or nitrates are found in your well water
- Biodegradable dye flushed through the system appears in the lake or stream

Additionally, there are many ways to keep your septic system in top shape, and reduce the chances of system failure:

- Have your system inspected on a regular basis (every 3 years is recommended)
- Avoid driving or parking vehicles on the drain field
- Do not dispose of materials in drains that enter the septic tank. These items (fats, grease, paper towels, disposable diapers, sanitary napkins, etc.) may clog the septic tank and other items (cleaning fluids, oils, paints, etc.) may not be treated and end up in groundwater.

Soils and Geology

Geology and soils play an extremely important role in controlling how water moves over and through a watershed. By studying the properties, position in the landscape and watershed hydrology associated with geology and soils, a better understanding can be achieved about how the watershed functions. In addition to their impact on water flow and quality, soils and geology play a pivotal role in a number of human activities, such as agricultural production, home site development, road construction, landscaping, etc. Thus, a general knowledge of soils is essential for implementation of successful watershed management activities.

Calumet and Manitowoc Counties are underlain primarily by Silurian-age (443-416 million years ago) dolostone. Dolostone is a carbonate-based rock; in other words, it is a rock that is rich the mineral dolomite ($CaMg(CO_3)_2$). Most carbonate rocks begin as deposition of calcium carbonate ($CaCO_3$), derived from a variety of biochemical or chemical sources, occurs on the bottom of an ocean. After burial, the grains of calcium carbonate along with other materials become lithified (turned to rock under pressure). Thus, the Silurian dolostone we see today is rich in dolomite (calcium carbonate) and may include indications of sea life from 416 million years past.

Soils may be classified in many ways, relating to their infiltration capacity, chemical composition, material and texture, etc. For example, soils are classified into several hydrologic groups (A, B, C and D) which describe general infiltration of the areas and water movement ability. All of these soil types may be found within the CalMan Lakes watershed. Hydrologic soil group A is made up of soils that have high infiltration rates when thoroughly wetted. They consist chiefly of deep, well- to excessively-drained sands and/or gravels. Hydrologic soil group B is characterized by soils with moderate infiltration when thoroughly wetted. These soils include those that are primarily moderately to very deep, moderately to well-drained and have moderately fine to moderately coarse textures. The soils in hydrologic group C have a slower rate of water infiltration when thoroughly wetted. This group includes soils with either a moderately impervious layer or soils with a moderately fine to fine texture. Lastly, hydrologic soil group D is characterized by soils with a very slow rate of water transmission and very slow infiltration rate when thoroughly wetted. This grouping includes clay soils with high swelling potential, soils with high permanent water table, soils with clay pan or clay layer at/near the surface, and shallow soils over nearly impervious materials. Generally speaking, hydrologic soil groups C and D are more likely to generate stream or overland flow, while groups A and B are more likely to have thorough infiltration.

Round Lake Watershed Soil Groups

The Round Lake watershed contains four soil types. The most common is the Kewaunee loam 6-12% slope (KnC2) at 45% of the watershed. The KnC2 soil type is characterized as being well-drained. It has a Hydrologic Soil Group category of C, which indicates the soil has a slow infiltration rate when thoroughly wet. This is due to the soil having a layer that impedes downward movement of water. The KnC2 grouping is susceptible to high levels of surface runoff and has a slope generally between 6-12%.

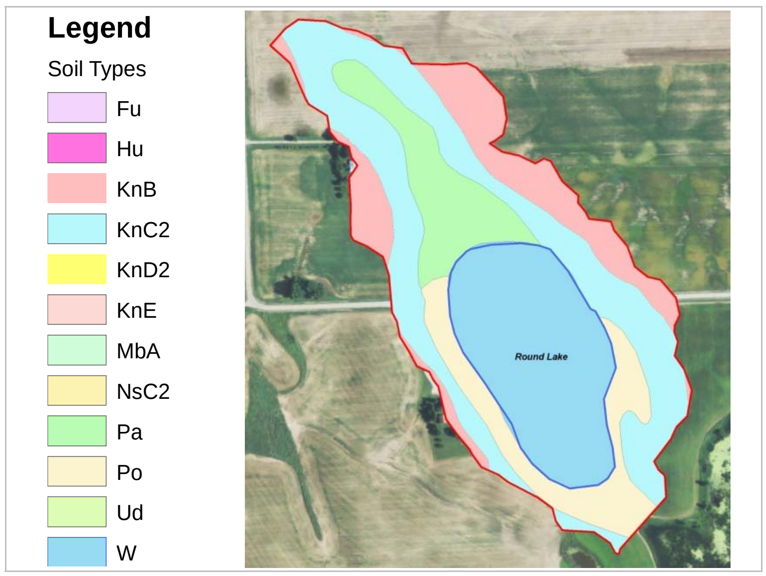

Figure 3.2-1. Round Lake watershed soil types. Data provided by Natural Resource Conservation Service Soil Survey.

The soils immediately north-northwest of Round Lake are classified as Palms Muck (Pa). At 16% of the watershed, this area holds a wetland complex that a good portion of the watershed drains to before entering Round Lake. Indeed, Palms muck is described as being subject to long and frequently ponding during the winter and spring and brief or long occasional ponding in late spring and fall. It is a soil that incorporates nearly 87% organic matter.

Boot Lake Watershed Soil Groups

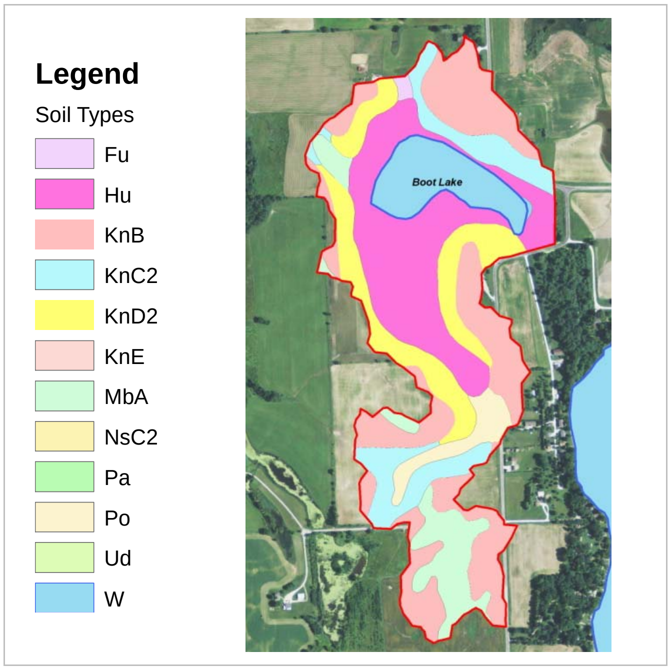

Figure 3.2-2. Boot Lake watershed soil types. Data provided by Natural Resource Conservation Service Soil Survey.

The Boot Lake watershed consists of seven soil types, of which the Kewaunee loam 2-6% slope (KnB) is the most common at 32% of the watershed. Similar to the Kewaunee loam (KnC2), it is a well drained soil that is classified as hydrologic soil grouping C, which indicates a slow infiltration rate. At 2-6% slope, the soil has a high surface runoff potential. The second most common soil in the watershed, which also surrounds the immediate area of Boot Lake, is the Houghton much (Hu) grouping. This is a poorly-drained soil (unless artificially drained) and has characteristics of slow infiltration rates and high runoff potential, as well as high organic matter percentage at nearly 85%. Because of slow infiltration rates, Palm mucks are known to pond frequent.

Long Lake Watershed Soil Groups

Similar to the Boot Lake watershed, the Long Lake watershed is dominated by Kewaunee loam 2-6% slope (KnB) at 29% of the watershed, and secondly by Houghton muck (Hu) at 22% of the watershed. Additional soil groups of interest in this watershed include Kewaunee loam 12-20% slope (KnD2) and Kewaunee loam 6-12% slope (KnC2). The KnD2 grouping consists of well-drained soils with a very high surface runoff rating due to their great slope. All of the Kewaunee loam units are characterized as having high sand (~44%) and silt (~40%) with a lesser amount of clay material (~16%), which contributes to this soil type's good draining capability.

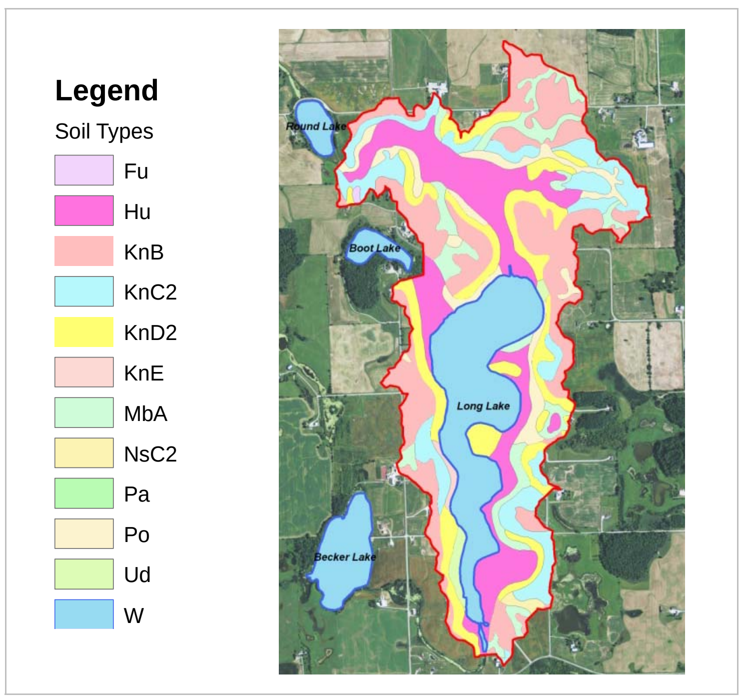

Figure 3.2-3. Long Lake watershed soil types. Data provided by Natural Resource Conservation Service Soil Survey.

Becker Lake Watershed Soil Groups

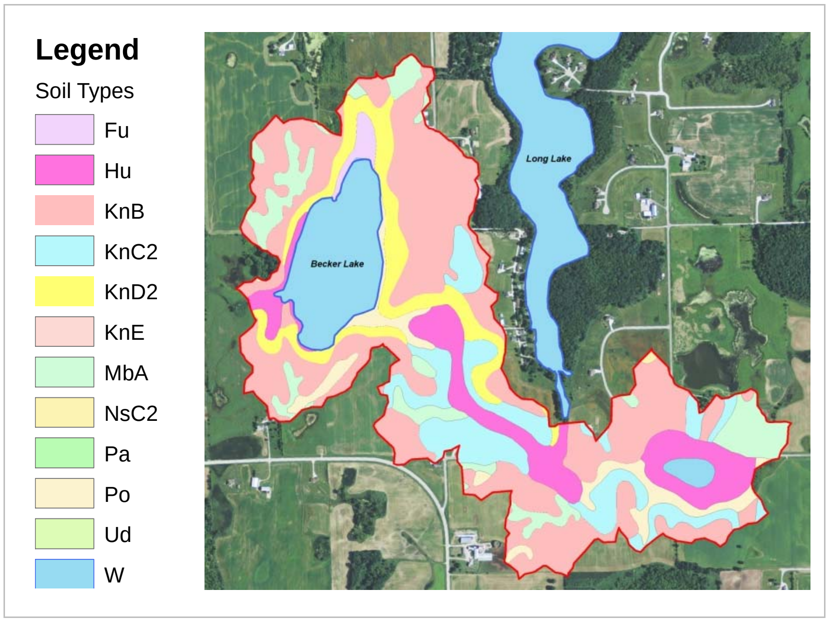

Figure 3.2-4. Becker Lake s watershed oil types. Data provided by Natural Resource Conservation Service Soil Survey.

The Becker Lake watershed, like the Boot and Long Lake watersheds, is dominated by the Kewaunee loam 2-6% slope (KnB) soil group at 46% of the total watershed. Kewaunee loam 6-12% (KnC2) and Houghton muck (Hu) make up smaller portions of the watershed as well at 14% and 13% respectively.

Land Slope and Nutrient Management

The slope of a land in a watershed determines its boundaries. Areas of high slope percentage generally have higher runoff rates and sediment yields. Additionally, these areas have higher susceptibility to further erosion, including gully formation. In small watersheds, overland flow is seen more so than channel flow, which occurs often in larger watersheds with a more complex and defined drainage network. In small watersheds, sheet and rill erosion is thus a primary concern. Sheet and rill erosion occur when water follows many paths over the land to reach a waterbody. In areas of higher slope, sheet and rill erosion are more prolific as the pull of gravity advances this form of water runoff. Thus, these areas are important to consider in watershed management planning as they often can be the location of high erosion.

Particularly in developed watersheds, slope can have a magnifying affect on sensitive areas. Wisconsin Nutrient Management Code 590 states that in high slope zones (greater than 12%), winter manure applications are prohibited. Winter manure applications are restricted within zones of greater than 9% slope – there may be an option for fields of up to 12% slope that exercise contoured or contour strip farming.

Within Figure 3.2-5, high slope zones are depicted in the CalMan Lakes watershed. Roughly 174 acres of land with 9-12% slope are located within the watershed, while 153 acres have greater than a 12% slope. Together, these areas make up 26% of the watershed. Figure 2.3-5 also displays Surface Water Quality Management Areas (SWQMAs). These include areas within 1,000 feet of lakes and ponds or within 300 feet of perennial rivers and streams. While there are four lakes within the CalMan Lakes watershed, the streams that connect them are considered intermittent.

Winter mechanical nutrient applications are prohibited in SWQMAs. Nutrient applications on unfrozen ground in SWQMA's are restricted and must be accompanied by at least one of the following four management actions:

1. Establish permanent vegetative buffers
2. Incorporate nutrient within three days
3. Maintain greater than 30% residue or vegetative cover
4. Establish cover crops after application

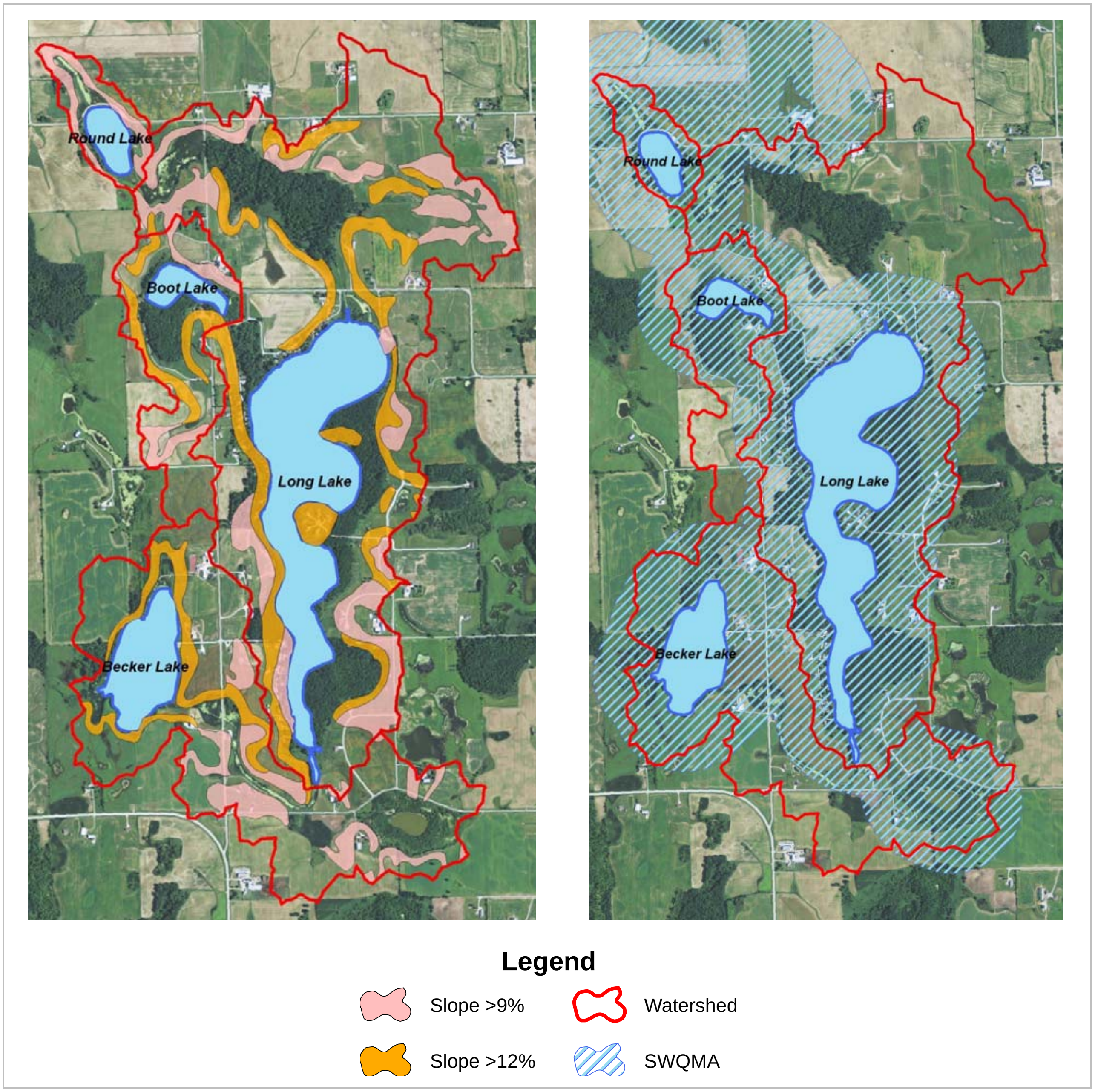

Figure 3.2-5. High slope zones and Surface Water Quality Management Areas. Data extracted from Wisconsin Manure Management Advisory System Interactive Map (http://www.manureadvisorysystem.wi.gov/).

Land Cover and Watershed Size

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, along with the factors discussed the previous section, 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, excessive 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. Additionally, there are a number of Best Management Practices (BMP's) that can be implemented on developed land to reduce the impact on water quality. These include nutrient management actions (alternative nutrient application, winter cover crops), vegetative buffer strips, manure containment systems, etc. In the end, if the phosphorus load is reduced greatly changes in lake water quality may be noticeable, (e.g. reduced algal abundance and better water clarity) and may even be enough to cause a shift in the lake's trophic state.

In systems with high WS:LA ratios, like those 10-15:1 or higher, the impact of land cover may be tempered by the amount of land draining to the lake. Situations actually occur where lakes with 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 enough to see a change in plant production. Both of these situations occur frequently in impoundments.

Regardless of the size of the watershed or the makeup of its land cover, it must be remembered that every lake is different and other factors, such as flushing rate, lake volume, sediment type, and many others, also influence how the lake will react to what is flowing into it. For instance, a deeper lake with a greater volume can dilute more phosphorus within its waters than a less voluminous lake and as a result, the production of a lake is kept low. However, in that same lake, because of its low flushing rate (high residence time, i.e., years), there may be a buildup of phosphorus in the sediments that may reach sufficient levels over time that internal nutrient loading may become a problem. On the contrary, a lake with a higher flushing rate (low residence time, i.e., days or weeks) may be more productive early on, but the constant flushing of its waters may prevent a buildup of phosphorus and internal nutrient loading may never reach significant levels.

The land use in the CalMan Lakes watershed is predominately agricultural-based. Approximately 38% (469 acres) of the land use in the entire watershed consisted of row crops in 2006, according to satellite imagery from that year. Pasture and grassland constitute the second most abundant land use, at 32% of the entire watershed (394 acres). The surface area of each of the four lakes makes up roughly 16% of the watershed, while wetlands (9%), rural residential land (3%) and forest (2%) round out the remaining land use in the watershed. Individually, each direct sub-watershed in the greater CalMan Lakes watershed holds high percentages of row crops (between 30% and 51%) as well as pasture/grass (between 19% and 51%). Figure 3.2-6 displays the individual sub-watershed characteristics for the CalMan Lakes, while land within the watershed is displayed in Map 2.

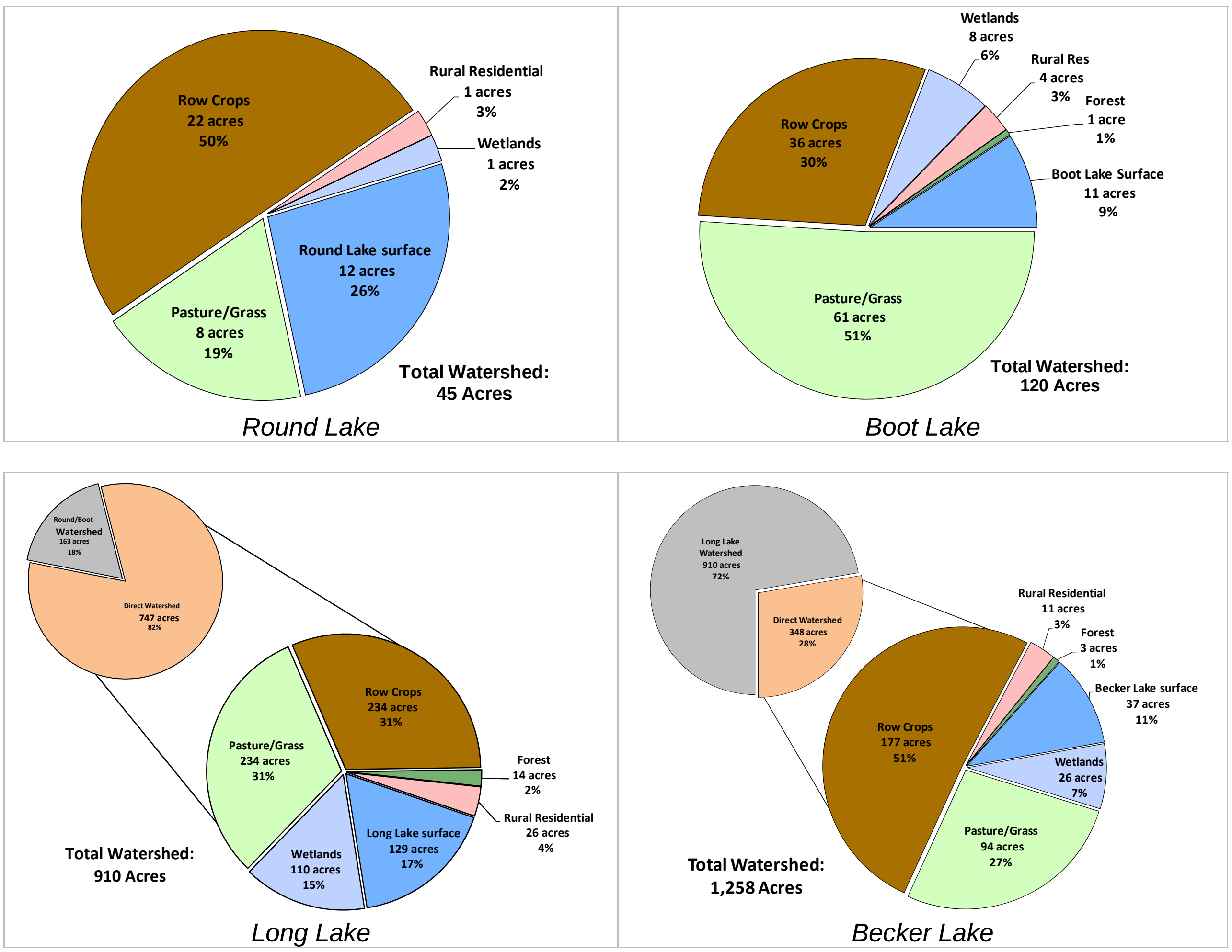

Figure 3.2-6. Land use within the CalMan Lakes sub-watersheds. Based upon National Land Cover Database (NLCD – Fry et. al 2011).

As mentioned above, the size of a watershed in relation to the lake to which it drains may have a profound impact on the lake's water quality and ecology. Round Lake, at the upper reaches of the CalMan Lakes watershed, has a watershed that is only three times larger than the size of the lake. Boot Lake, also at the upper reaches of the CalMan Lakes watershed, has roughly ten times the lake acreage draining to the lake. The larger Long Lake has a relatively small ratio, as its size encompasses a larger area in respect to its watershed. Finally, Becker Lake, at the bottom of the CalMan Lakes watershed, has a large watershed to lake area ratio which is the result of a large watershed and a moderately small lake. The watershed to lake area ratio impacts the quality and quantity of water a lake receives. Watershed to lake area ratios and lake flushing rate data area presented in Table 3.2-1. 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.

Table 3.2-1. CalMan Lakes watershed and hydrologic characteristics. Hydrology statistics computed through WiLMS (Panuska, 2003).

Lake Name	Direct Watershed to Lake Area Ratio	Lake Flushing Rate (1/yr)	Water Residence Time (years)
Round Lake	3:1	0.10	10.03
Boot Lake	10:1	0.53	1.90
Long Lake	6:1	0.37	2.70
Becker Lake	8:1	1.46	0.69

Watershed Modeling

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 – Panuska, 2003). 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. And, 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.

While WiLMS is a useful tool, like most models it has limitations and thus is considered a screening tool. In particular, WiLMS is useful in identifying if a watershed and lake ecosystem is functioning as expected. This is achieved through comparison of observed in-lake phosphorus concentrations to concentrations estimated through several predictive equations. A comparison of these two variables in a watershed model response summary will tell the user if the lake was modeled correctly, or if other factors are not being addressed in the model. These factors may include internal nutrient loading, misrepresentation in tributary nutrient loads, or complicated hydrologic patterns.

Using the land use data from Figure 3.2-6, WiLMS was used to model phosphorus inputs to each CalMan Lakes sub-watershed. These modeling are summarized in Figure 3.2-7. In general, the row crop land use was the primary contributor of phosphorus to the lakes, ranging from 42% of the annual phosphorus load in Becker Lake to 80% of the load in Round Lake. Pasture/grass land contributed significant portions of the phosphorus in some lakes, while the surface of each lake contributed to the overall load through atmospheric deposition. While Round and Boot Lakes were modeled as a single sub watershed each, modeling procedures for Long and Becker Lakes were a bit more complicated. Long Lake receives a portion of its phosphorus budget as input from Round and Boot Lakes, while Becker Lake receives input from Long Lake. While WiLMS estimates the amount of water and nutrients leaving each lake, the level of accuracy of this number is unknown because the streams between each of the CalMan Lakes are intermittent and "flashy". Unique characteristic of the watershed complicate this model, thus presenting uncertainty. As a result, modeled nutrient input data from upstream sources must be taken with caution. In Long Lake, it was estimated that contributions from Round and Boot Lake make up 17% of the phosphorus load, while the estimated 187 lbs of phosphorus flowing from Long Lake is estimated to comprise 49% of Becker Lake's phosphorus load (Figure 3.2-7 and Appendix C).

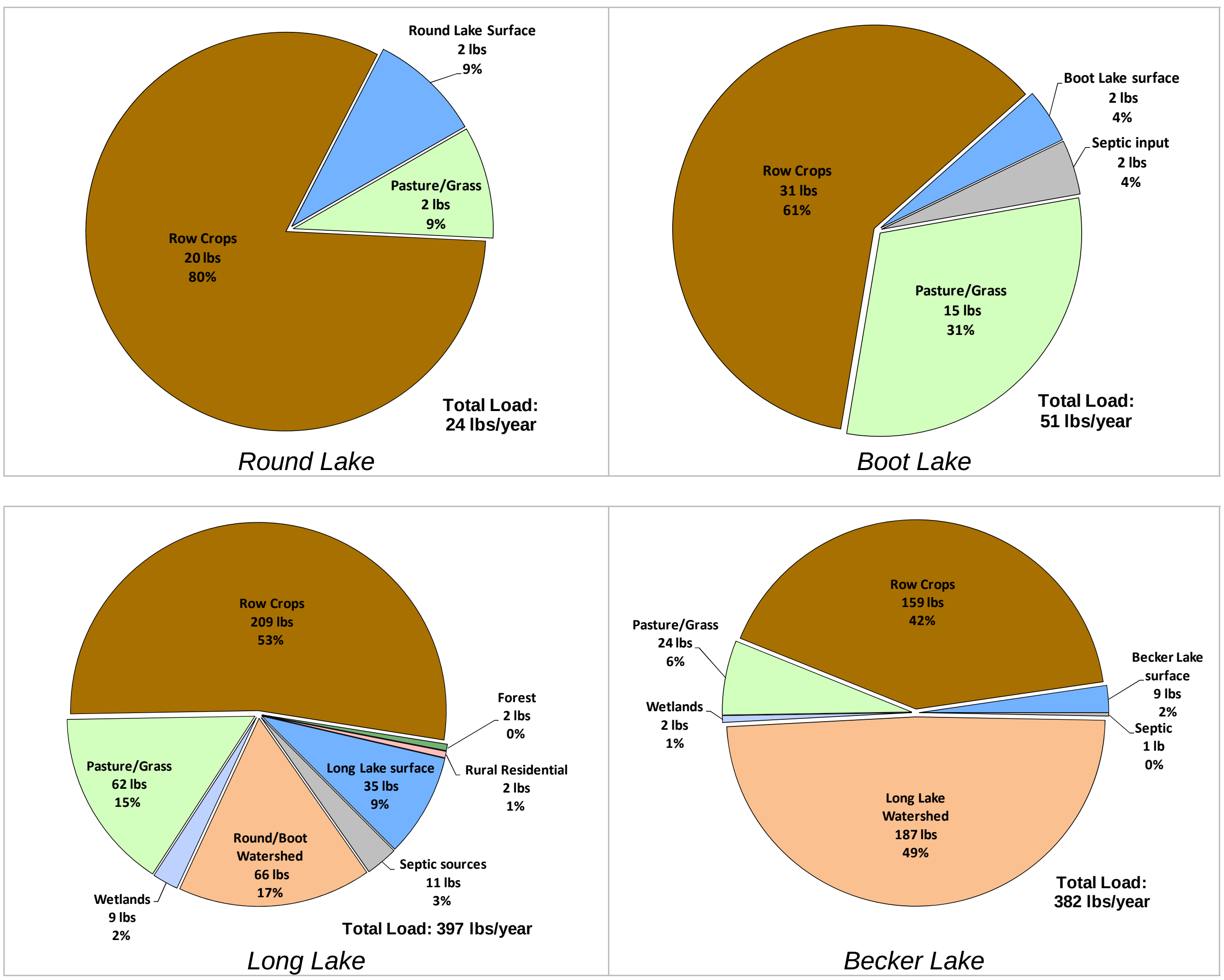

Figure 3.2-7. CalMan Lakes watershed phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

As part of WiLMS modeling procedures, estimated phosphorus values derived from predictive equations were compared to observed data collected from each of the CalMan Lakes. Two types of total phosphorus concentrations were examined: growing season mean (GSM) phosphorus and spring overturn (SPO) phosphorus. The GSM value indicates an average of all data collected during the open water growing season, which is early May through October. The dynamics of total phosphorus in a lake are much different during this time period versus the spring overturn (SPO) time period, which occurs shortly after ice leaves the lake and nutrients are relatively well distributed throughout the water column. WiLMS utilizes these data within several predictive equations to examine if the model is accurately portraying the in-field dynamics of the lake.

Table 3.2-2 displays the baseline modeling results as reported through WiLMS. In all circumstances, WiLMS predicted total phosphorus concentrations were much lower than observed via water quality sampling. The differences in these modeling exercises ranged from 33% to 74%, indicating that each model was unable to accurately assess the CalMan lake for which it was built. There are likely several reasons for this. First, WiLMS is best used for drainage systems; the intermittent status of the tributary streams connecting the CalMan Lakes adds a highly complicating factor to the model. Second, it is highly likely that internal nutrient loading is a significant source of phosphorus in each CalMan lake; however, its true magnitude has not been estimated; therefore, it has not been added to the WiLMS model. Third, land management practices, such as nutrient/manure application and crop rotation patterns are not accounted for within the model. Finally, the spatial location of land within the watershed is not fully realized within WiLMS, nor is the slope of the land; therefore, actual runoff likely differs in each watershed from the generalized coefficients that WiLMS utilizes. In the end, the predictive equations within WiLMS allow the user to not only determine inaccuracy of the model, but also make estimates as to how much phosphorus is unaccounted for within the model. Back-calculations of these equations produce an estimated amount of phosphorus that is likely entering the lake through one of the previously mentioned sources.

Table 3.2-2. WiLMS total phosphorus modeling results from the CalMan Lakes. GSM = growing season mean total phosphorus value, SPO = spring overturn total phosphorus value. Estimated unaccounted for phosphorus values determined through back-calculation of Canfield Bachman 1981 predictive equation in WiLMS.

Lake Name	Predicted GSM (ug/L)	Observed GSM (ug/L)	% Difference	Estimated lbsTP Unaccounted for
Round Lake	40	154	-74	110
Boot Lake	83	236	-65	111
Long Lake	58	86	-33	311
Becker Lake	75	176	-57	331

Lake Name	Predicted SPO (ug/L)	Observed SPO (ug/L)	% Difference
Round Lake	114	369	-69
Boot Lake	147	294	-50
Long Lake	120	189	-37
Becker Lake	110	328	-66

3.3 Shoreland Condition

Shoreland Condition Assessment and Coarse Woody Debris Assessment to be included here following Phase II studies.

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 the CalMan Lakes, 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 the CalMan Lakes 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 ≥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.

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

Bottom Screens

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

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

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

Water Level Drawdown

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

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

Advantages	Disadvantages
• Inexpensive if outlet structure exists. • May control populations of certain species, like Eurasian water-milfoil for a few years. • Allows some loose sediment to consolidate, increasing water depth. • May enhance growth of desirable emergent species. • Other work, like dock and pier repair may be completed more easily and at a lower cost while water levels are down.	• May be cost prohibitive if pumping is required to lower water levels. • Has the potential to upset the lake ecosystem and have significant 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 (*Phragmites australis*) and reed canary grass (*Phalaris arundinacea*). • Permitting process may require an environmental assessment that may take months to prepare. • Unselective.

Mechanical Harvesting

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

Costs

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

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

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	Nusiance natives species including duckweeds, trageted 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.

Advantages	*Disadvantages*
• Herbicides are easily applied in restricted areas, like around docks and boatlifts. • Herbicides can target large areas all at once. • If certain chemicals are applied at the correct dosages and at the right time of year, they can selectively control certain invasive species, such as Eurasian 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)	• 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.

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.

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

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

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

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

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

Analysis of 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 the CalMan Lakes; 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 the CalMan Lakes, 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 the CalMan Lakes. Comparisons will be displayed using boxplots that showing median values and upper/lower quartiles of lakes in the same ecoregion and in the state. Please note for this parameter, the Northern Lakes and Forests Ecoregion data includes both natural and flowage lakes.

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 the CalMan Lakes will be compared to lakes in the same ecoregion and in the state (Figure 3.4-1).

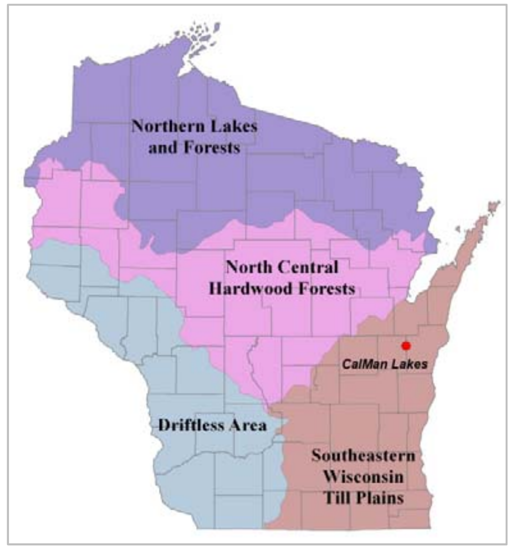

Figure 3.4-1. Location of the CalMan Lakes within the ecoregions of Wisconsin. After Nichols 1999.

The floristic quality of a lake is calculated using its species richness and average species conservatism. As mentioned above, species richness is simply the number of species that occur in the lake, for this analysis, only native species are utilized. Average species conservatism utilizes the coefficient of conservatism values for each of those species in its calculation. A species coefficient of conservatism value indicates that species likelihood of being found in an undisturbed (pristine) system. The values range from one to ten. Species that are normally found in disturbed systems have lower coefficients, while species frequently found in pristine systems have higher values. For example, cattail, an invasive native species, has a value of 1, while common hard and softstem bulrush have values of 5, and Oakes pondweed, a sensitive and rare species, has a value of 10. On their own, the species richness and average conservatism values for a lake are useful in assessing a lake's plant community; however, the best assessment of the lake's plant community health is determined when the two values are used to calculate the lake's floristic quality. The floristic quality is calculated using the species richness and average conservatism value of the aquatic plant species that were solely encountered on the rake during the point-intercept survey and does not include incidental species or those encountered during other aquatic plan 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 3.4-2). Eurasian water-milfoil is unique in that its primary mode of propagation is not by seed. It actually spreads by shoot fragmentation, which has supported its transport between lakes via boats and other equipment. In addition to its propagation method, Eurasian water-milfoil has two other competitive advantages over native aquatic plants, 1) it starts growing very early in the spring when water temperatures are too cold for most native plants to grow, and 2) once its stems reach the water surface, it does not stop growing like most native plants, instead it continues to grow along the surface creating a canopy that blocks light from reaching native plants. Eurasian water-milfoil can create dense stands and dominate submergent communities, reducing important natural habitat for fish and other wildlife, and impeding recreational activities such as swimming, fishing, and boating.

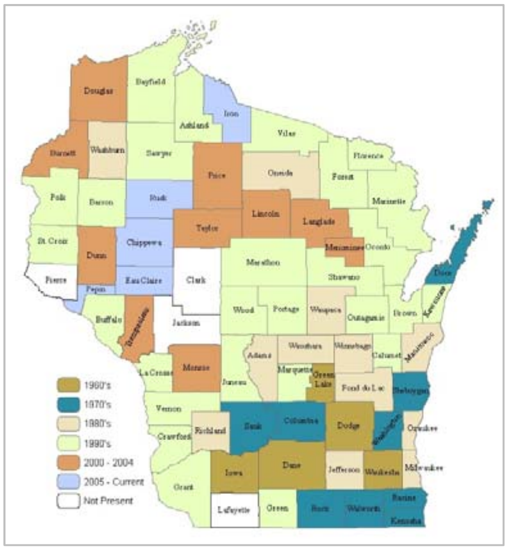

Figure 3.4-2. Spread of Eurasian water milfoil within WI counties. WDNR Data 2011 mapped by Onterra.

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

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

CalMan Lakes Aquatic Plant Surveys

Numerous plant surveys were completed as a part of this project. Because of the collaborative nature of this project, surveys were conducted a different times and also by different agencies. A description of each survey type is presented below.

Early Season Aquatic Invasive Species Survey

An Early Season Aquatic Invasive Species (ESAIS) survey was conducted in June of 2013 on each of the four CalMan Lakes by Onterra staff. During this meander based survey, aquatic invasive species are mapped using point-based or polygon-based methodologies, with notes taken on the density, depth and extent of each location that is mapped. There are several benefits of mapping species at this time of year. First, curly-leaf pondweed is at its peak growth so its full community may be realized. Also, Eurasian water milfoil is actively growing and is visible above other native plants in the water column. If Eurasian water milfoil was mapped during this survey, these sites were reassessed and the plants remapped later in the summer when Eurasian water milfoil was at its peak biomass. On some project lakes, an emergent invasive plant – pale yellow iris (*Iris pseudocorus*) was spotted and its geospatial locations marked.

Point-Intercept Survey

The point-intercept survey is a grid based survey methodology created by WDNR research scientists (Hauxwell, 2010). The point intercept survey is used to sampling the submergent (under water) aquatic plant community. During this survey, a boat is navigated to each sampling point on the lake and a rake is thrown over the side to sample the aquatic vegetation. The vegetation is identified and an estimate of abundance is made. Additional variables such as depth and substrate type are noted.

WDNR staff have completed a point-intercept survey on Long Lake each year from 2008-2012 as part of a long-term monitoring project. WDNR staff and Calumet County staff visited Becker and Round Lakes in 2013, while Boot Lake will be visited in 2014. Aquatic plant point-intercept survey data may be viewed in Appendix D.

Community Mapping Survey

While the point-intercept survey is an excellent tool to characterize the submergent aquatic plant community, sometimes emergent and floating-leaf plants may be under represented. This can occur when shallow depths or dense plant growth prevents navigation into areas of the lake. To further understand these plant communities, Onterra staff completed a community mapping survey in August 2013 on all four CalMan Lakes. The methodology for this survey was similar to that of the aquatic invasive species mapping surveys; data was collected on emergent and/or floating-leaf plant communities in a point-based or polygon-based manner.

Eurasian Water Milfoil Peak Biomass Survey

Eurasian water milfoil was known to exist in Long Lake, and hybrid water milfoil (Eurasian water milfoil x northern water milfoil) was known to exist in Becker Lake. These locations were first mapped during the ESAIS survey. In August, when Eurasian water milfoil and hybrid water milfoil reaches its peak growth (biomass), the mapping efforts of that June were reassessed to update colony size and extents.

Aquatic Plant Survey Results

A total of 17 different native plant species were identified from the CalMan Lakes, while six additional non-native plant species were found (Table 3.4-1). Please note that at the time of this writing one remaining survey – the Boot Lake point-intercept survey – has yet to be conducted. This survey is scheduled for summer 2014. Purple loosestrife was identified on all four of the CalMan Lakes. Four species, cattail sp., coontail and spatterdock, were identified within three of the four lakes. Thirteen species were found within only one of the four lakes. This is a testament to the individuality of the lakes; even though they are in close proximity to each other and at high water times even flow into one another, there are substantial differences in substrate, water quality and morphology that can result in different aquatic plant communities. This relationship will be examined further throughout this section.

Table 3.4-1. Aquatic plant species located in the CalMan Lakes. Species identified during 2012, 2013 and 2014 WDNR/Calumet County point-intercept surveys and Onterra 2013 community mapping surveys. Note that a point-intercept survey will be completed on Boot Lake in 2014, with results included in the next draft of this report.

Life Form	Scientific Name	Common Name	C-value	Round Lake	Boot Lake	Long Lake	Becker Lake
Emergent	*Acorus calamus*	Sweetflag	7	I			
	Decodon verticillatus	Water-willow	7			I	
	Eleocharis sp.	Spikerush sp.	N/A		I		
	Iris pseudacorus	Pale yellow iris	Exotic			I	
	Iris versicolor	Northern blue flag	5	I		I	
	Lythrum salicaria	Purple loosestrife	Exotic	I	I	I	I
	Phragmites australis	Giant reed	Exotic				I
	Sagittaria latifolia	Common arrowhead	3	I	I		
	Typha sp.	Cattail sp.	1		I	I	I
Submergent	*Ceratophyllum demersum*	Coontail	3	X		X	X
	Chara spp.	Muskgrasses	7			X	
	Elodea canadensis	Common waterweed	3	X			
	Elodea nuttalii	Slender waterweed	7	X			
	M. sibiricum x M. spicatum	Hybrid water milfoil	Exotic				X
	Myriophyllum spicatum	Eurasian water milfoil	Exotic			X	
	Potamogeton crispus	Curly-leaf pondweed	Exotic	X		I	X
	Potamogeton zosteriformis	Flat-stem pondweed	6				X
	Stuckenia pectinata	Sago pondweed	3	X		X	
FF	*Spirodela polyrhiza*	Greater duckweed	5	X			
FL	*Nuphar variegata*	Spatterdock	6	X		X	I
	Nymphaea odorata	White water lily	6			X	X
	Polygonum amphibium	Water smartweed	5				I
FL/E	*Sparganium eurycarpum*	Common bur-reed	5				I

FF = Free-floating; FL = Floating-leaf; FL/E = Floating-leaf/Emergent
X = Located on rake during point-intercept survey; I = Incidental species

In the CalMan Lakes, the number of species observed per lake was notably low in 2012, 2013 and 2014 surveys. Figure 3.4-3 displays the number of plants found within the point-intercept survey, as well as the additional species found incidentally. The total number of species is a combination of these two, however in comparing to ecoregion and state medians and computing conservatism values (see discussion below) only the plants located during the point-intercept survey are considered. All CalMan Lakes held much fewer species that the median species richness for lakes in the NCSE ecoregion and at the state-wide level. Plant growth may be limited in these lakes due to its exceptionally discolored water and mucky substrate, which limits the depth and available littoral habitat for some plant species.

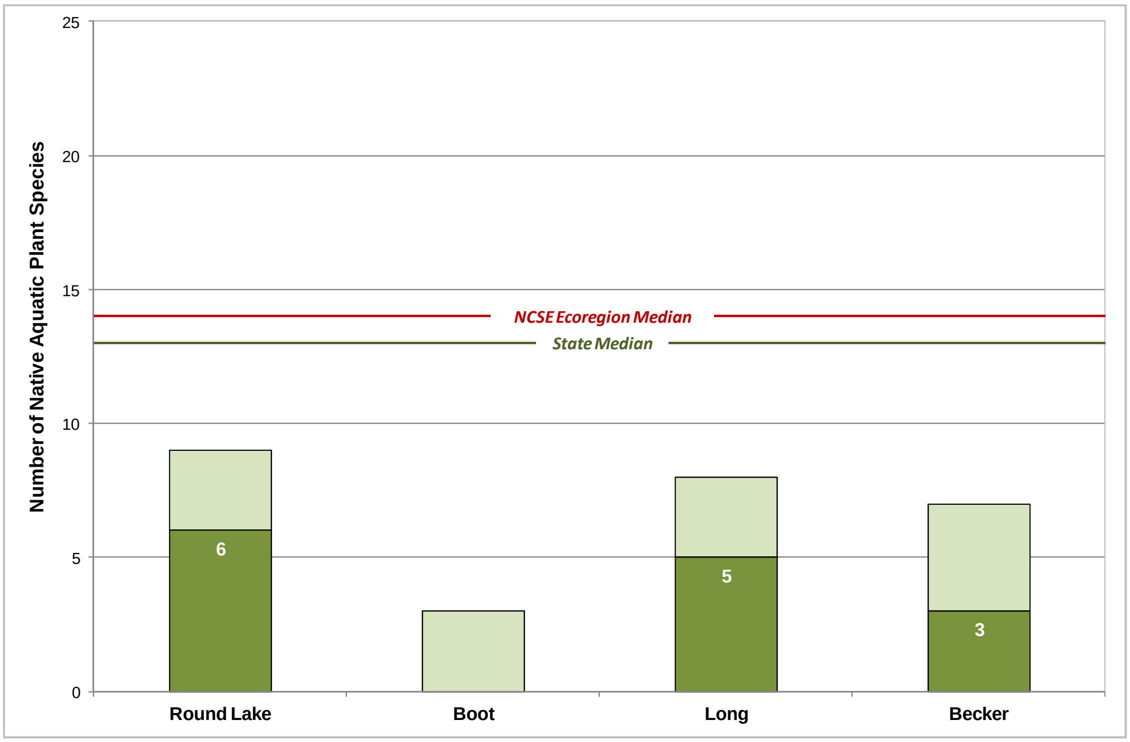

Figure 3.4-3 CalMan Lakes native species richness. Created using data from summer point-intercept and community mapping surveys. Chart includes species sampled directly during the point-intercept study (dark green) and species found incidentally (light green). Note that NCSE is the North Central and Southeastern Till Plains ecoregion after Nichols (1999).

In addition to determining the species composition of a lake, the point-intercept survey is able to produce data that tells managers the distribution and frequency of occurrence of species in the lake. 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). This distribution can be observed in Figure 3.4-4. The pie graphs depicted tell managers if one or two species are much more abundant than the other species, or if all species are well-distributed throughout the lake system. In Long Lake, Eurasian water milfoil accounts for a large portion of the aquatic plant community, while in Round Lake the species that are present in relatively well distributed fashion.

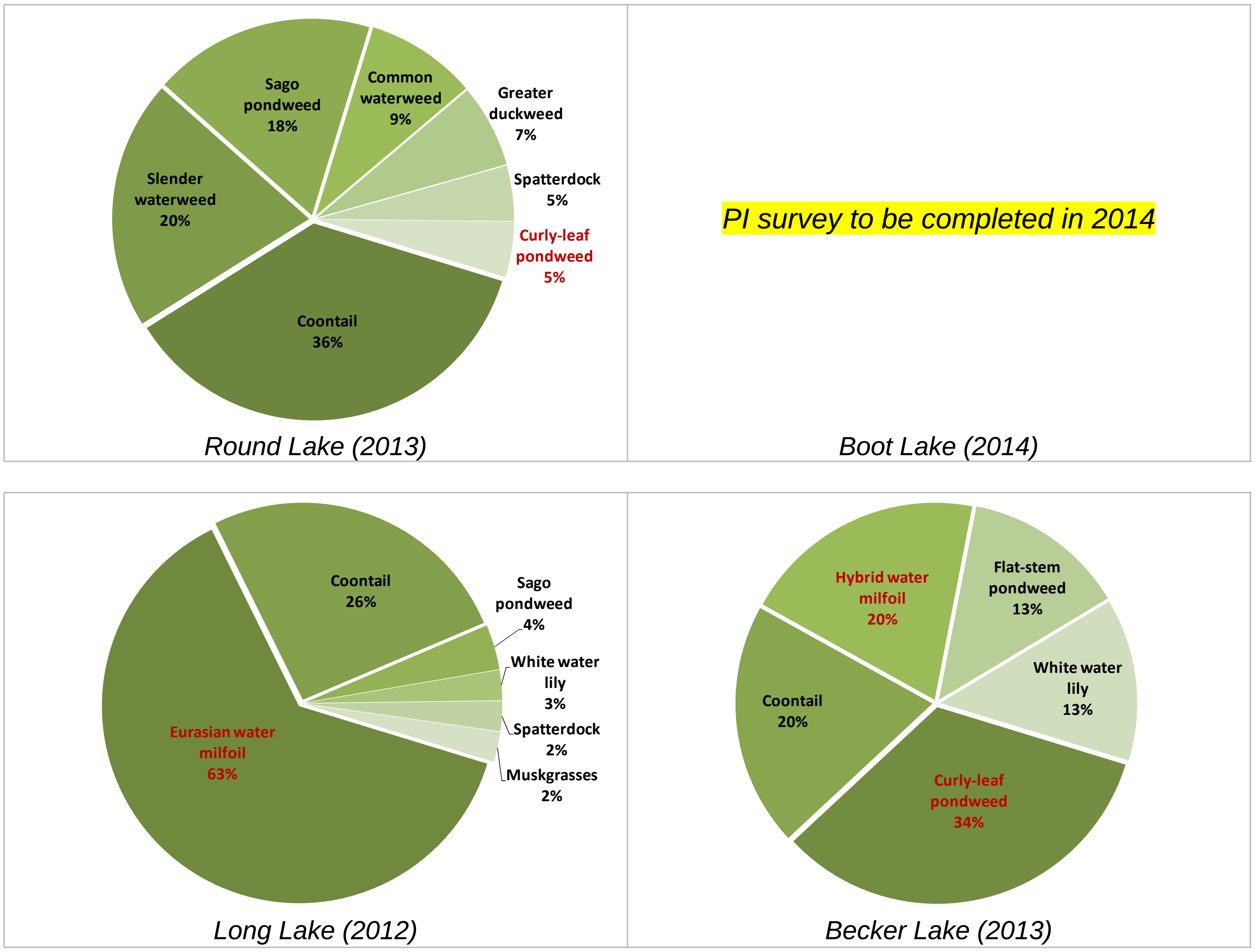

Figure 3.4-4 CalMan Lakes aquatic plant relative frequency of occurrence. Created using data from WDNR and Calumet County summer point-intercept surveys.

As discussed earlier, how evenly the species are distributed throughout the system and species richness together influence species diversity. In other words, a lake with many species is not necessarily diverse, and a lake with few species is not necessarily lacking diversity. Simpson's diversity index (1-D) is used to make this distinction.

Species diversity ranged from 0.53 to 0.78 in the CalMan Lakes (Figure 3.4-5). Long Lake, with its dominant Eurasian water milfoil population, has a relatively low diversity value due to the distribution of plants. Round Lake, as discussed above, has more species and these species are distributed in a moderate manner. This results in the highest Simpson's Diversity score for the CalMan Lakes, at 0.78.
While a method of characterizing diversity values as "Fair" or "Poor", etc. does not exist, lakes within the same ecoregion may be compared to provide an idea of how the CalMan Lakes scores rank. Using data obtained from WDNR Science Services, median values and upper/lower quartiles were calculated for 68 lakes within the Southeastern Wisconsin Till Plain ecoregion (Figure 3.4-6). All of the CalMan Lakes hold diversity that is below the NCSE ecoregion median.

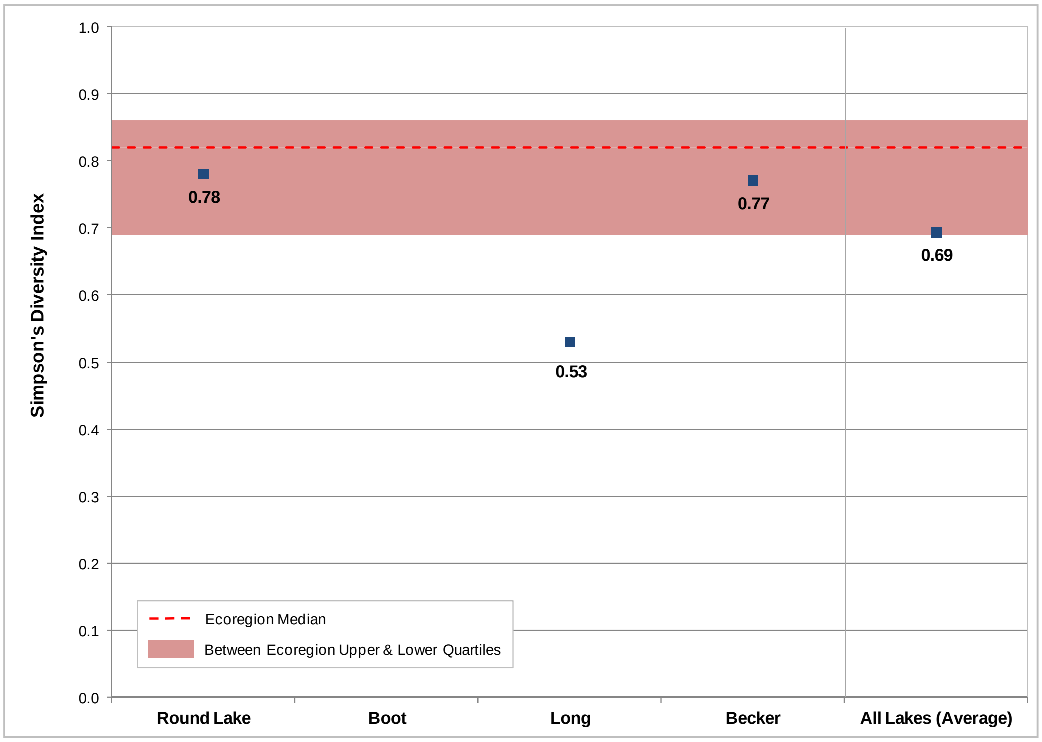

Figure 3.4-5 CalMan Lakes species diversity index. Created using data from summer point-intercept surveys. Ecoregion data provided by WDNR Science Services. Note that Boot Lake's point-intercept survey is scheduled for summer 2014.

The quality of a lakes aquatic plant species can be indicated by the conservatism value of the species. Data collected from the aquatic plant surveys indicate that the conservatism values of the CalMan Lakes plant communities are lower than both the ecoregion and state values (Figure 3.4-6). This means the majority of the project lakes have plant communities that are more indicative of disturbed conditions than those found in the state and the ecoregion. It also suggests the lakes play host to disturbance-tolerant plant species only (e.g., coontail, non-native species) and fewer or no sensitive species.

By combining the species richness and average conservatism values for each project lake, the Floristic Quality Index (FQI) value is obtained (equation shown below) (Figure 3.4-7). All of the project lakes fall well below the state and ecoregion median FQI value. Again, this illustrates that the CalMan Lakes have low quality plant communities.

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

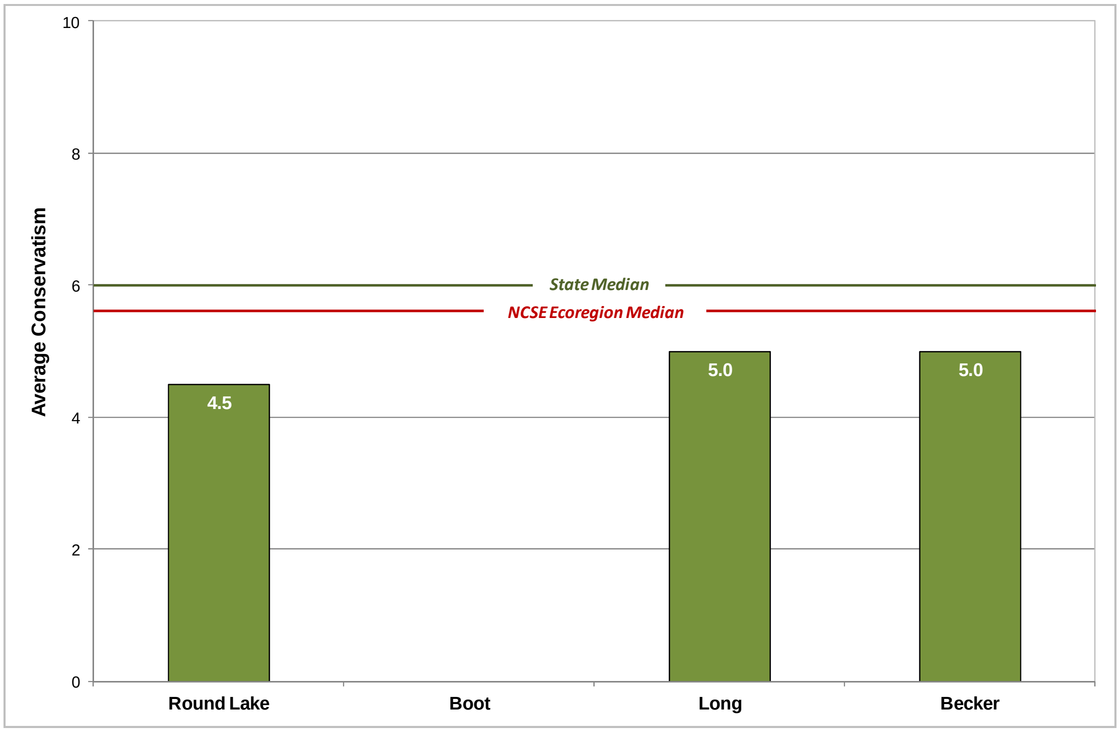

Figure 3.4-6 CalMan Lakes average native species' coefficients of conservatism. Created using data from summer point-intercept surveys.

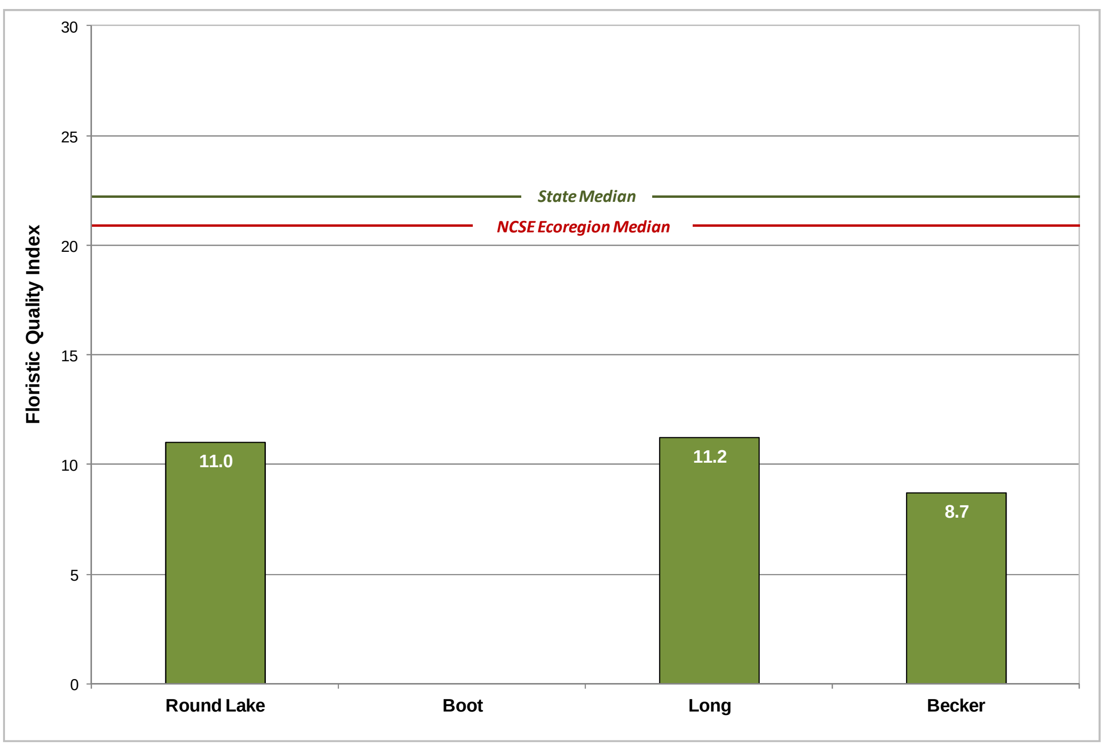

Figure 3.4-7. CalMan Lakes Floristic Quality Assessment. Created using data from summer point-intercept surveys.

Amongst other benefits, a healthy aquatic plant community in a lake provides habitat value for a variety of wildlife. Areas of emergent and floating-leaf plant communities provide valuable fish and wildlife habitat important to the ecosystem both inside and outside of the lake. These areas are utilized by adult fish for spawning, by juvenile fish as a nursery, and by forage fish for protection from predators. Wading birds can be found in these areas hunting fish and insects, and escaping dangerous predators. Finally, these communities protect shorelines from eroding, as they temper the energy on the waves approaching the shoreline from the interior of the lake.

The Calman Lakes contain minimal areas of these plant communities when compared to the total acreage of the lake (Maps 3, 4, 5 and 6). Figure 3.4-8 displays the percent of lake acreage occupied by either emergent, floating-leaf, or a combined emergent and floating-leaf plant communities. The presence of these communities are dependent upon several factors, including water depth and substrate type. Water clarity and general quality plays a role as well. Often, when disturbance of a waterbody occurs, the emergent and floating-leaf communities are impacted in terms of either the species that are present or their areal extents. Radomski and Goeman (2001) found a 66% reduction in vegetation coverage on developed shorelines when compared to undeveloped shorelines in Minnesota Lakes.

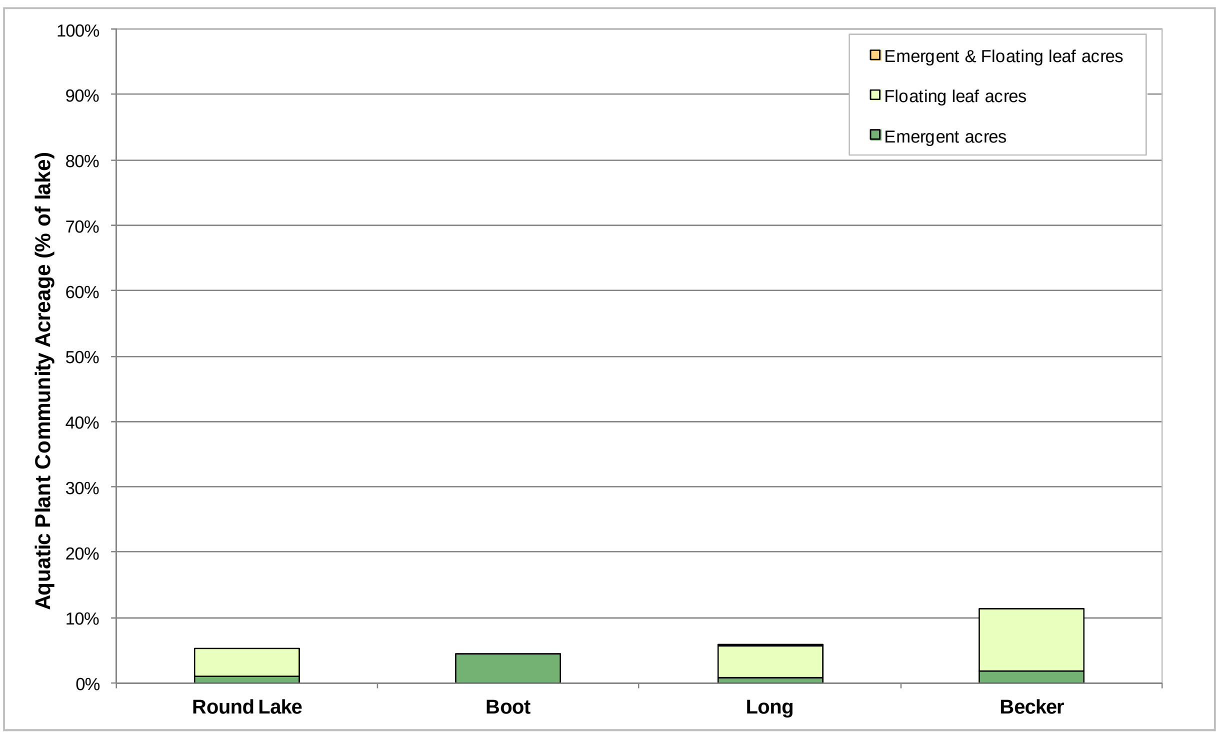

Figure 3.4-8. CalMan Lakes emergent and floating-leaf aquatic plant communities. Created using data from summer community mapping surveys.

Lakes that have varying substrate types generally support a higher number of plant species because the different habitat types that are available. Like terrestrial plants, different aquatic plant species are adapted to grow in certain substrate types; some species are only found growing in mucky substrates, others only in sandy areas, and some can be found growing in either. As discussed in the primer section, sediment data were collected at each sampling location within the littoral zone during the point-intercept survey. These data are displayed in Figure 3.4-9 for each lake.

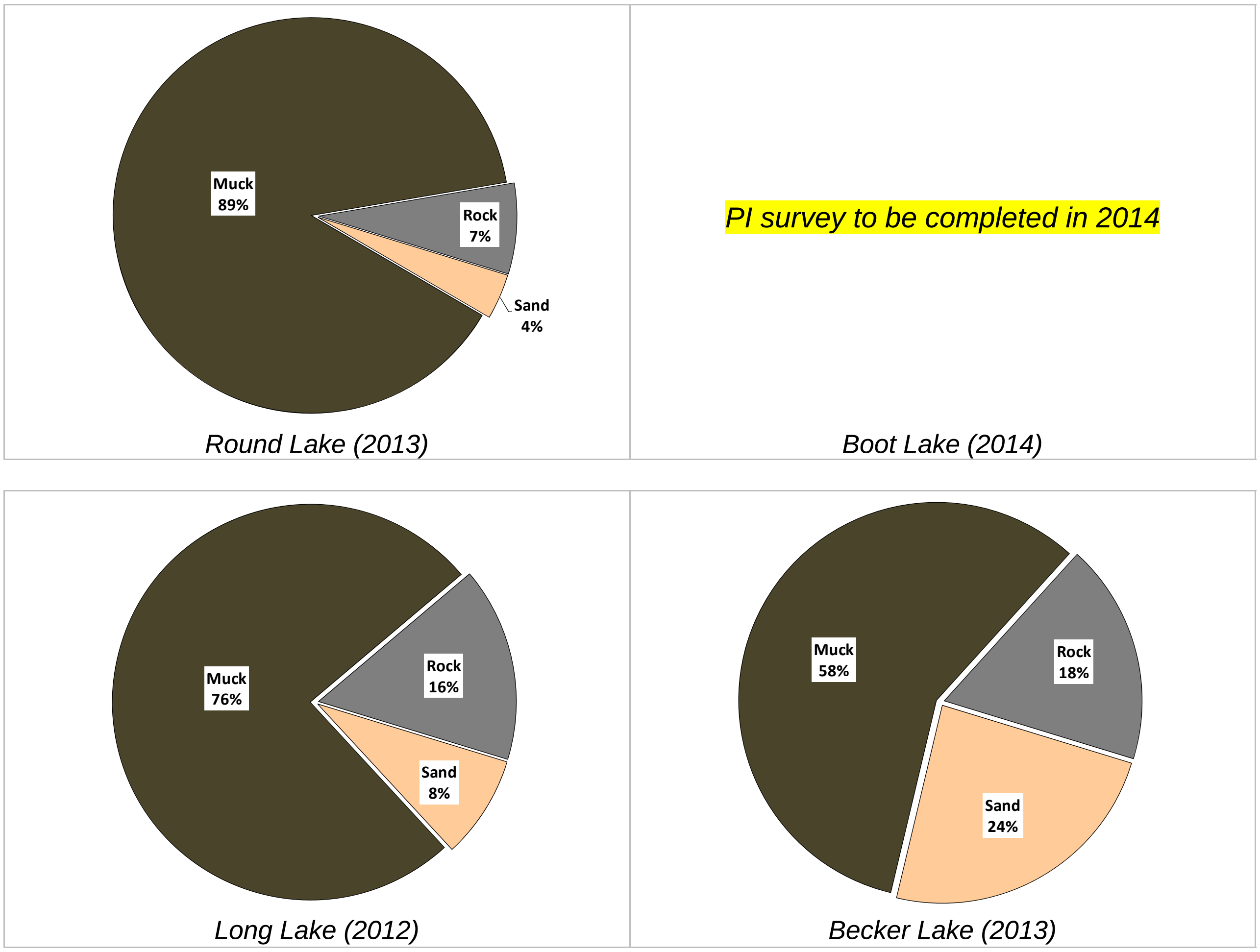

Figure 3.4-9 CalMan Lakes littoral substrate types. Created using data from WDNR and Calumet County summer point-intercept surveys.

Long Lake Aquatic Plant Community Trends

Long Lake has been included within the WDNR's long term lakes monitoring, which means that point-intercept studies have been conducted on the lake several times in recent years. This gives an indication of changes that may be occurring in the lake's aquatic plant community. WDNR staff conducted point-intercept surveys on the lake in 2008, 2010, 2011 and 2012.

During this time, the aquatic plant species experienced some fluctuations in their abundance. The frequency of species within the littoral zone (littoral frequency of occurrence) is displayed within Figure 3.4-10. Some annual variation was noted within the dataset, particularly with species such as Eurasian water milfoil, coontail, white water lily, sago pondweed and leafy pondweed. Eurasian water milfoil, coontail and sago pondweed exhibited statistically significant changes from 2008 to 2012. It should be noted that although curly-leaf pondweed is displayed on the graph, the point-intercept survey is typically conducted during late summer when this plant has lost much (possibly all) of its biomass. Therefore, conclusions should not be derived from this chart for this species.

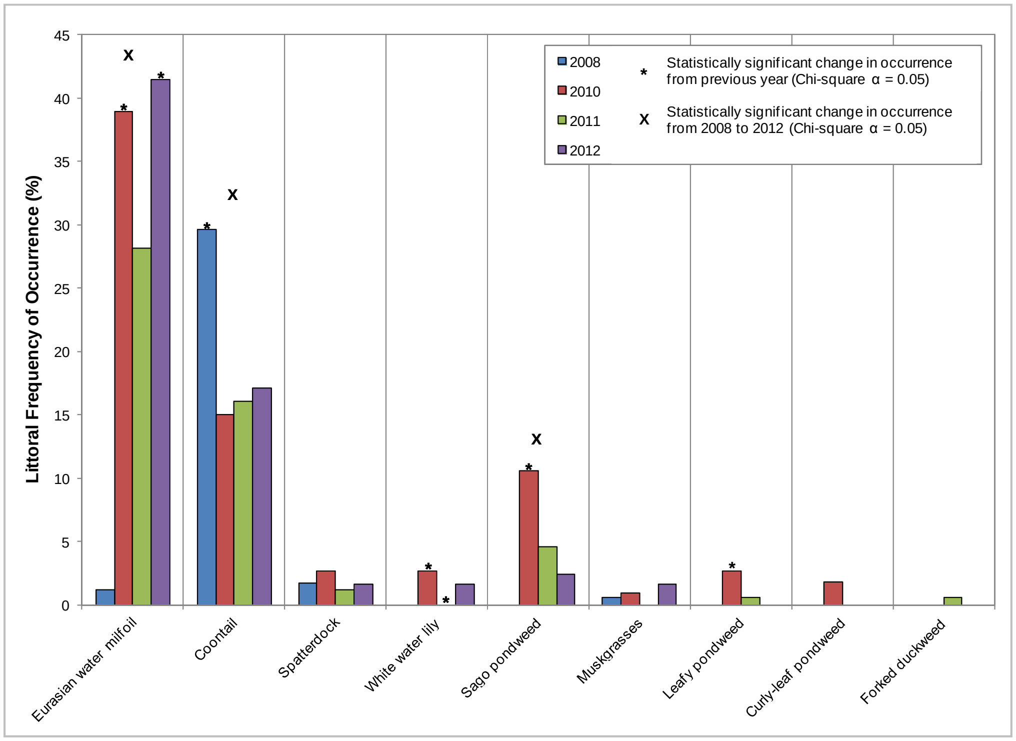

Figure 3.4-10. Long Lake aquatic plant frequency of occurrence analysis, 2008 and 2010-2012. Created from WDNR point-intercept data using Chi-square goodness of fit test (α=0.05)

Aquatic plant communities are dynamic, and the abundance of certain species from year to year can fluctuate depending on climatic conditions, herbivory, competition, water quality and disease among other factors. It is not known which factor(s) caused the detected changes in occurrence of plant species in Long Lake between 2008 and 2012. It is known however that fluctuations in occurrence of certain species over time are to be expected. However, if large reductions in occurrence or a complete loss of a species were observed, it may indicate an environmental disturbance such as pollution or displacement from invasive species.

Non-Native Aquatic Plant Species

As with most Wisconsin lakes, there is great concern with the CalMan Lakes stakeholders over the threat of aquatic invasive species. Calumet County staff, Long Lake Advancement Association and the Brillion Conservation Club have put forth much effort in educating area stakeholders and CalMan Lakes visitors about the threat that invasive species pose. Table 1.0-1 presents the known aquatic invasive species found in the CalMan Lakes.

Table 3.4-2. Aquatic Invasive Species located in the CalMan Lakes. Information obtained from a WDNR internet database (http://dnr.wi.gov/lakes/invasives/BySpecies.aspx).

Lake	AIS and Year Confirmed
Round Lake	Curly-leaf pondweed (2014) Purple loosestrife
Boot Lake	Purple loosestrife
Long Lake	Curly-leaf pondweed (1988) Eurasian water milfoil (2003) Pale yellow iris Purple loosestrife
Becker Lake	Curly-leaf pondweed (1993) Eurasian water milfoil (2009) Hybrid Eurasian/Northern water milfoil (2012) Purple loosestrife Phragmites

Eurasian water milfoil and Hybrid water milfoil

The beginning of this section discusses the spread of Eurasian water milfoil throughout Wisconsin and its ill effects on aquatic ecosystems and recreational opportunity. It is now known that a hybrid species between Eurasian water milfoil and the native northern water milfoil (hybrid water milfoil) exists in Wisconsin and elsewhere. In many cases, this species was originally determined to be Eurasian water milfoil, as morphological traits are very similar between this invasive plant and what is now known to be its hybrid relative. Often genetic testing is required to determine with certainty if a hybrid milfoil is present.

Control of Eurasian water milfoil is often attempted through herbicide applications, typically with the chemical 2,4-D. Though conditions to reach success (plant mortality) can be difficult to achieve, chemical applications to control Eurasian water milfoil have been documented to be successful, albeit often with regrowth of the targeted species after a period of time (years). In recent years, there had been anecdotal and scientific reports by lake managers indicating that herbicide applications failed to control hybrid water milfoil colonies where conditions should have produced control. It is now believed that hybrid water milfoil not only grows faster than Eurasian water milfoil, but also displays less sensitivity to herbicide (2,4-D) applications (LaRue et. al. 2013).

Of the CalMan Lakes, Long Lake is known to hold Eurasian water milfoil while Becker Lake is believed to hold Eurasian water milfoil as well as hybrid water milfoil. During 2013, a sample of Long Lake milfoil was confirmed to be pure strain Eurasian water milfoil through genetics. Genetic analysis was conducted upon a Becker Lake milfoil sample in July of 2012 to confirm the presence of hybrid water milfoil.

Long Lake was surveyed first during the 2013 ESAIS survey and later in August to map Eurasian water milfoil at its peak growth. Eurasian water milfoil was found to occur through much of the littoral zone in substantial density (Map 7). In all, nearly 20 acres of Eurasian water milfoil was mapped throughout the lake. During this same time, hybrid water milfoil was mapped on Becker Lake. Hybrid water milfoil was found in the littoral zone in several areas of the lake, with highly dense colonies being found in the along the northern and southern as well as southeast and southwest shorelines (Map 8). In all, roughly 2.5 acres were delineated within the lake.

Curly-leaf pondweed

Curly-leaf pondweed was mapped during the 2013 ESAIS survey on Becker, Round and Long Lakes. The curly-leaf pondweed on Round Lake covered the vast majority of the littoral zone in varying densities; in all, about 3.6 acres of colonized curly-leaf pondweed were observed (Map 9). Only two occurrences of curly-leaf pondweed were documented in Long Lake in June 2013. Data from a previous aquatic invasive species survey (in which the same methodology was used) indicated that in 2009 curly-leaf pondweed plants could be found around much of the lake's littoral zone (Maps 10). The reason for this apparent decline is unknown, but perhaps may be related to competition with Eurasian water milfoil or changes in environmental conditions. Becker Lake held densely matted curly-leaf pondweed in June 2013, occurring intermingled with Eurasian water milfoil (Map 11).

Purple Loosestrife, Giant Reed and Pale Yellow Iris

These three non-native species are emergent, wetland species that may be found along the shorelines of Wisconsin's lakes. Purple loosestrife (*Lythrum salicaria*) is a perennial herbaceous plant native to Europe and was likely brought over to North America as a garden ornamental. This plant escaped from its garden landscape into wetland environments where it is able to out-compete our native plants for space and resources. First detected in Wisconsin in the 1930's, it has now spread to 70 of the state's 72 counties. Purple loosestrife largely spreads by seed, but also can vegetatively spread from root or stem fragments. Populations of purple loosestrife were observed along much of the Boot Lake shoreline (Map 4), within several colonies on Long Lake's northern shoreline (Map 5) and to a minimal extent along Becker and Round Lakes (Maps 3 and 6).

There are a number of effective control strategies for combating this aggressive plant, including herbicide application, biological control by native beetles, and manual hand removal. At this time, hand removal by volunteers is likely the best option as it would decrease costs significantly. Additional purple loosestrife monitoring would be required to ensure the eradication of the plant from the shorelines and wetland areas around the CalMan Lakes.

Giant reed (*Phragmites australis*) is a tall, perennial grass that was introduced to the United States from Europe. While a native strain of this species exists in Wisconsin, it is believed that the plants located on Becker Lake are of the non-native, invasive strain. Giant reed forms towering, dense colonies that overtake native vegetation and replace it with a monoculture that provides inadequate sources of food and habitat for wildlife. Giant reed was found growing in a single location on Becker Lake's shoreline in 2013 (Map 6). Because this species has the capacity to displace the valuable wetland plants along the exposed shorelines of the lake and elsewhere, it is recommended that these plants be removed by cutting and bagging the seed heads and applying herbicide to the cut ends. This management strategy is most effective when completed in late summer or early fall when the plant is actively storing sugars and carbohydrates in its root system in preparation for over-wintering. The giant reed infestation is in its very early stages, and eradication is likely a realistic outcome if control actions are taken quickly.

Pale yellow iris (*Iris pseudacorus*) is a large, showy iris with bright yellow flowers. Native to Europe and Asia, this species was sold commercially in the United States for ornamental use and has since escaped into Wisconsin's wetland areas forming large monotypic colonies and displacing valuable native wetland species. Pale yellow iris was observed growing on the shoreline of Long Lake in several locations (Maps 5). At this time, the only means of controlling pale-yellow iris populations is continual hand removal and monitoring.

3.5 Fisheries Data Integration

Fisheries data will be researched and included through Phase II of this project (2014-2015)

4.0 SUMMARY AND CONCLUSIONS

Phase I

The design of the first phase of this project was intended to fulfill several objectives:

1. Systematically document the conditions of Round, Boot, Long and Becker Lakes based upon numerous ecological components
2. Develop a baseline understanding of potential sources and causes of impairment
3. Engage resource managers and lake stakeholders in planning process
4. Utilize ecological and sociological data in preparing for advanced studies of the lakes' watersheds in future phases

The Phase I studies of the CalMan Lakes Watershed Management Planning Project have led to a good understanding of the baseline ecological conditions and impairments that exist in the four lakes. As outlined in the Water Quality Section, all four lakes suffer from poor water quality conditions including excess nutrient content, algal blooms, low water clarity and low dissolved oxygen levels. The sources of this impairment are not well known, but what is known is that nutrient loading likely occurs from both within the lake (internally) and from surface water runoff (externally).

The Watershed Section outlines the extent of agricultural land use within the relatively small watershed. A lake's water quality is largely a reflection of its watershed; therefore, when land within a watershed is developed, neighboring waterbodies are impacted by the change in hydrology and pollutant transport that accompanies the land development. It is strongly believed that the developed agricultural land in the CalMan Lakes watershed is responsible for transporting excessive nutrients into these lakes. To quantify this transport, additional monitoring is required; these steps are outlined further below.

Knowledge of a lake's aquatic plant community can be used to assess its ecological condition. This is done through examining the diversity of the plant community and assessing the number of species (richness) the lakes holds as well as the quality of each of these species. The presence of aquatic invasive species is believed to be an indicator of a disturbed lake ecosystem as well. Through several aquatic plant surveys, data were collected pertaining to both the native and non-native aquatic plant communities of the CalMan Lakes. These data indicate that the lakes are largely impaired as evidenced by native communities consisting of low species richness, low diversity, and low quality species. Because of light limitation due to turbid or algae-dominated water, aquatic plants occurred to a maximum depth of only several feet in these lakes, meaning that this habitat type covers a small area in each lake. Additionally, multiple non-native species were found in most of the lakes, further indicating a disturbed setting. Comparatively, the CalMan Lakes rank low in richness and diversity scores when examined against other lakes in the ecoregion and similar lakes statewide.

With the conclusion of Phase I, this project is well underway to identifying the stressors, sources and potential for remedial action in the CalMan Lakes watershed. The following page identifies the recommended steps for proceeding onward with this project.

Future Planning and Study Recommendations

Phase I of this planning project has successfully documented baseline conditions of the water quality, watershed, aquatic plant communities and habitat potential for the CalMan Lakes. Although much has been learned about these lakes and their ecological conditions, further studies are required to better quantify the sources and causes of these impairments, which would guide decision-making in future phases as well as for appropriate management actions that can be implemented within the lakes and their surrounding watersheds. These actions will continue to be developed as this phased project continues. Specific recommendations include:

1. Continuing the Management Planning Process through a Lake Protection Grant in the Lake Management Plan Implementation subcategory
   Much baseline information has been collected on the CalMan Lakes, however in order to properly determine what management actions are feasible (and estimate the level of mitigation they might produce), the CCRCD should continue investigating the impairment of these lakes through a February 1, 2015 Lake Protection grant application. Additional studies will be able to determine more accurately from where pollution is originating and determine the applicability of specific control actions. This study would incorporate many of the components listed in Recommendations 2-8 below.

2. Continue Baseline Water Quality Monitoring
   During Phase I of the project, baseline water quality was monitored at the deepest point in each project lake by Onterra and Calumet County staff. This monitoring design was consistent with methodology developed by USEPA and WDNR, which would create data applicable for analysis through Clean Water Act Section 303(d) reporting. Baseline monitoring of the lakes should be continued, either through trained volunteers enrolled in the Citizens Lake Monitoring Network or through Calumet County staff. This monitoring will ensure that data is collected in a manner comparable to the WDNR's Long Term Trends methodology, which in turn ensures that reliable data is available in the future for continuing management decision-making.

3. Tributary Monitoring
   Phase II of this project would begin the monitoring necessary to compute a full nutrient budget. This monitoring should include tributary flow studies as well as monitoring aimed at quantifying in-lake nutrient dynamics. Due to the complexities associated with monitoring four lakes, one of which has numerous tributary inputs, one summer should be spent analyzing hydrologic conditions within the watershed. The primary tributaries to Round, Long and Becker Lakes would be monitored with velocity and flow sensors, which would be installed during spring of 2014. Continuous flow would be logged at these locations with grab samples of nutrient concentration collected by Calumet County staff during rain-based runoff events and baseflow conditions. The flow/velocity meters would monitor the times in which active flow would be occurring, both in terms of a positive (towards the lake) and negative (backflow from the lake due to a full culvert) direction. It is anticipated that spring snowmelt and rain-based runoff would be missed due to the timing of notification of the project being awarded (early April). Because it is believed that the intermittent tributary streams are dry during the summer months, much of the valuable tributary flow and nutrient concentration data may come during 2015 and potentially 2016.

4. <u>In-lake Phosphorus Dynamics Monitoring</u>
   Baseline data indicate interesting nutrient recycling patterns in the CalMan Lakes. In order to quantify the amount of internal nutrient loading each lake is receiving and to further compartmentalize the nutrient budget, advanced in-lake water quality monitoring is required. Total phosphorus samples would be collected in late summer of 2015 to create a phosphorus profile of the water column in each lake. A dissolved oxygen and temperature profile would also be created during this visit. This information would allow the determination of the average sediment phosphorus release for the purposes of creating a lake nutrient budget.

5. <u>Sediment Core Sampling</u>
   Sediment core sampling and analysis should be conducted in Phase III (during the In-lake phosphorus dynamic monitoring) in order to compare pre-settlement to current conditions. Bottom sediment cores would be collected from each lake and sent to the WDNR for analysis of algal, macrophytes and nutrient data. This type of analysis will give managers a picture of what conditions were in these lakes prior to human settlement.

6. <u>Ground water monitoring</u>
   Ground water would be monitored in the CalMan Lakes through the use of mini-peizometers. This component would allow managers to determine the areas of inflow/outflow as well as obtain an understanding on the general nutrient characteristics of the groundwater, thus adding accuracy and certainty to the lake nutrient budget.

7. <u>Shoreland Condition Assessment</u>
   The CalMan Lakes may be impacted from runoff occurring from the immediate shoreland area. While direct quantification of this runoff is difficult to achieve, an understanding of potential impacts may be granted through shoreland surveys. The immediate shoreline of each CalMan Lake should be surveyed and classified based upon its potential to negatively impact the system due to shoreline development and other anthropogenic impacts. Examples of these negative impacts include shoreland areas that are maintained in an unnatural manner and include impervious surfaces. Habitat variables could be examined and documented during the survey for a variety of species, including both terrestrial and aquatic wildlife. Ultimately, the information would be integrated within the plan and used to prioritize areas for restoration and protection that would likely have a benefit to the lake ecosystem.

8. <u>Coarse Woody Habitat Assessment</u>
   As lakes become more developed, it is common to see the clearing of downed trees from the shorelines near property owners' residences. This structure is important habitat for fish and other aquatic organisms, warranting an understanding of this habitat type. A survey collecting these data would be useful in determining whether the lake management plan should include the enhancement of woody structure in the lakes.

9. <u>Continued Stakeholder Engagement</u>
   Future studies should continue to allow public input opportunities, such as the Kick-off, planning and project update meetings Phase I included. Stakeholder engagement allows the public an opportunity to both comment upon and keep updated on project components, while allowing involvement in the project as well.

5.0 IMPLEMENTATION PLAN

To be developed in the concluding phase of the
CalMan Watershed Management Planning Project

6.0 METHODS

Lake Water Quality

Baseline water quality conditions were studied to assist in identifying potential water quality problems in the CalMan Lakes (e.g., elevated phosphorus levels, anaerobic conditions, etc.). Water quality was monitored at the deepest point in each lake that would most accurately depict the conditions of the lake (Map 1). Samples were collected with a 3-liter Van Dorn bottle at the subsurface (S) and near bottom (B). Sampling occurred once in spring, fall, and winter and three times during summer. Samples were kept cool and preserved with acid following standard protocols. All samples were shipped to the Wisconsin State Laboratory of Hygiene for analysis. The parameters measured included total and dissolved phosphorus, chlorophyll-*a*, total kjeldahl nitrogen, nitrate-nitrite nitrogen, ammonia nitrogen, laboratory conductivity, laboratory pH, total alkalinity, total suspended solids, calcium

In addition, during each sampling event Secchi disk transparency was recorded and a temperature, pH, and dissolved oxygen profile was completed using a Hach LDO 30D.

Watershed Analysis

The watershed analysis began with an accurate delineation of the the CalMan Lakes drainage area using U.S.G.S. topographic survey maps and base GIS data from the WDNR. Watershed delineations were determined for each project lake. 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

Early Season AIS Survey

Surveys of curly-leaf pondweed were completed on the the CalMan Lakes during mid to late June in order to correspond with the anticipated peak growth of the curly-leaf pondweed. Please refer to each individual lake section for the exact date in which each survey was conducted. Visual inspections were completed throughout the lake by completing a meander survey by boat. Data was collected using a Trimble GeoXT Global Positioning System (GPS) with sub-meter accuracy. AIS colonies were mapped based upon density into categories of point based or polygon based areas.

Point-Intercept Macrophyte Survey

Comprehensive surveys of aquatic macrophytes were conducted on the system to characterize the existing communities within each lake and included 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 (Hauxwell 2010) was used to complete the studies. WDNR staff and Calumet County staff completed the studies in 2012 (Long Lake), 2013 (Becker and Round Lake) and Boot Lake (2014).

Community Mapping

During the species inventory work, the aquatic vegetation community types within each 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 each of the lakes.

Eurasian Water Milfoil Peak Biomass Survey

Eurasian water milfoil colonies were mapped using a Trimble GeoXT Global Positioning System (GPS) with sub-meter accuracy. This occurred first in June during the ESAIS survey, and the data was refined further with a visit to each CalMan Lake in August of 2013. Eurasian water milfoil colonies were mapped based upon density into categories of point based or polygon based areas.

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