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# Three Lakes Chain

Oneida County, Wisconsin

## Comprehensive Management Plan

February 2014



Sponsored by:

**Three Lakes Waterfront Association**

Wisconsin Department of Natural Resources  
Grant Program



**Three Lakes Chain**  
Oneida County, Wisconsin  
**Comprehensive Management Plan**  
February 2014

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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:

**Three Lakes Chain of Lakes Planning Committee**

The Planning Committee was comprised of 2-5 riparian property owners from the following lakes:

Virgin Lake  
Big Lake  
Deer Lake  
Big Fork Lake

Whitefish Lake  
Dog Lake  
Big Stone Lake  
Fourmile Lake

The Thoroughfare  
Crystal (Mud) Lake  
Laurel Lake

**Organization**

Town of Three Lakes

**Wisconsin Dept. of Natural Resources**

Tim Plude  
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*Note: Individual lake maps are included within each individual lake section*

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- A. Public Participation Materials
- B. Stakeholder Survey Response Charts and Comments
- C. Act 31 Committee Report
- D. Water Quality Data
- E. Watershed Analysis WiLMS Results
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## INDIVIDUAL LAKE SECTIONS

Individual lake reports are drafted as separate attachments to the chain-wide document.

## 1.0 INTRODUCTION

The Three Lakes Chain of Lakes is a 6,900+ acre flowage residing in north-eastern Oneida County, WI (Map 1). The Three Lakes Chain serves as the upper part of the Eagle River Chain of Lakes, draining north as the Eagle River and over the Burnt Rollways Dam.

Since its inception, the Three Lakes Waterfront Association (TLWA), along with its long-time partner, the Town of Three Lakes, has worked to prevent introduction and establishment of aquatic invasive species within the chain of lakes. The groups have approached this sometimes overwhelming task through diligent volunteer monitoring of the chain's littoral zone (Adopt-A-Shoreline) and an annual educational initiative that includes direct contact with lake stakeholders through multiple avenues, such as conducting annual meetings with educational speakers, staffing informational booths and manning the chain's many landings with Clean Boats / Clean Waters watercraft inspectors. The association also educates stakeholders through more passive activities, like direct mailings, newsletters and signage at boat landings.

Along with preventing aquatic invasive species establishment within the chain, it has been the long-term objective of the TLWA to create comprehensive management plans for the 21 lakes and two connecting waterways (the Thoroughfare and Townline Creek) within the Three Lakes Chain over a span of five to ten years. This project began with studies on Long Lake due to the discovery of Eurasian water milfoil and subsequent need for immediate attention. Beginning with discussions in 2009/2010, a phased approach was developed to address each lake within the chain, starting from the top of the chain (south) and working downstream towards Long Lake and the Eagle River above the Burnt Rollways Dam (Map 1). Developing management plans for small clusters of lakes within the chain allow for financial savings to be realized in overall project costs while creating a manageable process that allows for sufficient attention to be applied to each lake's needs. This is opposed to completing all plans simultaneously, which would facilitate great cost savings, but only produce generic plans for each lake and the chain as a whole. Financial assistance was obtained through the Wisconsin Department of Natural Resources' Lake Management Grant Program for each phase of the project.

*Note: This chain-wide management plan and individual lake plans will serve as the deliverable for Phase III of this Chain-wide project. As additional lakes are studied over the course of the remaining phases, their individual lake plans will be included to this report, and the Chain-wide section will be updated appropriately. Updates from previous phases (e.g. monitoring of Eurasian water milfoil in Virgin Lake) will be included in future reports.*

The Three Lakes Chain is a highly sought after location amongst recreationists and anglers. In addition to the 14 public boat landings on the chain, there is access to the eight boat landings on the Lower Eagle River Chain by traveling over the Burnt Rollways Dam using the tracked boat-lift system. These intense public use opportunities most likely contributed to two small areas on the chain (Virgin Lake and Long Lake/Eagle River channel) becoming populated with Eurasian water milfoil. Throughout the project, Onterra staff continued to monitor these known infestations as well as sweeping new areas for signs of invasive species as well. During this time, the TLWA and Town of Three Lakes worked to educate stakeholders about Eurasian water milfoil and other aquatic invasive species; and along with the Clean Boats / Clean Waters program, help reduce new infestations to the chain and reduce the risk of Eurasian water milfoil from the chain infecting other area waterbodies.

## 2.0 STAKEHOLDER PARTICIPATION

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

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

### ***Project Planning Process***

#### **Kick-off Meeting**

On July 23, 2011, Tim Hoyman met with members of the TLWA for a dual -purpose meeting. First, an update was provided on activities associated with the Long Lake Management Plan and Eagle River Channel Eurasian water milfoil control and monitoring project. Then, the management planning project for the Phase I and Phase II lakes was discussed in detail. At that point in time, field studies had been completed for the Phase I lakes and activities regarding the Phase II lakes were underway. All project components were discussed and reported upon as available. Following the presentation, Mr. Hoyman answered many questions on general lake ecology as well as how the chain-wide management planning process would be conducted.

#### **Planning Committee Meetings**

Planning meetings were conducted periodically through the chain-wide study, and focused upon the lakes involved with each current phase. On April 20, 2012, Tim Hoyman and Dan Cibulka met with a planning committee consisting of stakeholders from Phase I and Phase II lakes. The Onterra staff met with Phase III representatives on July 11, 2013. During these meetings, Mr. Hoyman and Mr. Cibulka went over the study results from lakes represented. All project components, including water quality analyses, watershed studies, aquatic plant surveys and stakeholder survey information were discussed in detail. Many questions were answered by Mr. Hoyman and Mr. Cibulka pertaining to issues such as aquatic invasive species, nutrient concentrations within the lakes, dissolved oxygen levels and navigation/safety.

Within Phase I and II of the project, a meeting was held to brainstorm on the initial Implementation Plan. On August 23, Tim Hoyman and Dan Cibulka met again the Phase I and II lakes Planning Committee. During this meeting, the committee and Onterra staff discussed management goals the TLWA would implement for protecting and preserving the Three Lakes Chain of Lakes, and what steps would need to occur to reach these goals. The Implementation Plan (see Implementation Plan section) is largely the result of these conversations. Within each



following phase, the lake representatives were asked to look over the Implementation Plan and if any revisions or additions were required a second meeting would be held.

### **Management Plan Review and Adoption Process**

Prior to the first Planning Committee Meeting of each phase, the Results Section of this document (Section 3.0) as well as the individual lake sections were sent to all planning committee members for their review and preparation for the meeting. Following discussions at the second Planning Committee Meeting, Onterra staff drafted this report's Implementation Plan and sent it to TLWA board members for review. Their comments were integrated to the plan, and a first official draft was sent to the WDNR for a review in December of 2012. The WDNR approved of the Phase I and II plan in September of 2013. A draft containing updates from Phase III of the project was sent to the WDNR in December 2013, with commentary and a final product of this plan produced in February of 2014.

### **Stakeholder Survey**

As a part of phase of Phase II of this project, a stakeholder survey was distributed to TLWA members and non-member riparian property owners. This survey was designed by Onterra staff and the TLWA planning committee in September of 2011. The draft survey was sent to a WDNR social scientist for review that same month. During October 2011, the eight-page, 32-question survey was mailed to 1,694 riparian property owners in the Three Lakes Chain of Lakes watershed. Thirty-six percent of the surveys were returned. The data were summarized and analyzed by Onterra for use at the planning meetings and within the management plan. The full survey and results can be found in Appendix B, while discussion of those results is integrated within the appropriate sections of the management plan and a general summary is discussed below. Following review of the survey data by Onterra and TLWA board members, Onterra staff assisted Jerry Schiedt of the TLWA in preparing a presentation of the survey results. Mr. Schiedt delivered this presentation to TLWA members at their July 2012 annual meeting.

Based upon the results of the Stakeholder Survey, much was learned about the people that use and care for Three Lakes Chain of Lakes. Thirty-seven percent of stakeholders are year-round residents, while 33% live on the chain seasonally and 23% visit on weekends throughout the year (Appendix B – Question #2). Fifty-nine percent of stakeholders have owned their property for over 15 years, and 35% have owned their property for over 25 years.

The following sections (Water Quality, Watershed, Aquatic Plants and Fisheries Data Integration) discuss the stakeholder survey data with respect to these particular topics. Figures 2.0-1 and 2.0-2 highlight several other questions found within this survey. More than half of survey respondents indicate that they use a canoe or kayak on the chain (Question #9). Motorboats of various sizes, pontoon boats, and rowboats were also popular choices on this question. On an intense recreational system such as Three Lakes Chain of Lakes, the importance of responsible boating activities is increased. The need for boating responsibly increases during weekends, holidays, and during times of nice weather or good fishing conditions as well, due to increased traffic on the lake. As seen on Question #10, several of the top recreational activities on the lake involve boat use. Three Lakes Chain stakeholders overwhelmingly indicated that watercraft use (jet skiing, water skiing/tubing and motor boating) has increased since they obtained their property (Question #11). Furthermore, boat traffic was ranked as the highest factor negatively impacting the Three Lakes Chain, and was ranked as the second top concern

regarding the Chain of Lakes as well (Question #20 and #21). Comments were recorded regarding this issue on the Three Lakes Chain – both supporting the use of watercraft and criticizing the use of watercraft (Appendix B – Written Comments).

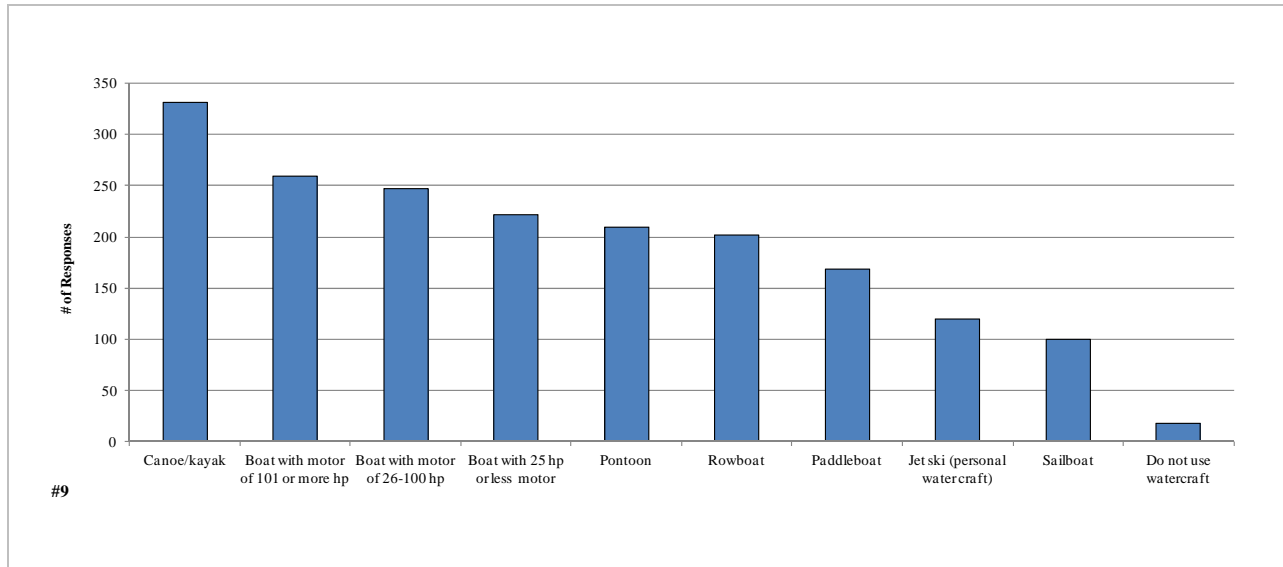
To gather information about opinions on watercraft speed and use on the chain, the TLWA, with assistance from Onterra staff and approval from social scientists at the WDNR, developed two questions on the stakeholder survey regarding the matter. The majority of survey respondents indicated that the number of slow-no-wake areas on the chain are “just right” (Question #11). 75% of all respondents indicated that they support the Wisconsin boating regulation prohibiting boaters from operating their boats at speeds greater than slow-no-wake 100 feet from shore and/or structures (Questions #12).

This regulation is known as Wisconsin Act 31, and was enacted in 2010. This act was set into place because of the disturbance to the lake that can result from boating at high speeds in this zone. Specifically, shoreline erosion, disruption of lake bottom sediments and nutrients, and destruction of aquatic organism habitats may occur. Safety for swimmers, slow-moving watercraft and other recreationalists was also considered into Act 31. Legislators writing this regulation realized there may be times when local authorities may wish to enact their own ordinances, either in addition to this regulation or in opposition to opt out of Act 31.

The Town of Three Lakes created a committee (Three Lakes Act 31 Advisory Committee) to examine this regulation and offer a recommendation to the Three Lakes Board of Supervisors on the applicability of Act 31 to the Three Lakes Chain of Lakes. The Committee offered a recommendation in favor of opting out of Act 31, and ultimately in 2010/2011 the Town of Three Lakes decided to opt out of the Act as well. Thus, the 100-foot rule does not apply to any waterbodies within the Town of Three Lakes (on the Three Lakes Chain or otherwise). The Committee’s overall recommendation included suggestions for areas to be slow-no-wake zones, policing and enforcement options, and areas designated as quiet sport (canoe/kayak) zones, caution zones, or shallow water areas. A report detailing the Committee’s consideration of Act 31 and their recommendations can be found in Appendix C.

Several concerns noted throughout the stakeholder survey include watercraft issues as described above and within the written comments portion of Appendix B, concern over aquatic invasive species detection and control, and Native American spear harvesting of walleye on the Three Lakes Chain. Spearing regulations and harvest data is summarized with the Fisheries Data Integration Section and aquatic invasive species information is detailed within the Aquatic Plants Section. Discussion regarding watercraft use on the Three Lakes Chain of Lakes is described completely within Appendix C, and is touched upon in the Summary & Conclusions section as well as within the Implementation Plan.

Question #9: What types of watercraft do you currently use on the lake?



Question #10: Please rank up to three activities that are important reasons for owning your property on or near the lake.

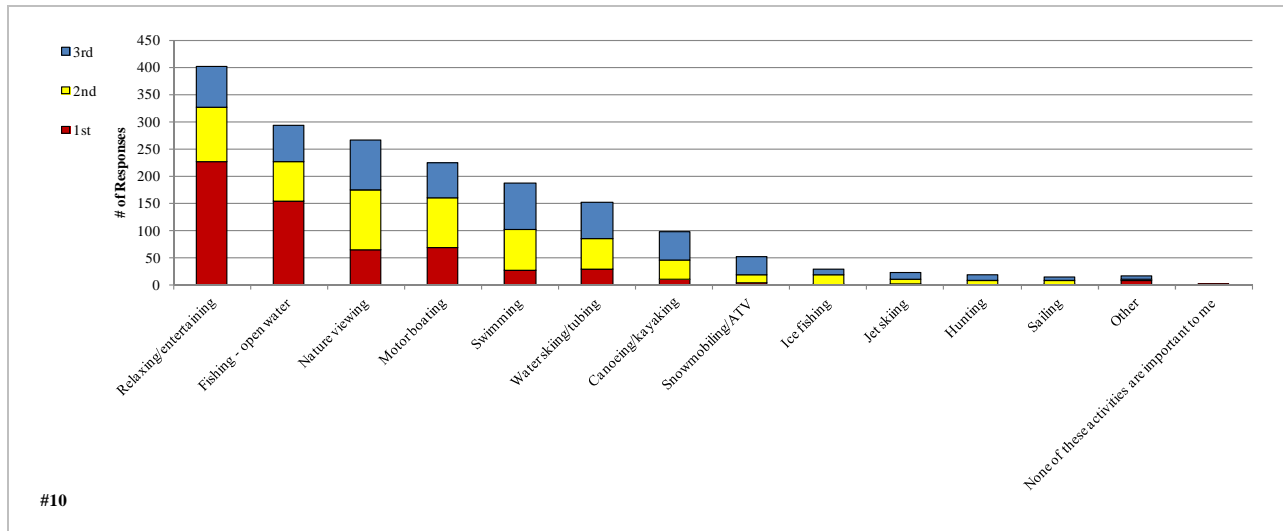
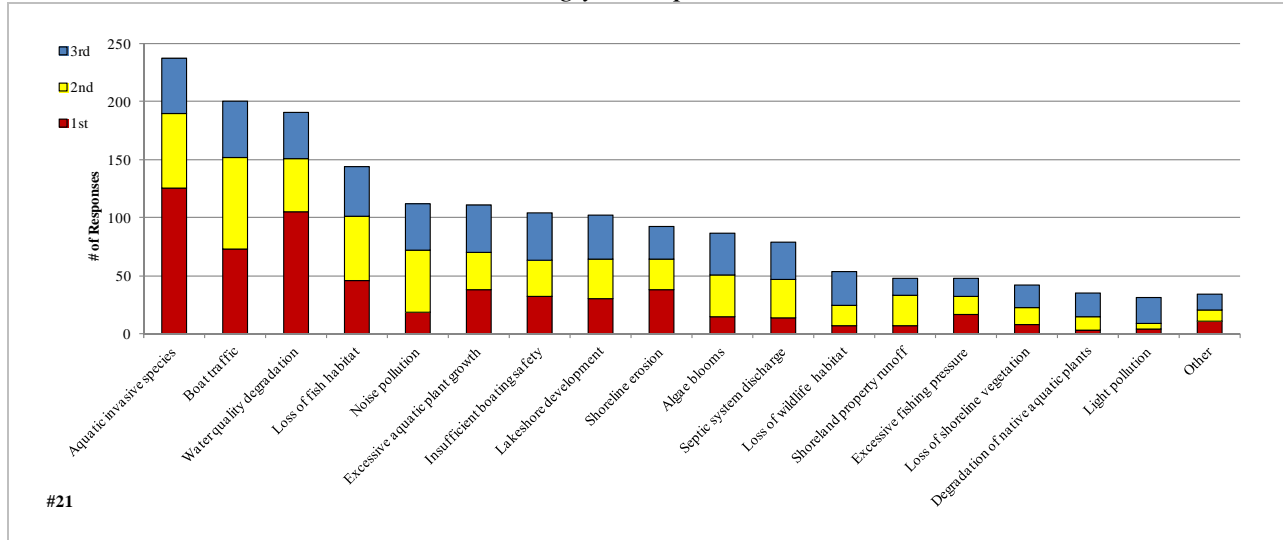
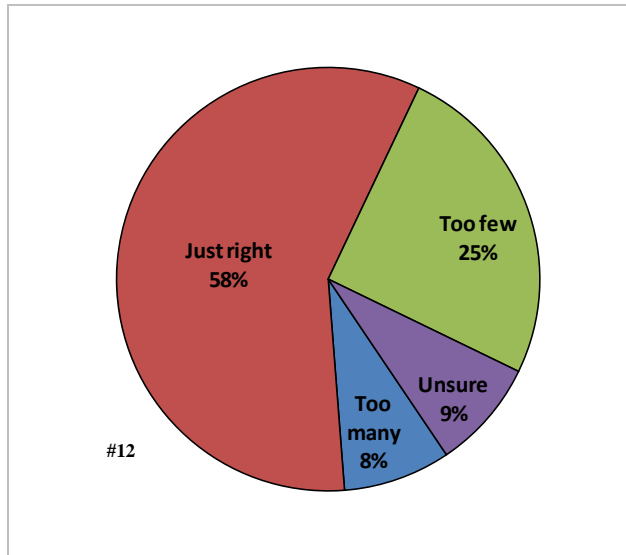


Figure 2.0-1. Select survey responses from the Three Lakes Chain Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

Question #21: Please rank your top three concerns regarding Three Lakes Chain of Lakes, with 1 being your top concern.



Question #12: What is your opinion of the number of slow-no-wake areas on the entire Three Lakes Chain?



Question #13: Do you support or oppose the Wisconsin boating regulation prohibiting boaters from operating their boats at speeds greater than slow-no-wake 100 feet from shore and/or structures?

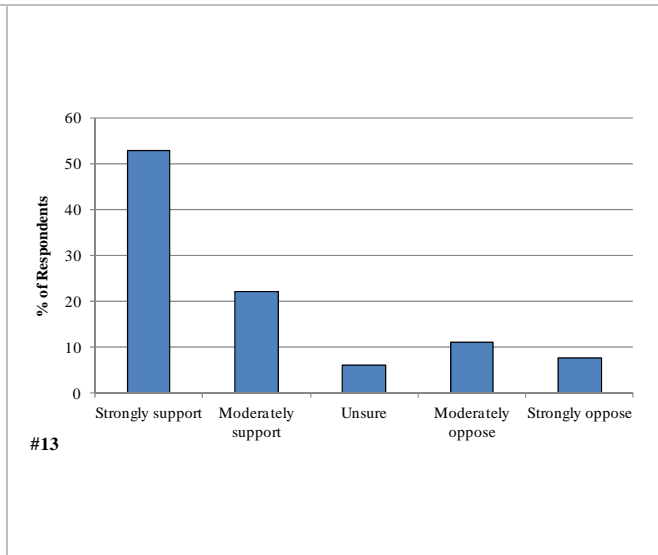


Figure 2.0-2. Select survey responses from the Three Lakes Chain Stakeholder Survey, continued. Additional questions and response charts may be found in Appendix B.

### **Three Lakes Chain of Lakes Stakeholder AIS Concerns**

As with most Wisconsin lakes, there is great concern with Three Lakes Chain of Lakes stakeholders over the threat of aquatic invasive species. The Town of Three Lakes and TLWA have put forth much effort in educating area stakeholders and Three Lakes Chain visitors about the threat that invasive plants pose. Approximately 99% of stakeholder survey respondents indicated that they have heard of aquatic invasive species (Appendix B, Question #16). About 78% indicated they believe aquatic invasive species are present in their lake (Question #17). When asked what aquatic invasive species were present in their lake, survey respondents selected Eurasian water milfoil, rusty crayfish, Chinese mystery snail, *Heterosporosis*, and purple loosestrife as top choices. Table 2.0-1 lists the confirmed aquatic invasive species in each of the Three Lakes Chain lakes.

96% of survey respondents indicated that they are either somewhat or very concerned about the spread of invasive species to their lake (Question #19), and this topic was ranked first on a list of concerns stakeholders have regarding their lake (Question #21). Invasive species management can be a costly, time consuming and complicated task. Control strategies often become dependent on the stage of infestation, environmental factors of the ecosystem, and budget constraints of the managing entities. When it comes to managing plant species, Three Lakes Chain stakeholders favor an integrated control using several methodologies most (Question #24).

While no reasonable and efficient control strategy exists for several of the species on Table 2.0-1 (banded and Chinese mystery snails and rusty crayfish), several effective methods have been utilized for control of Eurasian water milfoil and purple loosestrife. For the Three Lakes Chain of Lakes in which aquatic invasive plants are present, the history and management strategy for each is discussed further within that lake's Aquatic Plant Section and Implementation Plan.

**Table 2.0-1. Aquatic Invasive Species located on the Three Lakes Chain.** Information obtained from WDNR internet databases (Invasive Species – How Wisconsin Is Doing - [www.dnr.wi.gov/lakes/invasives/Default.aspx](http://www.dnr.wi.gov/lakes/invasives/Default.aspx) & Surface water data viewer - [http://dnr.wi.gov/org/water/data\\_viewer.htm](http://dnr.wi.gov/org/water/data_viewer.htm)).

Lake	AIS and Year Confirmed
Big Lake	Chinese Mystery Snail (2011), Rusty Crayfish (2002), Purple Loosestrife (2010)
Big Fork Lake	Chinese Mystery Snail (2007), Pale yellow iris (2012)
Big Stone Lake	Banded Mystery Snail (2007), Chinese Mystery Snail (2007), Purple Loosestrife (2011), Rusty Crayfish (2002),
Crystal (Mud) Lake	Rusty Crayfish (2002)
Deer Lake	Chinese Mystery Snail (2007), Rusty Crayfish (2002)
Dog Lake	Rusty Crayfish (2002)
Fourmile Lake	Rusty Crayfish (2002), Pale yellow iris (2012)
Island Lake	Rusty Crayfish (Unknown)
Laurel Lake	Chinese Mystery Snail (2011), Purple Loosestrife (2011), Rusty Crayfish (2002)
Little Fork Lake	Chinese Mystery Snail (2007), Rusty Crayfish (2002)
Long Lake	Eurasian water milfoil (Eagle River channel - 2006), Hybrid cattail (2009), Purple Loosestrife (2009), Rusty Crayfish (1964)
Maple Lake	Banded Mystery Snail (2007), Chinese Mystery Snail (2007)
Medicine Lake	Chinese Mystery Snail (2007)
Planting Ground Lake	Chinese Mystery Snail (2007), Rusty Crayfish (Unknown)
Range Line Lake	Banded Mystery Snail (2007), Chinese Mystery Snail (2007), Rusty Crayfish (2002)
The Thoroughfare	Chinese Mystery Snail (2005)
Townline Lake	Chinese Mystery Snail (2005), Rusty Crayfish (2002)
Whitefish Lake	Rusty Crayfish (1957)
Virgin Lake	Eurasian water milfoil (2010)

## 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 Three Lakes Chain of Lakes is compared to other lakes in the state with similar characteristics as well as to lakes within the northern region (Appendix D). 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 Three Lakes Chain of 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.

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 processes that occur within a lake. Internal nutrient loading is an excellent example that is described below.

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

## 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 overlying water. This can result in very high concentrations of phosphorus in the hypolimnion. Then, during the spring and fall turnover events, these high concentrations of phosphorus are mixed within the lake and utilized by algae and some macrophytes. This cycle continues year after year and is termed "internal phosphorus loading"; a phenomenon that can support nuisance algae blooms decades after external sources are controlled.

The first step in the analysis is determining if the lake is a candidate for significant internal phosphorus loading. Water quality data and watershed modeling are used to screen non-candidate and candidate lakes following the general guidelines below:

### Non-Candidate Lakes

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

### Candidate Lakes

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

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

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

### Comparisons with Other Datasets

The WDNR document Wisconsin 2012 Consolidated Assessment and Listing Methodology (WDNR 2012A) 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 Three Lakes Chain of Lakes will be compared to lakes in the state with similar physical characteristics. The WDNR groups Wisconsin's lakes into 6 classifications (Figure 3.1-1).

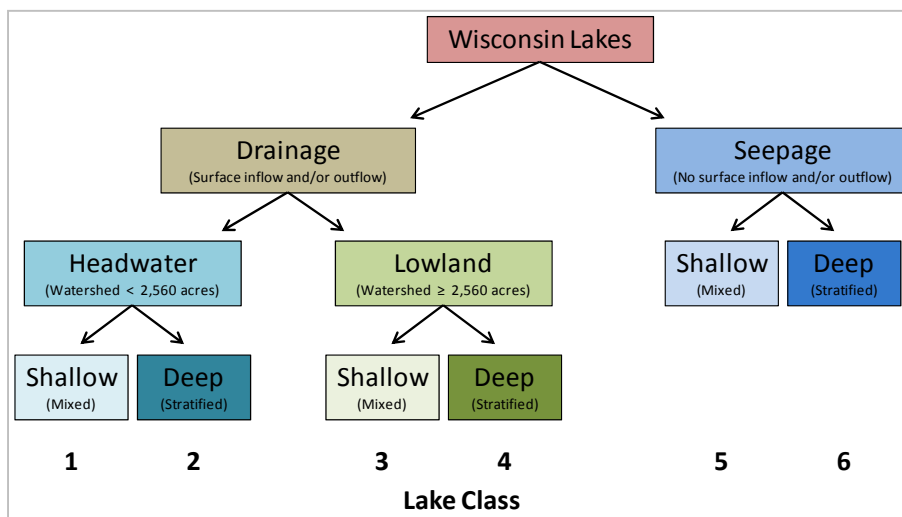
First, the lakes are classified into two main groups: shallow (mixed) or deep (stratified). These lakes differ in many ways; for example, in their oxygen content and where aquatic plants may be found. Shallow lakes tend to mix throughout or periodically during the growing season and as a result, remain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

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

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

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

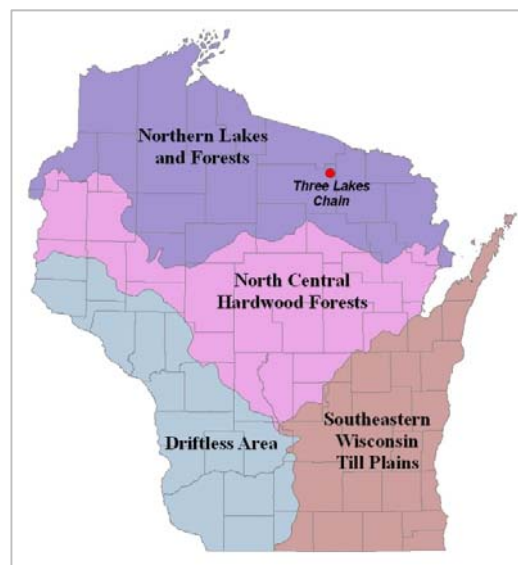
Lowland drainage lakes have a watershed of greater than 4 square miles.



**Figure 3.1-1. Wisconsin Lake Classifications.** Adapted from WDNR 2012A.

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

The Wisconsin 2012 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.



**Figure 3.1-2. Location of Three Lakes Chain within the ecoregions of Wisconsin.** After Nichols 1999.

These data along with data corresponding to statewide natural lake averages, historic, current, and average data from Three Lakes Chain of Lakes are displayed in Figures 3.1-3 - 3.1-6. Please note that the data in these graphs represent concentrations and depths taken only during the growing season (April-October) or summer months (June-August). Furthermore, the phosphorus and chlorophyll-*a* data represent

only surface samples. Surface samples are used because they represent the depths at which algae grow and depths at which phosphorus levels are not greatly influenced by phosphorus being released from bottom sediments.

### **Three Lakes Chain of Lakes Water Quality Analysis**

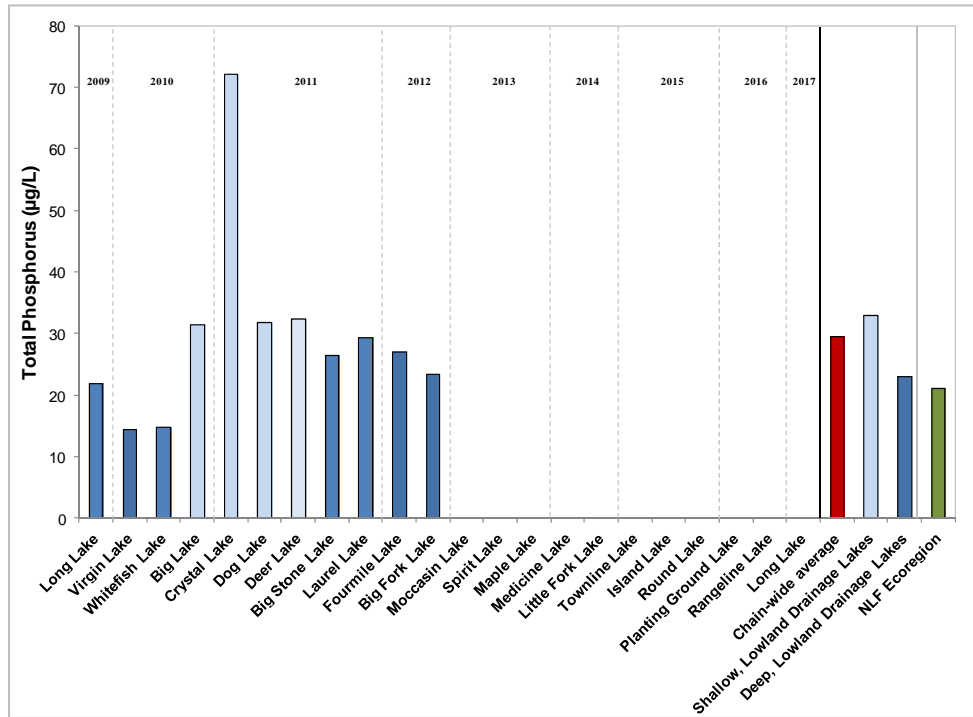
#### **Three Lakes Chain of Lakes Nutrient Content and Clarity**

The amount of historical water quality data existing on the Three Lakes Chain varies by lake. Several lakes have volunteers that are actively monitoring their lake through the WDNR's Citizens Lake Monitoring Network (CLMN), collecting nutrient samples or Secchi disk clarity data several times each summer. Many lakes do not have active CLMN volunteers and because of this, there are no historic 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.

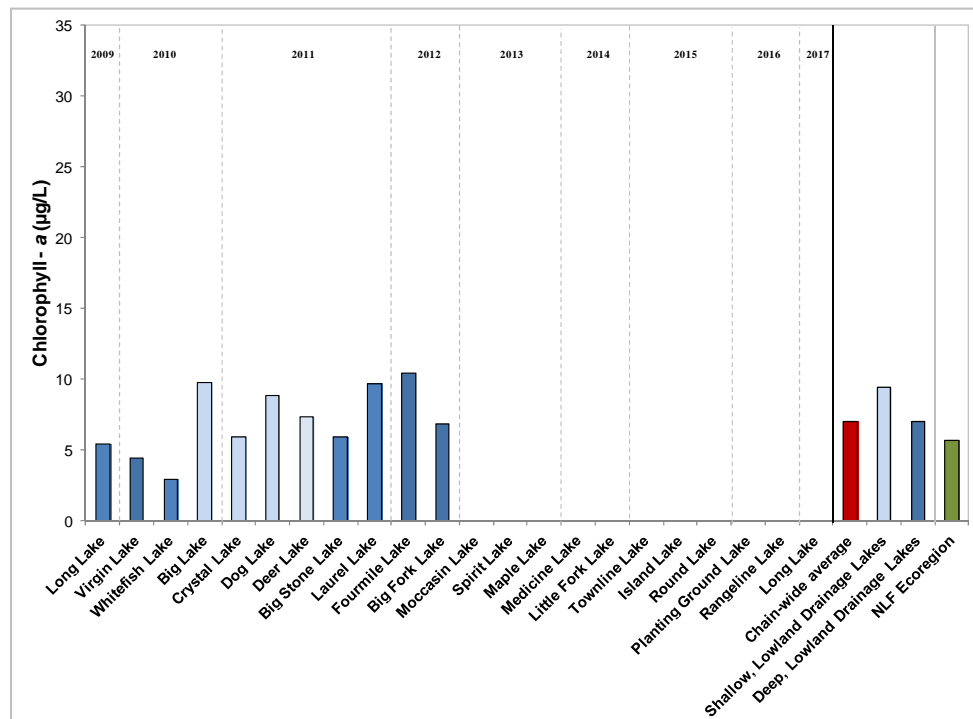
Onterra staff collected water quality samples and monitored Secchi disk clarity on each Three Lakes Chain lake during the course of this project. Monitoring occurred during the spring, summer, fall and following winter of each project phase (Phase I lakes sampled in 2010/2011, Phase II lakes sampled in 2011/2012, etc.). Long Lake completed a management plan in 2009, so data obtained through that process are displayed in the figures below. As a part of the current management project consisting of the entire Three Lakes Chain, Long Lake will be sampled again in 2017. Please note on the following figures that comparisons are best made across lakes of similar classification (shallow, lowland drainage lakes in light blue and deep, lowland drainage lakes in dark blue). Unless otherwise indicated, parameters represent samples collected from the sub-surface of each lake.

Total phosphorus values ranged largely between 14 and 32  $\mu\text{g/L}$  (Figure 3.1-3). However, Crystal (Mud) Lake's average summer concentration averaged 72  $\mu\text{g/L}$  in 2011. This value is exceptionally high, exceeding the value for other shallow, lowland drainage lakes across the state and region. All other lakes are near or even below the median value for their respective lake class (shallow or deep lowland drainage lakes) for this parameter. These levels are normal and healthy for Wisconsin Lakes.

Average summer chlorophyll-*a* concentrations vary little within the Three Lakes Chain of Lakes (Figure 3.1-4). Several lakes include average summer concentrations that lie only slightly above the median value for their respective lake class (Big, Laurel and Fourmile), while most lie below this benchmark value. Regardless, all lakes display average chlorophyll-*a* values that are healthy for their ecosystem. As with aquatic macrophytes (aquatic plants), light penetration into the water column is necessary for algae to grow. As discussed further below, algae growth may be limited to a certain extent in the Three Lakes Chain due to the naturally stained water.



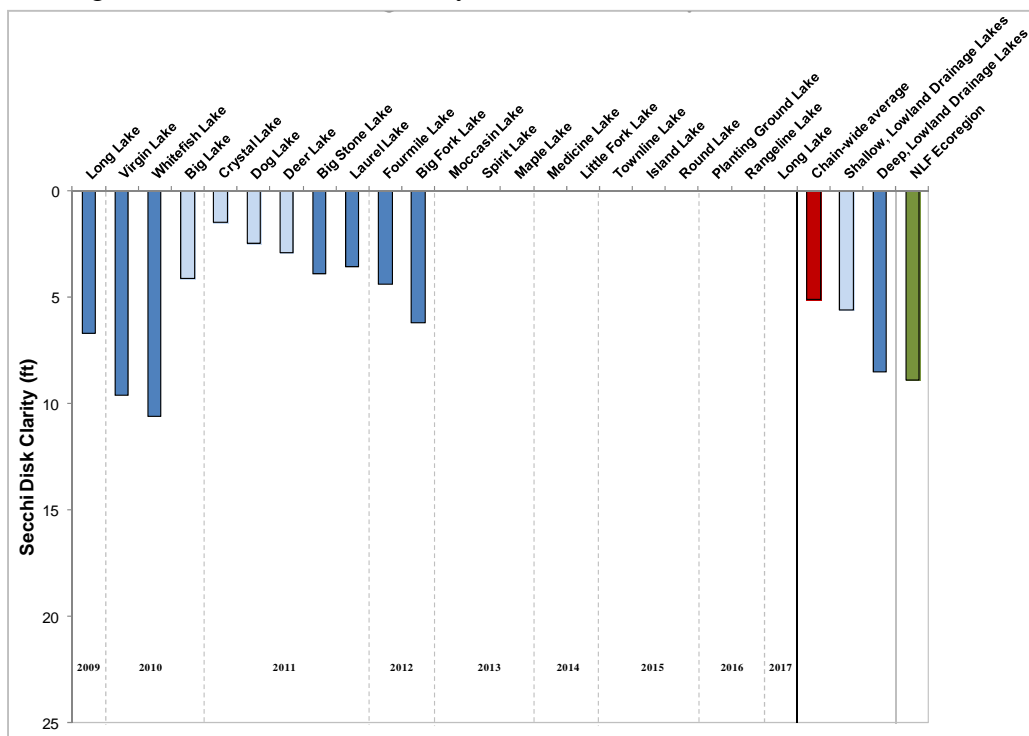
**Figure 3.1-3. Three Lakes Chain and comparable lakes total phosphorus concentrations.** Comparables include Class 3 (light blue) and Class 4 (dark blue) lakes and Northern Lakes and Forests ecoregion median values. Values calculated with summer month surface sample data and methodology using WDNR 2012A.



**Figure 3.1-4. Three Lakes Chain and comparable lakes chlorophyll-a concentrations.** Comparables include Class 3 (light blue) and Class 4 (dark blue) lakes and Northern Lakes and Forests ecoregion median values. Values calculated with summer month surface sample data and methodology using WDNR 2012A.

Average summer Secchi disk clarity ranged from 1.5 feet deep to 10.6 feet deep in the Three Lakes Chain lakes (Figure 3.1-5). In the two lakes at the upper reaches of the chain (Virgin and Whitefish Lakes) Secchi disk depth was the greatest, falling above the value for similar deep, lowland drainage lakes statewide. Several lakes displayed average Secchi depths between one and four feet of depth. While the water in these lakes can be said to have very low clarity, the reason is not because of excessive algae, as established above. Systems with large watersheds (discussed further in the Watershed Section) drain many acres of forested lands and wetlands. When water drains these tracts of land into a lake, naturally occurring organic acids accumulate and stain the lake water a dark brown color. This is the cause of the Three Lakes Chain’s “root beer” color. Furthermore, it is this factor that is limiting light penetration into the waters of the lakes which in turn limits algal production as well as the depth of aquatic plant growth (see the Aquatic Plant Section).

Beginning in 2012, a parameter called “true color” was added to the water quality sampling regime for the Three Lakes Chain project. True color is a measurement of the dissolved organic materials in water. Water samples collected in April and July 2012 were measured for this parameter, and were found to be at 120 Platinum-cobalt units (Pt-co units, or PCU) and 70 PCU in Fourmile Lake. During these same time periods, true color was measured at 100 PCU and 50 PCU in Big Fork Lake. 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. This helps to explain the stained colors of the Three Lakes Chain, as this parameter indicates the higher level of dissolved organics acids that are naturally found in the lakes here.



**Figure 3.1-5. Three Lakes Chain and comparable lakes Secchi disk clarity values.** Comparables include Class 3 (light blue) and Class 4 (dark blue) lakes and Northern Lakes and Forests ecoregion median values. Values calculated with summer month surface sample data and methodology using WDNR 2012A.



### Limiting Plant Nutrient of Three Lakes Chain of Lakes

Using average nitrogen and phosphorus concentrations from all lakes included in the Three Lakes Chain of Lakes study, a nitrogen:phosphorus ratio was calculated for each lake (Table 3.1-1). In all lakes, the ratio weighed heavily in favor of nitrogen, rather than phosphorus. This finding indicates that all of the lakes of the Three Lakes Chain of Lakes are indeed phosphorus limited as are the vast majority of Wisconsin lakes. In general, this means that cutting phosphorus inputs may limit plant growth within the lakes.

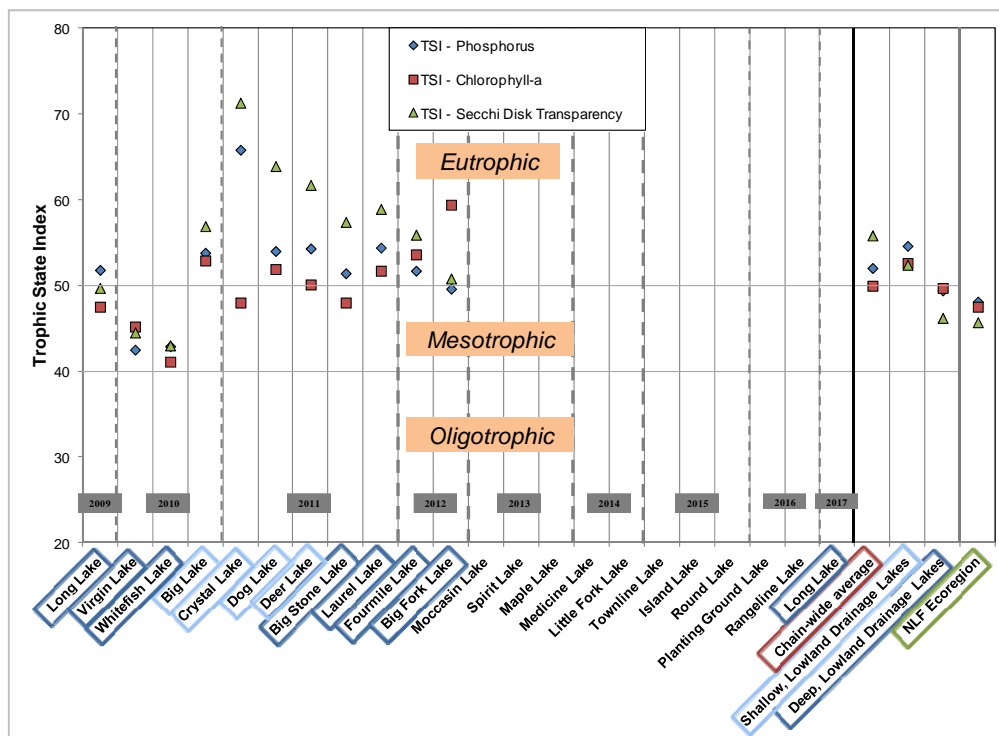
**Table 3.1-1. Three Lakes Chain nitrogen and phosphorus values and N:P ratios.** Ratios calculated from sub-surface samples taken in summer from each lake.

Project Phase	Lake Name	Avg. Summer Nitrogen (µg/L)	Avg. Summer Phosphorus (µg/L)	N:P Ratio
Long Lake - 2009	Long Lake	665	21.8	31:1
Phase I - 2010	Virgin Lake	543	14.3	38:1
	Whitefish Lake	520	14.7	35:1
	Big Lake	953	31.4	30:1
Phase II - 2011	Crystal (Mud) Lake	1160	72.0	16:1
	Dog Lake	950	31.7	30:1
	Deer Lake	860	32.3	27:1
	Big Stone Lake	710	26.5	27:1
	Laurel Lake	1010	29.3	34:1
Phase III - 2012	Big Fork Lake	590	27.0	20:1
	Fourmile Lake	480	23.3	23:1
Phase IV - 2013	Moccasin Lake			
	Spirit Lake			
	Maple Lake			
Phase V - 2014	Little Fork Lake			
	Medicine Lake			
Phase VI - 2015	Island Lake			
	Round Lake			
	Townline Creek			
	Townline Lake			
Phase VII - 2016	Rangeline Lake			
	Planting Ground Lake			
Phase VIII - 2017	Long Lake			

### Three Lakes Chain of Lakes Trophic State

Figure 3.1-6 contain the Trophic State Index (TSI) values for Three Lakes Chain of 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; particularly with the Three Lake Chain's stained water which impacts Secchi disk clarity much. Many of the lakes within the

chain fall within the range of eutrophic – characterized higher phosphorus and chlorophyll-*a* content. Several lakes, such as Virgin and Whitefish, rank within the mesotrophic category, this is not surprising, seeing that they are at the very top of the Three Lakes Chain and are not influenced by the other lakes (further discussion of this topic takes place in the Watershed Section).



**Figure 3.1-6. Three Lakes Chain and comparable lakes Trophic State Index values.** Comparables include Class 3 (light blue) and Class 4 (dark blue) lakes and Northern Lakes and Forests ecoregion median values. Values calculated with summer month surface sample data and methodology using WDNR 2012A.

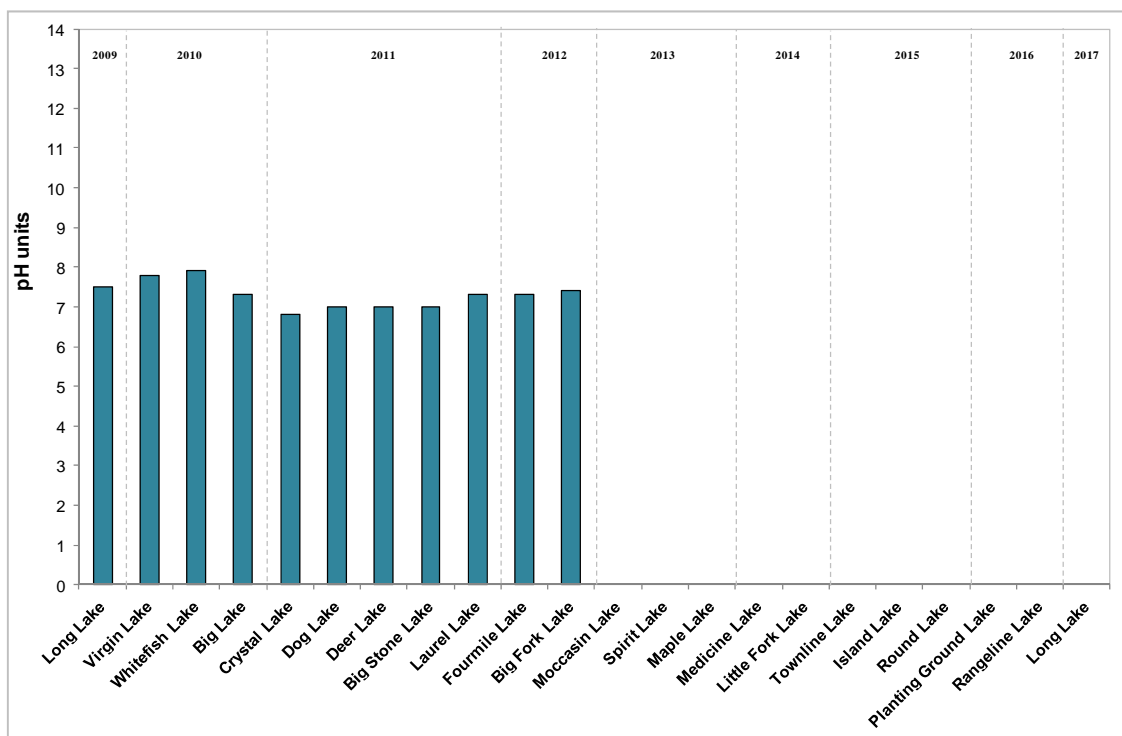
### Additional Water Quality Data Collected on the Three Lakes Chain of Lakes

The water quality section is centered on lake eutrophication. However, parameters other than water clarity, nutrients, and chlorophyll-*a* were collected as part of the project. These other parameters were collected to increase the understanding of the Three Lakes Chain of 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

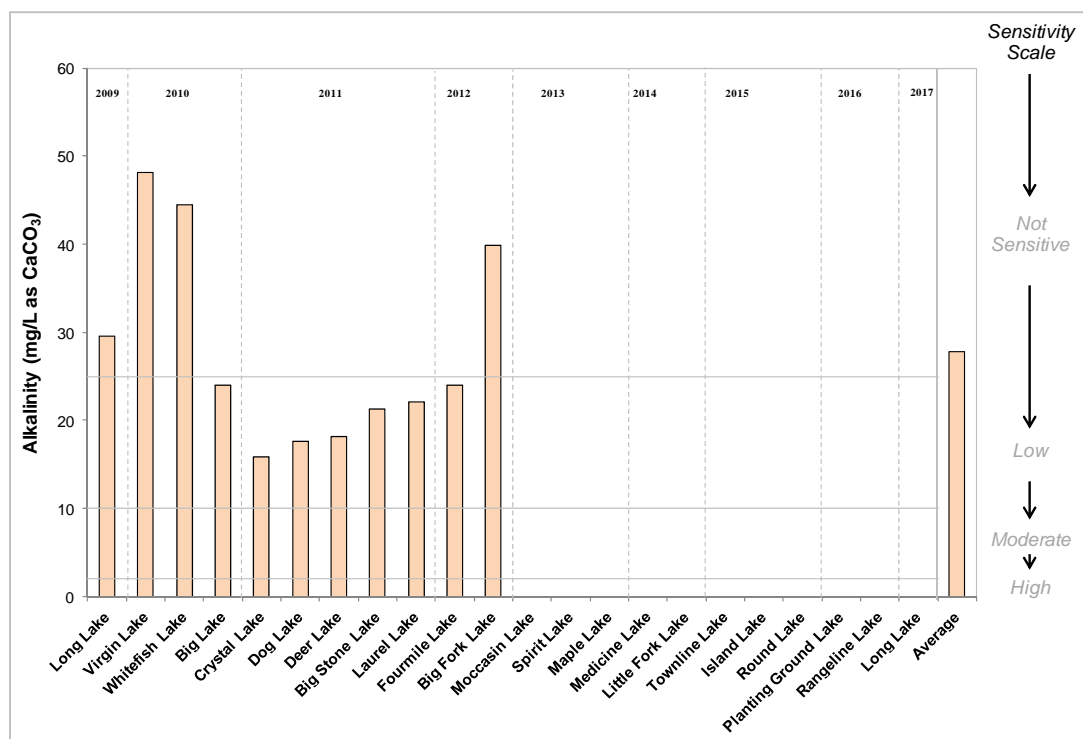


as walleye becomes inhibited (Shaw and Nimphius, 1985). The variability in pH between lakes is most likely attributable to a number of environmental factors, with the chief determiner being geology near the lake and within its surface and underground watersheds. On a smaller scale within a lake or between 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. Within the Three Lakes Chain, there is little variability between lakes, as is to be expected on a string of connected waterbodies (Figure 3.1-7). The values seen within the chain lakes are near neutral and are normal for Wisconsin lakes.



**Figure 3.1-7. Three Lakes Chain pH values.** Data collected from summer month surface samples.

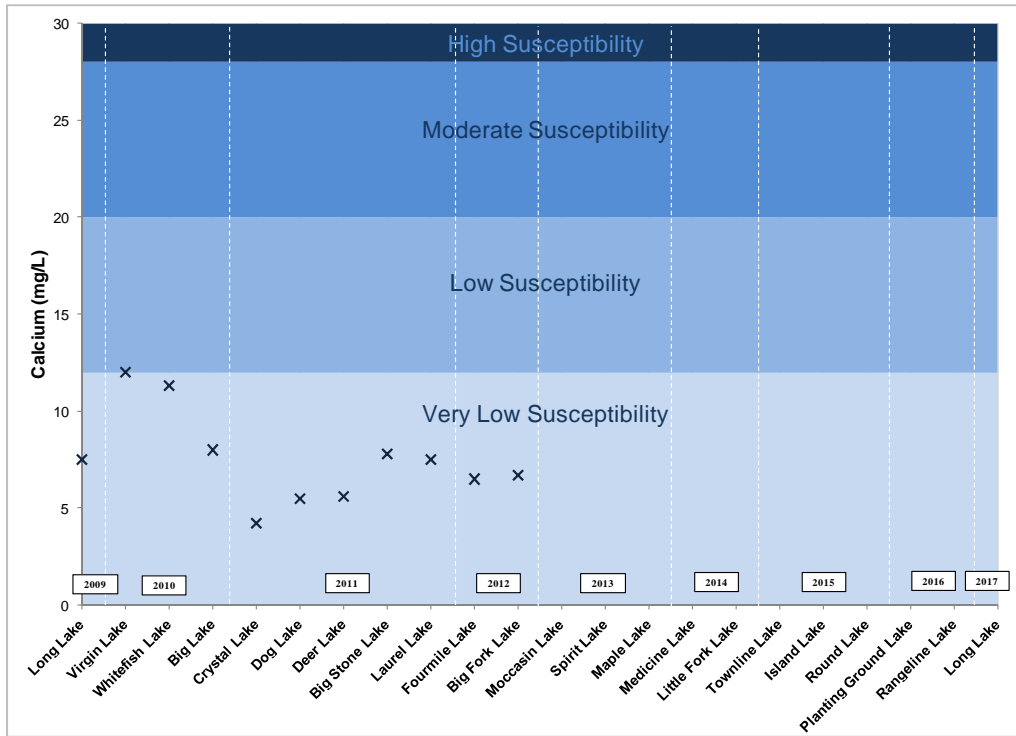
Alkalinity is a lake’s capacity to resist fluctuations in pH by neutralizing or buffering against inputs such as acid rain. The main compounds that contribute to a lake’s alkalinity in Wisconsin are bicarbonate ( $\text{HCO}_3^-$ ) and carbonate ( $\text{CO}_3^{2-}$ ), which neutralize hydrogen ions from acidic inputs. These compounds are present in a lake if the groundwater entering it comes into contact with minerals such as calcite ( $\text{CaCO}_3$ ) and/or dolomite ( $\text{CaMgCO}_3$ ). 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 is variable between the Three Lakes Chain of Lakes, but still within expected ranges for northern Wisconsin lakes (Figure 3.1-8). Alkalinity determines the sensitivity of a lake to acid rain. Values between 2.0 and 10.0 mg/L as  $\text{CaCO}_3$  are considered to be moderately sensitive to acid rain, while lakes with values of 10.0 to 25.0 mg/L as  $\text{CaCO}_3$  are considered to have low sensitivity, and lakes above 25.0 mg/L as  $\text{CaCO}_3$  are non-sensitive.



**Figure 3.1-8. Three Lakes Chain alkalinity values and acid rain sensitivity ranges.** Data collected from summer surface samples.

Like associated pH and alkalinity, the concentration of calcium within a lake's water depends on the geology of the lake's watershed. Recently, calcium concentration has been used to determine what lakes can support zebra mussel populations if they are introduced. These studies, conducted by researchers at the University of Wisconsin-Madison, have led to a suitability model called Smart Prevention (Vander Zanden and Olden 2008). This model relies on measured or estimated dissolved calcium concentration to indicate whether a given lake in Wisconsin is suitable, borderline suitable, or unsuitable for sustaining zebra mussels. Within this model, suitability was estimated for approximately 13,000 Wisconsin waterbodies and is displayed as an interactive mapping tool ([www.aissmartprevention.wisc.edu](http://www.aissmartprevention.wisc.edu)).

Nearly all the lakes within the Three Lakes Chain are suitable for zebra mussel establishment based upon pH; Crystal (Mud) Lake (pH=6.8) falls slightly outside of this range. However, as indicated on Figure 3.1-9, the calcium concentrations within the chain lakes are at the very low end for zebra mussel suitability. Virgin Lake, with calcium concentrations of 12.0 mg/L, is on the Low/Very Low Susceptibility borderline. Overall, these data indicate calcium levels may be a limiting factor in allowing the lakes within the Three Lakes Chain of Lakes to support zebra mussels, should they be introduced.



**Figure 3.1-9. Three Lakes Chain zebra mussel susceptibility analysis, based upon calcium concentration.** Created from lake surface calcium values. Calcium susceptibility range adapted from Whittier et al. 2008.

## 3.2 Watershed Assessment

### *Watershed Modeling*

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

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

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

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

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

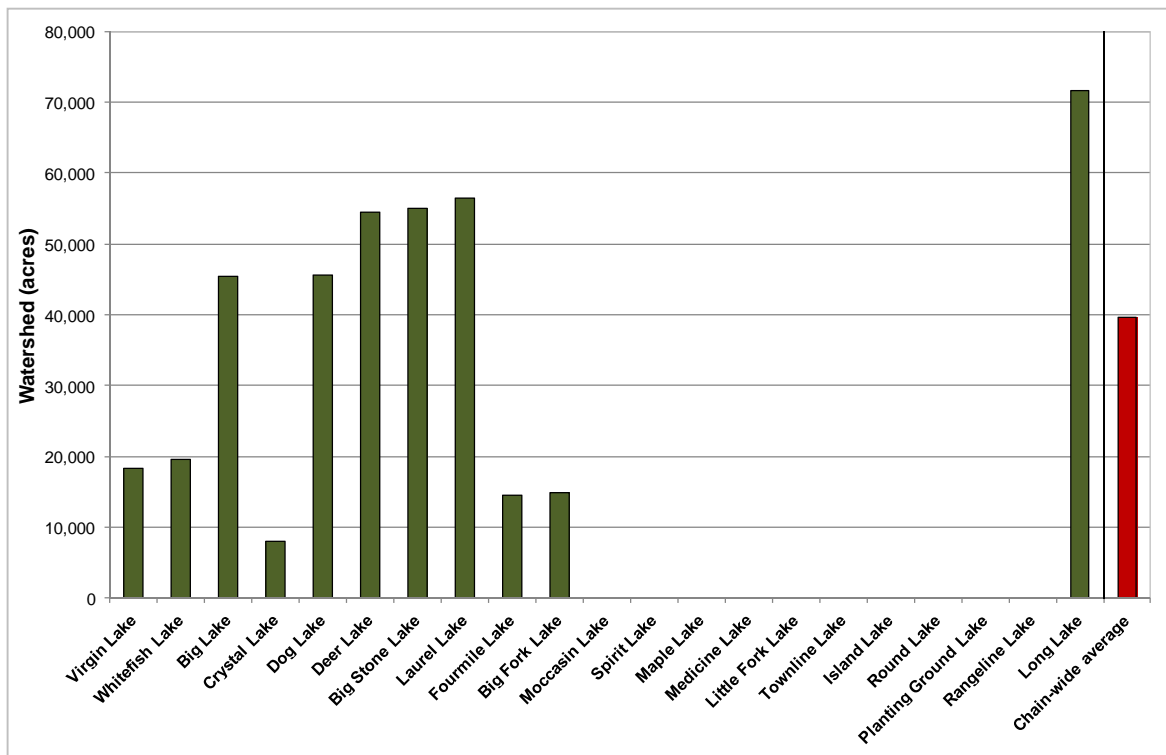
A lake's flushing rate is simply a determination of the time required for the lake's water volume to be completely exchanged. Residence time describes how long a volume of water remains in the lake and is expressed in days, months, or years. The parameters are related and both determined by the volume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

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

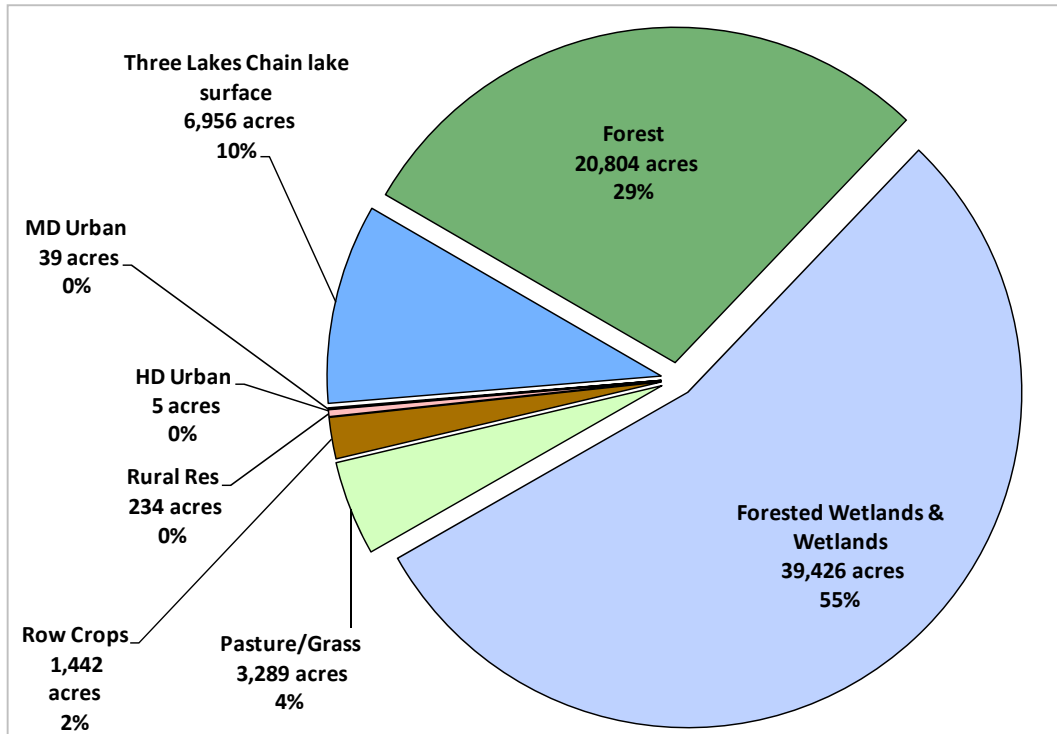
A reliable and cost-efficient method of creating a general picture of a watershed's affect on a lake can be obtained through modeling. The WDNR created a useful suite of modeling tools called the Wisconsin Lake Modeling Suite (WiLMS – Panuska, 2003). Certain morphological attributes of a lake and its 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. Predictive models are also included within WiLMS that are valuable in validating modeled phosphorus loads to the lake in question and modeling alternate land cover scenarios within the watershed. Finally, if specific information is available, WiLMS will also estimate the significance of internal nutrient loading within a lake and the impact of shoreland septic systems.

As discussed above, the size of the watershed in relation to the size of the lake can have a considerable impact on the lake's water quality. There is an incredibly large amount of land draining to each of the Three Lakes Chain lakes (Figure 3.2-1 and Map 2)The watershed to lake area ratios of the Three Lakes Chain lakes are all exceptionally large, with the smallest ratio being Big Lake at a ratio of 50:1. Approximately 72,196 acres of land drains to the Three Lakes Chain lakes, the majority (55% or 39,426 acres) of which is classified as wetland (Figure 3.2-2). Forested lands account for the second largest land cover type in the watershed (29% or 20,804 acres) while the surface of the Three Lakes Chain lakes is the third largest cover type at 10% (6,956 acres). Pasture/grass (4%) and row crops (2%) are found within the watershed to a lesser extent, while insignificant amounts of rural residential and urban areas exist as well.

*Once completed near the end of this project, phosphorus modeling results will be discussed here. Watershed modeling data will be produced in Appendix E.*



**Figure 3.2-1. Three Lakes Chain watershed size, in acres.** Lakes are arranged in approximate order of furthest upstream to furthest downstream.



**Figure 3.2-2. Three Lakes Chain watershed land cover types in acres.** Based upon National Land Cover Database (NLCD – Fry et. al 2011)

*Phosphorus loading chart will be included here once completed.*

**Figure 3.2-3. Three Lakes Chain of Lakes watershed phosphorus loading in pounds.** Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

### 3.3 Shoreland Condition

#### ***The Importance of a Lake's Shoreland Zone***

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

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

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

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

#### **Shoreland Zone Regulations**

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

#### **Wisconsin-NR 115: Wisconsin's Shoreland Protection Program**

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



shoreland ordinances. Passed in February of 2010, the final NR 115 allowed many standards to remain the same, such as lot sizes, shoreland setbacks and buffer sizes. However, several standards changed as a result of efforts to balance public rights to lake use with private property rights. The regulation sets minimum standards for the shoreland zone, and requires all counties in the state to adopt shoreland zoning ordinances of their own. County ordinances may be more restrictive than NR 115, but not less so (though Act 170 allows for less restrictive standards for existing non-conforming structures). These policy regulations require each county to amend ordinances for vegetation removal on shorelands, impervious surface standards, nonconforming structures and establishing mitigation requirements for development. Minimum requirements for each of these categories are described below. Please note that at the time of this writing, NR 115 is under review by the State of Wisconsin and updates will likely occur in February of 2014.

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

### **Wisconsin Act 31**

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

### **Shoreland Research**

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

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

Shorelands provide much in terms of nutrient retention and mitigation, but also play an important role in wildlife habitat. Woodford and Meyer (2003) found that green frog density was negatively correlated with development density in Wisconsin lakes. As development increased,

the habitat for green frogs decreased and thus populations became significantly lower. Common loons, a bird species notorious for its haunting call that echoes across Wisconsin lakes, are often associated more with undeveloped lakes than developed lakes (Lindsay et al. 2002). And studies on shoreland development and fish nests show that undeveloped shorelands are preferred as well. In a study conducted on three Minnesota lakes, researchers found that only 74 of 852 black crappie nests were found near shorelines that had any type of dwelling on it (Reed 2001). The remaining nests were all located along undeveloped shoreland.

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



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

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

### **National Lakes Assessment**

Unfortunately, along with Wisconsin’s lakes, waterbodies within the entire United States have shown to have increasing amounts of developed shorelands. The National Lakes Assessment (NLA) is an Environmental Protection Agency sponsored assessment that has successfully pooled together resource managers from all 50 U.S. states in an effort to assess waterbodies, both

natural and man-made, from each state. Through this collaborative effort, over 1,000 lakes were sampled in 2007, pooling together the first statistical analysis of the nation's lakes and reservoirs.

Through the National Lakes Assessment, a number of potential stressors were examined, including nutrient impairment, algal toxins, fish tissue contaminants, physical habitat, and others. The 2007 NLA report states that *“of the stressors examined, poor lakeshore habitat is the biggest problem in the nations lakes; over one-third exhibit poor shoreline habitat condition”* (USEPA 2009). Furthermore, the report states that *“poor biological health is three times more likely in lakes with poor lakeshore habitat”*.

The results indicate that stronger management of shoreline development is absolutely necessary to preserve, protect and restore lakes. This will become increasingly important as development pressured on lakes continue to steadily grow.

### **Native Species Enhancement**

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



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



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

### **Cost**

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

Most restoration work can be completed by the landowner themselves. To decrease costs further, bare-root form of trees and shrubs should be purchased in early spring. If additional assistance is needed, the lakefront property owner could contact an experienced landscaper. For properties with erosion issues, owners should contact their local county conservation office to discuss cost-share options. In general, a restoration project with the characteristics described below would have an estimated materials and supplies cost of approximately \$1,400. The more native vegetation a site has, the lower the cost. Owners should contact the county's regulations/zoning department for all minimum requirements. The single site used for the estimate indicated above has the following characteristics:

- Spring planting timeframe.
- 100' of shoreline.
- An upland buffer zone depth of 35'.
- An access and viewing corridor 30' x 35' free of planting (recreation area).
- Planting area of upland buffer zone 2- 35' x 35' areas
- Site is assumed to need little invasive species removal prior to restoration.
- Site has only turf grass (no existing trees or shrubs), a moderate slope, sandy-loam soils, and partial shade.
- Trees and shrubs planted at a density of 1 tree/100 sq ft and 2 shrubs/100 sq ft, therefore, 24 native trees and 48 native shrubs would need to be planted.
- Turf grass would be removed by hand.
- A native seed mix is used in bare areas of the upland buffer zone.
- An aquatic zone with shallow-water 2 - 5' x 35' areas.

- Plant spacing for the aquatic zone would be 3 feet.
- Site would need 70' of erosion control fabric to protect plants and sediment near the shoreland (the remainder of the site would be mulched).
- Soil amendment (peat, compost) would be needed during planting.
- There is no hard-armor (rip-rap or seawall) that would need to be removed.
- The property owner would maintain the site for weed control and watering.

<i>Advantages</i>	<i>Disadvantages</i>
<ul style="list-style-type: none"> <li>● Improves the aquatic ecosystem through species diversification and habitat enhancement.</li> <li>● Assists native plant populations to compete with exotic species.</li> <li>● Increases natural aesthetics sought by many lake users.</li> <li>● Decreases sediment and nutrient loads entering the lake from developed properties.</li> <li>● Reduces bottom sediment re-suspension and shoreland erosion.</li> <li>● Lower cost when compared to rip-rap and seawalls.</li> <li>● Restoration projects can be completed in phases to spread out costs.</li> <li>● Once native plants are established, they require less water, maintenance, no fertilizer; provide wildlife food and habitat, and natural aesthetics compared to ornamental (non-native) varieties.</li> <li>● Many educational and volunteer opportunities are available with each project.</li> </ul>	<ul style="list-style-type: none"> <li>● Property owners need to be educated on the benefits of native plant restoration before they are willing to participate.</li> <li>● Stakeholders must be willing to wait 3-4 years for restoration areas to mature and fill-in.</li> <li>● Monitoring and maintenance are required to assure that newly planted areas will thrive.</li> <li>● Harsh environmental conditions (e.g., drought, intense storms) may partially or completely destroy project plantings before they become well established.</li> </ul>

### **Three Lakes Chain of Lakes Shoreland Zone Condition**

#### **Shoreland Development**

The lakes within the Three Lakes Chain were surveyed as a part of this project to determine the extent of their degree of development. Lakes were visited during each appropriate phase, generally during the late summer to conduct this survey. A lake's shoreland zone can be classified based upon the amount of human disturbance (vegetation removal, construction of rip-rap or seawalls, etc.). In general, more developed shorelands are more stressful on a lake ecosystem, while definite benefits occur from shorelands that are left in their natural state. Figure 3.3-1 displays a diagram of shoreland categories, from "Urbanized", meaning the shoreland zone is completely disturbed by human influence, to "Natural/Undeveloped", meaning the shoreland has been left in its original state.

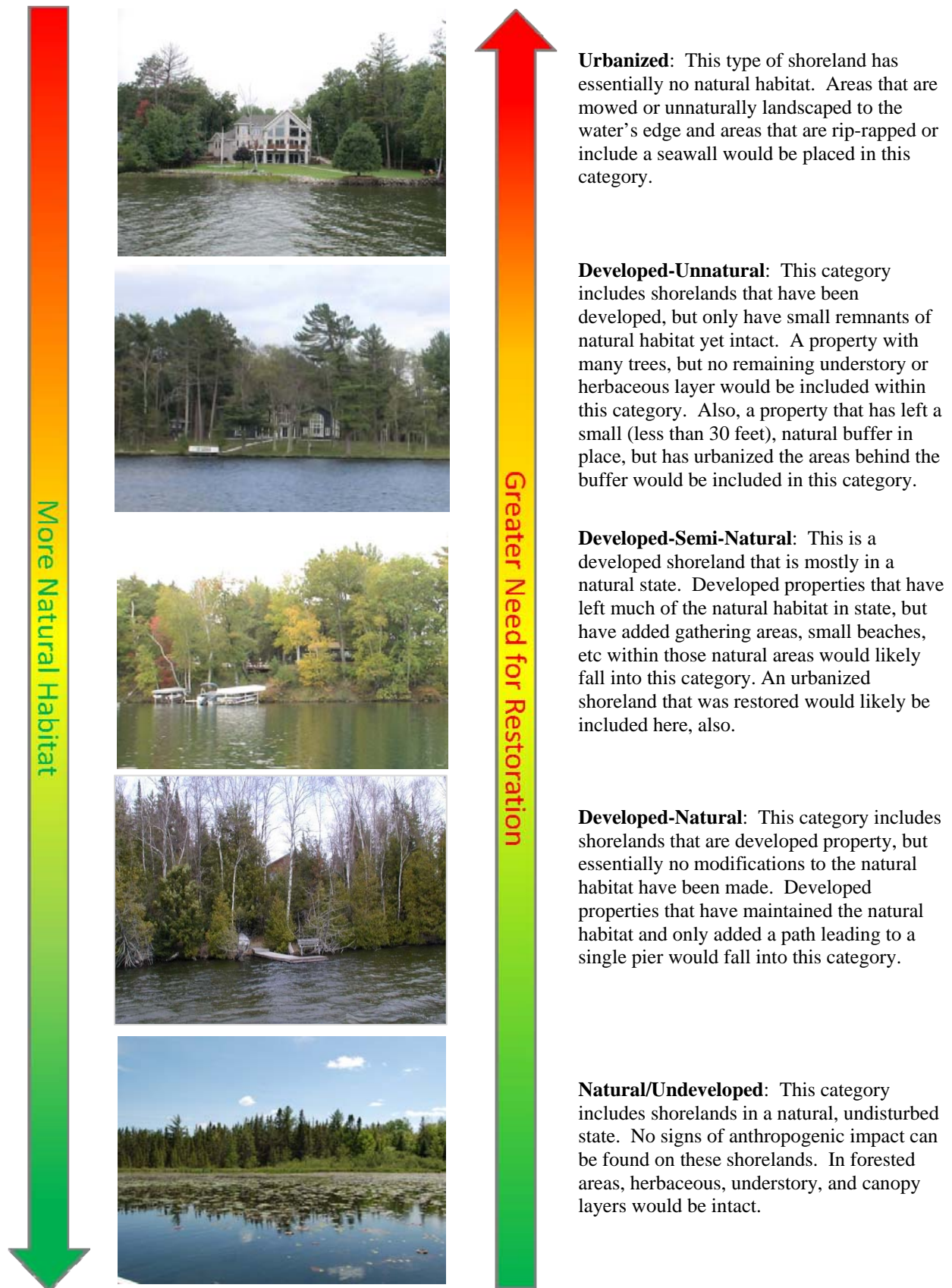
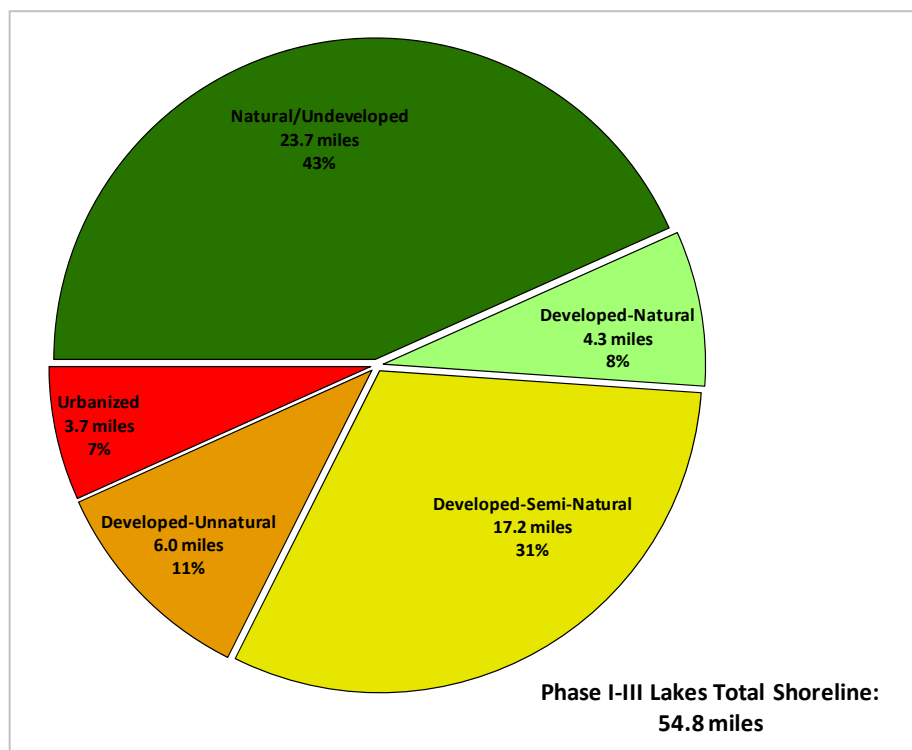


Figure 3.3-1. Shoreline assessment category descriptions.

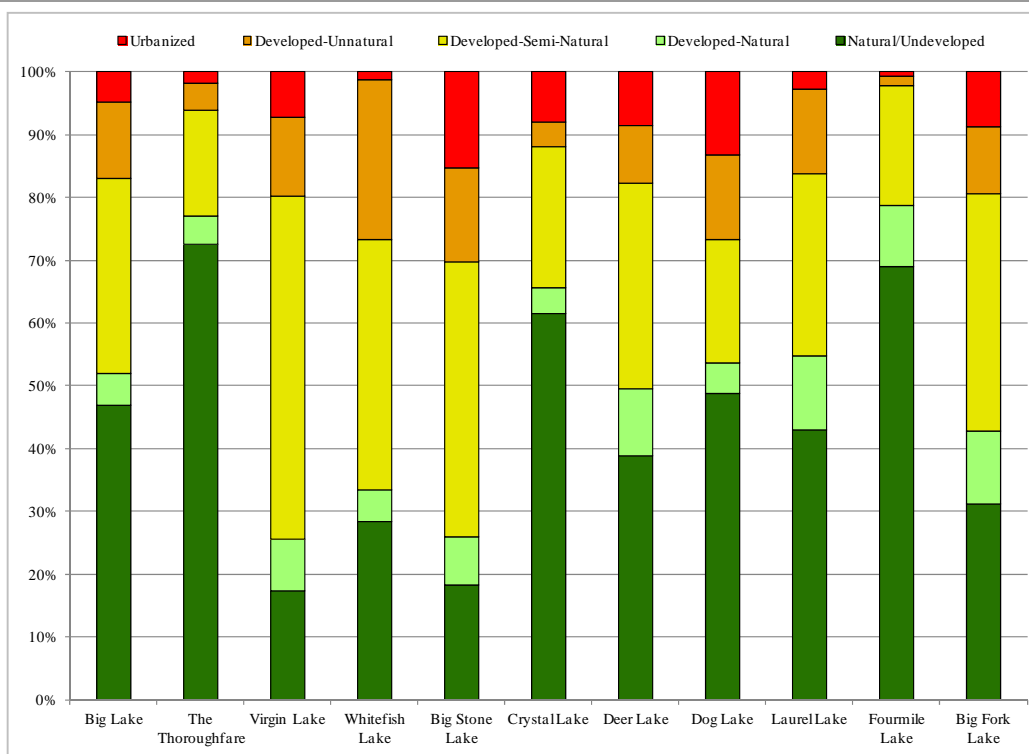
On each of Three Lakes Chain of Lakes, the development stage of the entire shoreline was surveyed during field studies using a GPS unit to map the shoreline. Onterra staff only considered the area of shoreland 35 feet inland from the water's edge, and did not assess the shoreline on a property-by-property basis. During the survey, Onterra staff examined the shoreline for signs of development and assigned areas of the shoreland one of the five descriptive categories in Figure 3.3-1.

The Three Lakes Chain of Lakes has stretches of shoreland that fit all of the five shoreland assessment categories. Some of the lakes surveyed had more areas of natural shoreline than others. In all, the Phase I, II and III Three Lakes Chain lakes contain approximately about 28 miles of natural/undeveloped and developed-natural shoreline (Figure 3.3-2). These shoreland types provide the most benefit to the lake and should be left in their natural state if at all possible. A little over 9.7 miles of urbanized and developed-unnatural shoreline were recorded during field surveys. Figure 3.3-3 provides a breakdown of each Phase I, II and III lake's shoreland condition, while each individual lake section discusses the shoreline condition further. Maps of each lake and the location of these categorized shorelands are included within each individual lake section as well.



**Figure 3.3-2. Phase I, II and III Three Lakes Chain total shoreland classification.** Based upon field surveys conducted in late summer 2010-2012.





**Figure 3.3-3. Phase I, II and III Three Lakes Chain shoreline condition breakdown.** Based upon late summer 2010-2012 field surveys. Locations of these categorized shorelands can be found on maps within each individual lake section.

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

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

## 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 rotoation, 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 Three Lakes Chain of 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 Three Lakes Chain of 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 ( $\geq 160$  acres or  $\geq 50\%$  of the lake littoral area). Additionally, it is important to note that local permits and U.S. Army Corps of Engineers regulations may also apply. For more information on permit requirements, please contact the WDNR Regional Water Management Specialist or Aquatic Plant Management and Protection Specialist.

## Manual Removal

Manual removal methods include hand-pulling, raking, and hand-cutting. Hand-pulling involves the manual removal of whole plants, including roots, from the area of concern and disposing them out of the waterbody. Raking entails the removal of partial and whole plants from the lake by dragging a rake with a rope tied to it through plant beds. Specially designed rakes are available from commercial sources or an asphalt rake can be used. Hand-cutting differs from the other two manual methods because the entire plant is not removed, rather the plants are cut similar to mowing a lawn; however Wisconsin law states that all plant fragments must be removed. One manual cutting technique involves throwing a specialized “V” shaped cutter into the plant bed and retrieving it with a rope. The raking method entails the use of a two-sided straight blade on a telescoping pole that is swiped back and forth at the base of the undesired plants.



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

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

### Cost

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

<i>Advantages</i>	<i>Disadvantages</i>
<ul style="list-style-type: none"> <li>• Very cost effective for clearing areas around docks, piers, and swimming areas.</li> <li>• Relatively environmentally safe if treatment is conducted after June 15<sup>th</sup>.</li> <li>• Allows for selective removal of undesirable plant species.</li> <li>• Provides immediate relief in localized area.</li> <li>• Plant biomass is removed from waterbody.</li> </ul>	<ul style="list-style-type: none"> <li>• Labor intensive.</li> <li>• Impractical for larger areas or dense plant beds.</li> <li>• Subsequent treatments may be needed as plants recolonize and/or continue to grow.</li> <li>• Uprooting of plants stirs bottom sediments making it difficult to conduct action.</li> <li>• May disturb benthic organisms and fish-spawning areas.</li> <li>• Risk of spreading invasive species if fragments are not removed.</li> </ul>



## 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.

<i>Advantages</i>	<i>Disadvantages</i>
<ul style="list-style-type: none"> <li>• Immediate and sustainable control.</li> <li>• Long-term costs are low.</li> <li>• Excellent for small areas and around obstructions.</li> <li>• Materials are reusable.</li> <li>• Prevents fragmentation and subsequent spread of plants to other areas.</li> </ul>	<ul style="list-style-type: none"> <li>• Installation may be difficult over dense plant beds and in deep water.</li> <li>• Not species specific.</li> <li>• Disrupts benthic fauna.</li> <li>• May be navigational hazard in shallow water.</li> <li>• Initial costs are high.</li> <li>• Labor intensive due to the seasonal removal and reinstallation requirements.</li> <li>• Does not remove plant biomass from lake.</li> <li>• Not practical in large-scale situations.</li> </ul>

## 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.

<b>Advantages</b>	<b>Disadvantages</b>
<ul style="list-style-type: none"> <li>• Inexpensive if outlet structure exists.</li> <li>• May control populations of certain species, like Eurasian water-milfoil for a few years.</li> <li>• Allows some loose sediment to consolidate, increasing water depth.</li> <li>• May enhance growth of desirable emergent species.</li> <li>• Other work, like dock and pier repair may be completed more easily and at a lower cost while water levels are down.</li> </ul>	<ul style="list-style-type: none"> <li>• May be cost prohibitive if pumping is required to lower water levels.</li> <li>• Has the potential to upset the lake ecosystem and have significant effects on fish and other aquatic wildlife.</li> <li>• Adjacent wetlands may be altered due to lower water levels.</li> <li>• Disrupts recreational, hydroelectric, irrigation and water supply uses.</li> <li>• May enhance the spread of certain undesirable species, like common reed (<i>Phragmites australis</i>) and reed canary grass (<i>Phalaris arundinacea</i>).</li> <li>• Permitting process may require an environmental assessment that may take months to prepare.</li> <li>• Unselective.</li> </ul>

## 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.



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## 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.

<b>Advantages</b>	<b>Disadvantages</b>
<ul style="list-style-type: none"> <li>• Immediate results.</li> <li>• Plant biomass and associated nutrients are removed from the lake.</li> <li>• Select areas can be treated, leaving sensitive areas intact.</li> <li>• Plants are not completely removed and can still provide some habitat benefits.</li> <li>• Opening of cruise lanes can increase predator pressure and reduce stunted fish populations.</li> <li>• Removal of plant biomass can improve the oxygen balance in the littoral zone.</li> <li>• Harvested plant materials produce excellent compost.</li> </ul>	<ul style="list-style-type: none"> <li>• Initial costs and maintenance are high if the lake organization intends to own and operate the equipment.</li> <li>• Multiple treatments are likely required.</li> <li>• Many small fish, amphibians and invertebrates may be harvested along with plants.</li> <li>• There is little or no reduction in plant density with harvesting.</li> <li>• Invasive and exotic species may spread because of plant fragmentation associated with harvester operation.</li> <li>• Bottom sediments may be re-suspended leading to increased turbidity and water column nutrient levels.</li> </ul>

### Herbicide Treatment

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



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

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



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

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

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

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

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

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

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

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

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

**Cost**

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

<i>Advantages</i>	<i>Disadvantages</i>
<ul style="list-style-type: none"> <li>• Herbicides are easily applied in restricted areas, like around docks and boatlifts.</li> <li>• Herbicides can target large areas all at once.</li> <li>• 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.</li> <li>• Some herbicides can be used effectively in spot treatments.</li> <li>• Most herbicides are designed to target plant physiology and in general, have low toxicological effects on non-plant organisms (e.g. mammals, insects)</li> </ul>	<ul style="list-style-type: none"> <li>• All herbicide use carries some degree of human health and ecological risk due to toxicity.</li> <li>• Fast-acting herbicides may cause fishkills due to rapid plant decomposition if not applied correctly.</li> <li>• 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.</li> <li>• Many aquatic herbicides are nonselective.</li> <li>• Some herbicides have a combination of use restrictions that must be followed after their application.</li> <li>• Overuse of same herbicide may lead to plant resistance to that herbicide.</li> </ul>

**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.

<i>Advantages</i>	<i>Disadvantages</i>
<ul style="list-style-type: none"> <li>• Milfoil weevils occur naturally in Wisconsin.</li> <li>• Likely environmentally safe and little risk of unintended consequences.</li> </ul>	<ul style="list-style-type: none"> <li>• Stocking and monitoring costs are high.</li> <li>• This is an unproven and experimental treatment.</li> <li>• There is a chance that a large amount of money could be spent with little or no change in Eurasian water-milfoil density.</li> </ul>

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

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

**Cost**

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

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

## **Analysis of Current Aquatic Plant Data**

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

As described in more detail in the methods section, multiple aquatic plant surveys were completed on Three Lakes Chain of 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 Three Lakes Chain of 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

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

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 Three Lakes Chain of 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.

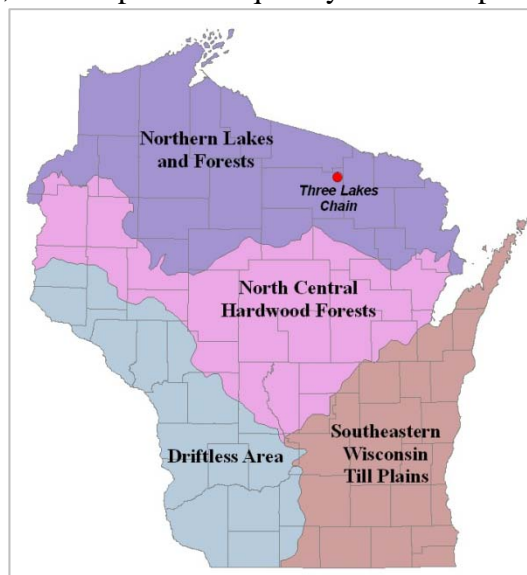


## Floristic Quality Assessment

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

Ecoregions are areas related by similar climate, physiography, hydrology, vegetation and wildlife potential. Comparing ecosystems in the same ecoregion is sounder than comparing systems within manmade boundaries such as counties, towns, or states.

The floristic quality of a lake is calculated using its species richness and average species conservatism. As mentioned above, species richness is simply the number of species that occur in the lake, for this analysis, only native species are utilized. Average species conservatism utilizes the coefficient of conservatism values for each of those species in its calculation. A species coefficient of conservatism value indicates that species likelihood of being found in an undisturbed (pristine) system. The values range from one to ten. Species that are normally found in disturbed systems have lower coefficients, while species frequently found in pristine systems have higher values. For example, cattail, an invasive native species, has a value of 1, while common hard and softstem bulrush have values of 5, and Oakes pondweed, a sensitive and rare species, has a value of 10. On their own, the species richness and average conservatism values for a lake are useful in assessing a lake's plant community; however, the best assessment of the lake's plant community health is determined when the two values are used to calculate the lake's floristic quality. The floristic quality is calculated using the species richness and average conservatism value of the aquatic plant species that were solely encountered on the lake during the point-intercept survey and does not include incidental species or those encountered during other aquatic plant surveys.



**Figure 3.4-1. Location of Three Lakes Chain within the ecoregions of Wisconsin.**  
After Nichols 1999.

## Community Mapping

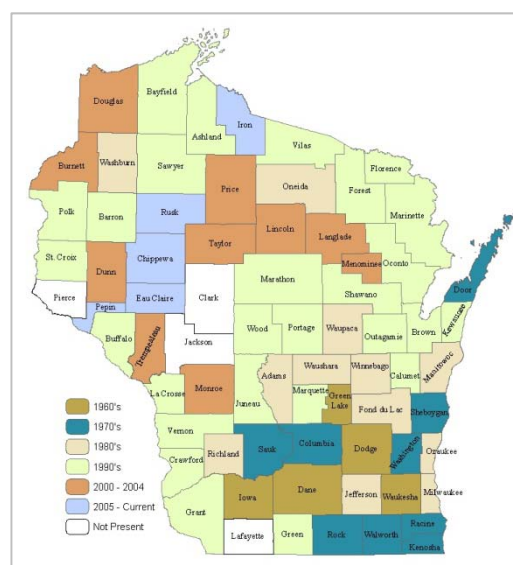
A key component of the aquatic plant survey is the creation of an aquatic plant community map. The map represents a snapshot of the important plant communities in the lake as they existed during the survey and is valuable in the development of the management plan and in comparisons with surveys completed 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.

## **Aquatic Plant Survey Results**

Numerous plant surveys were completed as a part of this project. In June of each year, early-season aquatic invasive species surveys were completed on each project lake for that year. This meander-based survey is done at this time to coincide with the peak-growth period of curly-leaf pondweed. Additionally, during this time of the year Eurasian water milfoil is taller in the water column than native plants so it may be easier to pick out should it be present. This meander-based survey did not locate any occurrences of curly-leaf pondweed within any of the project lakes. It is believed that this aquatic invasive species either does not occur in Three Lakes Chain of Lakes or exists at an undetectable level. However, curly-leaf pondweed does exist in several nearby lakes, including Little Saint Germain, Kentuck and Pine Lakes. On some project lakes, an emergent invasive plant – pale yellow iris (*Iris pseudocorus*) was spotted and its geospatial locations marked. Discussion of this plant takes place at the end of this section and in the appropriate individual lake sections.

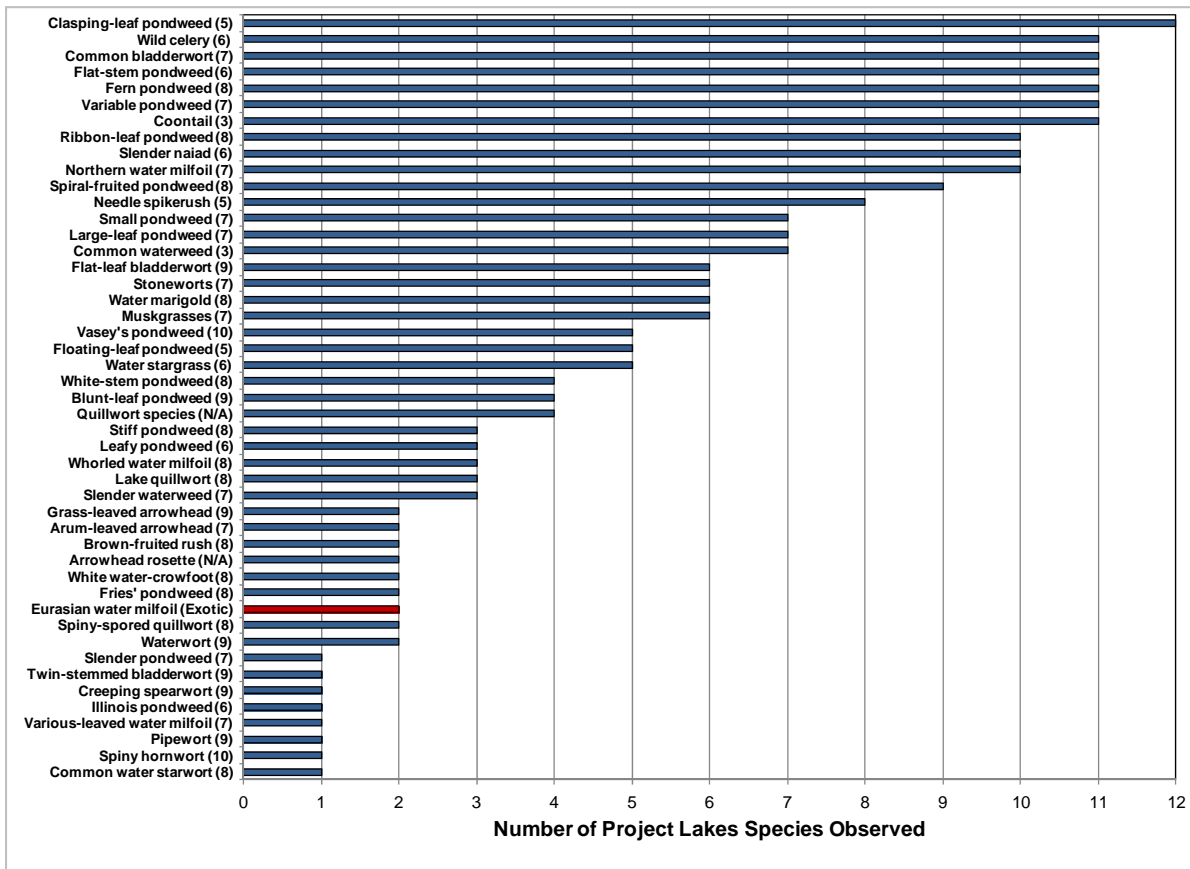
The point intercept surveys were conducted on the Three Lakes Chain of Lakes in the months of July and August of each project year by Onterra. Additional surveys were completed during this time by Onterra to create the aquatic plant community maps (See “Aquatic Plant Community Map” after each individual lake section). Aquatic plant point-intercept survey data may be viewed in Appendix F.

A total of 92 different plant species were identified from the 11 Phase I, II and III lakes involved with this project, as well as Long Lake, which completed a management planning project in 2009 (Figures 3.4-3, 3.4-4). The submergent pondweed species, clasping-leaf pondweed, was found within all 12 of these lakes. Five emergent or floating-leaf species were found within all 12 lakes as well. Many species were found only occasionally; 22 species were found within only one of the 12 lakes. This adds testament to the individuality of each of the lakes, even though essentially they are all part of the same chain of lakes. One aquatic plant located within five of these lakes is considered to be particularly rare –Vasey’s Pondweed (*Potamogeton vaseyi* – Photo 3.4-1). This species is listed as a species of special concern by the Natural Heritage Inventory Program. As the project continues on with Phase IV - Phase VII, this analysis will be expanded to encompass the lakes as they are studied.

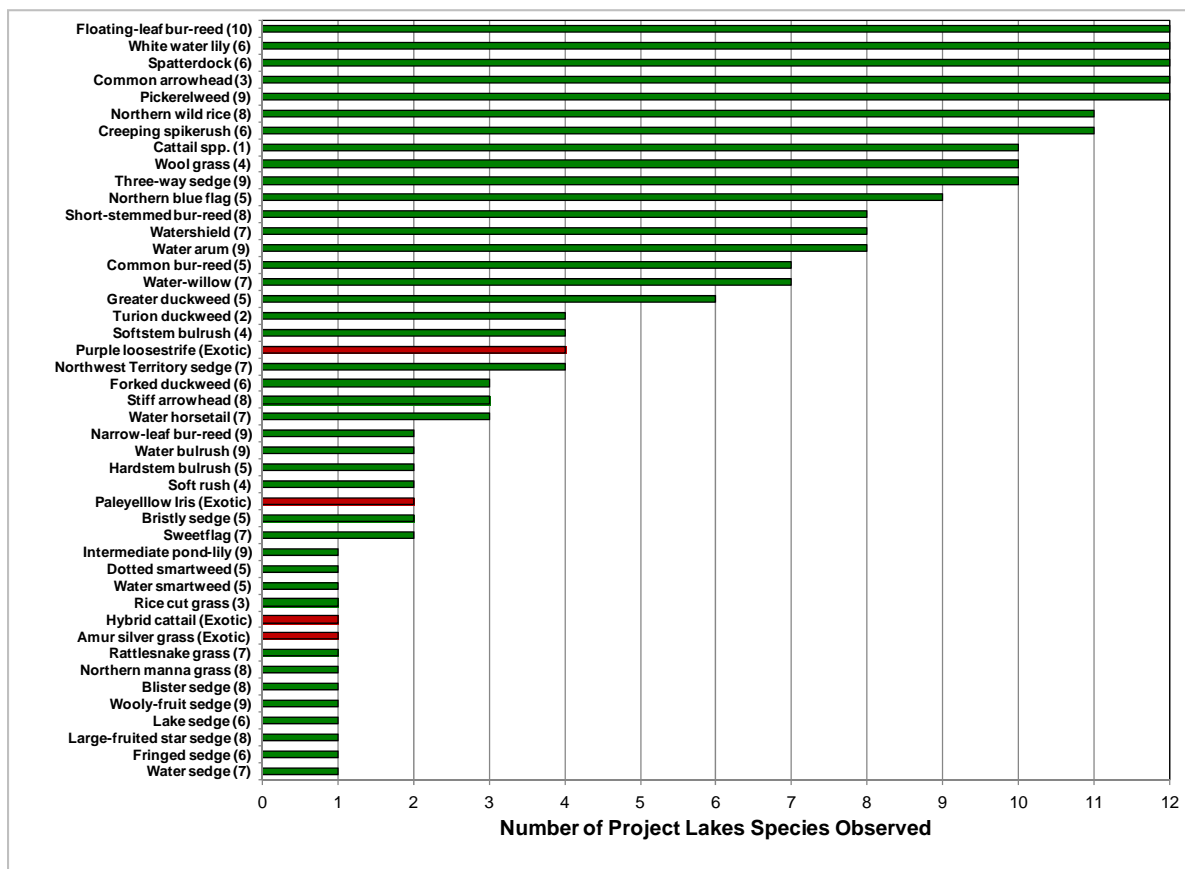
Five of the species found during the plant surveys are considered non-native, invasive species: Eurasian water milfoil was the only submergent exotic plant found within the chain (Virgin Lake and the Long Lake Channel). Several emergent exotic plants were found, including purple loosestrife, located on the margins of Laurel, Long, Big Stone and Big Lake, hybrid cattail, located along Long Lake, and Amur silver grass, located on the shoreline of Big Lake. In 2012, another invasive emergent plant, pale yellow iris, was found along much of the Big Fork Lake shoreline and in areas of Fourmile Lake as well. Another species, sweetflag, was once classified as exotic (not quite “invasive”), but now is thought to have become naturalized with the native flora found in the upper United States. Because of their importance, the exotic species will be discussed in depth within the individual lake vegetation sections.



Photo 3.4-1 Special concern species Vasey's pondweed (*Potamogeton vaseyi*).



**Figure 3.4-3 Three Lakes Chain submergent aquatic plant species occurrence.** Created using data from point intercept and community mapping surveys. Exotic species indicated with red. Native species' coefficients of conservatism (C) are in parentheses.  
\* State species of special concern



**Figure 3.4-4 Three Lakes Chain emergent, floating-leaf and free-floating aquatic plant species occurrence.** Created using data from point intercept and community mapping surveys. Exotic species indicated with red. Native species' coefficients of conservatism (C) are in parentheses.

*\*Sweetflag, an exotic plant, is now thought to be naturalized in Wisconsin.*

The Three Lakes Chain of Lakes vary somewhat in their physical, biological and chemical attributes. Even though all of the lakes are connected, there is some variance in substrate, nutrient concentrations, algae concentrations, pH, clarity, alkalinity and watershed/shoreland characteristics. The substrate and water chemical composition of a lake influences aquatic plant species composition and abundance, and has the ability to create completely different plant communities among lakes that may be located across the street from each other. Generally speaking, lakes can be divided into two main groups based upon their plant community composition: 1) lakes that are dominated by plants of the isoetid growth form, and 2) lakes dominated by plants of the elodeid growth form.

Plant species of the isoetid growth form are small, slow growing, inconspicuous submerged plants that have evergreen leaves located in a rosette and are usually found growing in sandy soils within the near-shore areas of a lake (Boston and Adams 1987, Vestergaard and Sand-Jensen 2000). Some isoetid species found in the Three Lakes Chain of Lakes include pipewort, brown-fruited rush and needle spikerush. Conversely, submerged species of the elodeid growth form have leaves on tall, erect stems which grow up into the water column. The elodeid growth



form includes plants such as common waterweed, coontail and many varieties of pondweeds and milfoils.

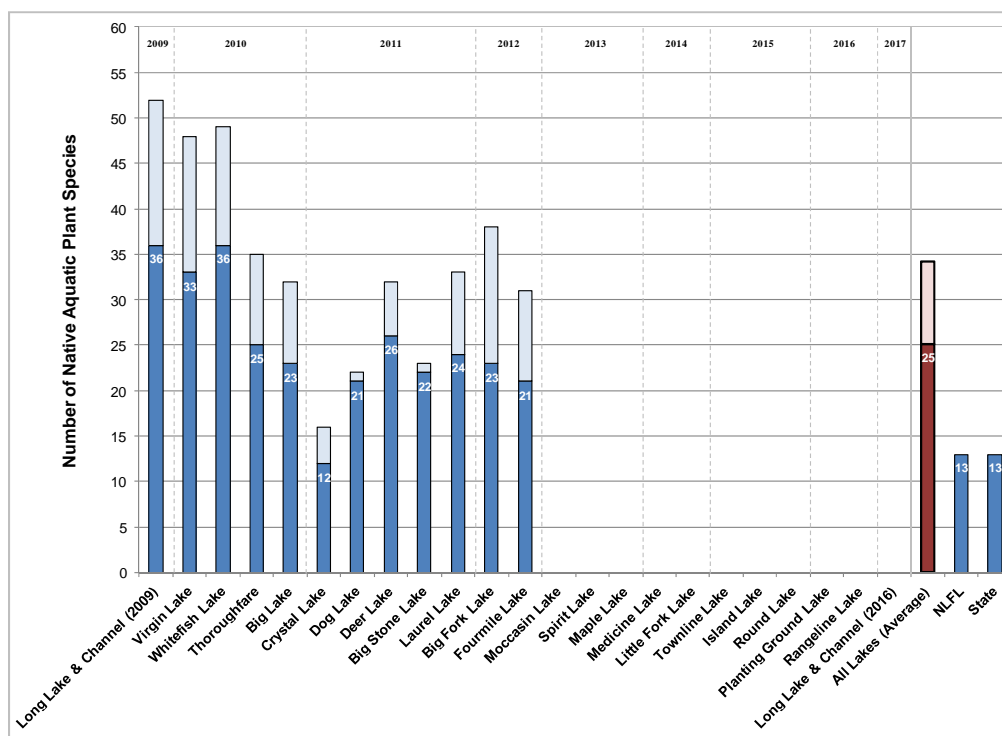
Alkalinity is the primary water chemistry factor determining whether a lake is dominated by plant species of the isoetid or elodeid growth form (Vestergaard and Sand-Jensen 2000). As mentioned in the Water Quality Section, alkalinity measures the concentration of calcium carbonate ( $\text{CaCO}_3$ ) in the lake water and is a close descriptor of the amount of bicarbonate present. Isoetids, unable to use bicarbonate as source of carbon for photosynthesis, are typically found in lakes of lower alkalinity as they are adapted to grow in areas where carbon is limited. Through an extensive, permeable root system, isoetids are able to release oxygen into the sediment. This stimulates microbial decomposition while decreasing sediment pH (Urban et al. 2006). In turn, the decomposition process increases sediment carbon, which is not useable by plants of the elodeid growth form.

In lakes with higher alkalinity, elodeids grow in abundance as they are able to utilize the bicarbonate as a carbon source. In lakes with moderate alkalinity levels, both elodeids and isoetids may be found. While some of the project lakes displayed these alkalinity levels, most lakes were overwhelmingly dominated by elodeid plants, with instances of isoetid plants being found occasionally. While isoetid species are physically able to grow in lakes with higher alkalinity, their short stature makes them susceptible to shading from the much taller, leafy elodeid species which often restricts their growth to shallow, wave-exposed sites with coarse sediments (Vestergaard and Sand-Jensen 2000). Floating-leaf species, such as spatterdock and white water lily, obtain most of their carbon from the atmosphere, allowing them to be prevalent in most Wisconsin lakes.

Increases in alkalinity and sedimentation from residential development around a lake may result in creating a more suitable habitat for the taller elodeids, displacing isoetid species. As a result, many of the isoetid species have higher conservatism values as they are intolerant of disturbance and are indicators of high quality lake environments. Isoetid dominated lakes tend to be lower in species richness than elodeid dominated lakes. In general, the lakes within the Three Lakes Chain may be described as elodeid dominated lakes.

In the Three Lakes Chain of Lakes, the number of species observed per lake varied from 16 species in Crystal (Mud) Lake to 52 native species in Long Lake & the Eagle River Channel, with an average of 34 species per lake (Figure 3.4-5). Please note that Figure 3.4-5 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. 11 of the 12 Phase I-III lakes met or exceeded the Northern Lakes Ecoregion median for species richness. Crystal (Mud) Lake, with 12 native species, fell just short of this standard comparison level. Plant growth may be limited in this lake due to its exceptionally discolored water and mucky substrate, which limits the depth and available littoral habitat for some plant species.

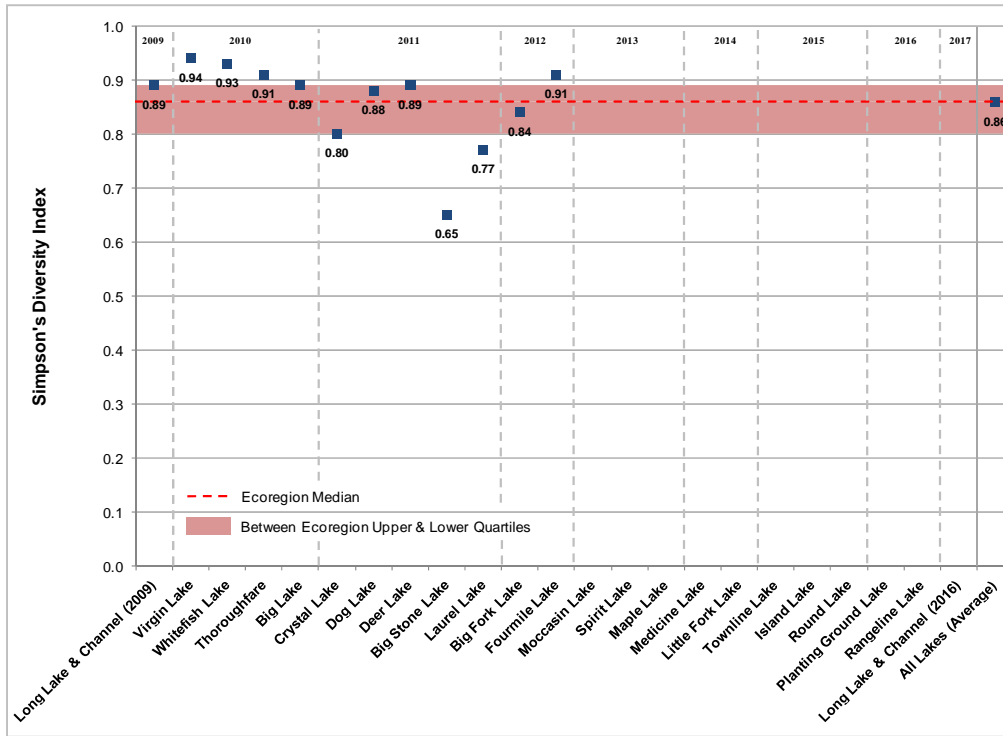




**Figure 3.4-5 Three Lakes Chain native species richness.** Created using data from summer point-intercept and community mapping surveys. Chart includes incidental species (light colored bars). Note that NLFL is the Northern Lakes and Forests Lakes ecoregion after Nichols (1999).

Like species richness, the Three Lakes Chain of Lakes had a wide range of plant species diversity (Figure 3.4-6). 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 0.65 to 0.94 in the Three Lakes Chain of Lakes (Figure 3.4-6). Big Stone Lake, even with having moderate species richness, has a relatively low diversity value due to the distribution of plants within the lake. As discussed within the Big Stone Lake Aquatic Plant Section, wild celery dominates the plant community with a relative frequency of 58%. In comparison, Virgin Lake (Simpson's Diversity value of 0.94) has high distribution of the most commonly found plants; the most common plants in this lake have a relative frequency of 9%. 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 Three Lakes Chain of lakes' scores rank. Using data obtained from WDNR Science Services, median values and upper/lower quartiles were calculated for 109 lakes within the Northern Lakes and Forests ecoregion (Figure 3.4-6). Eight of the lakes rank above the median for the ecoregion, and ten of the lakes are either within the upper and lower quartile value range, or above it.

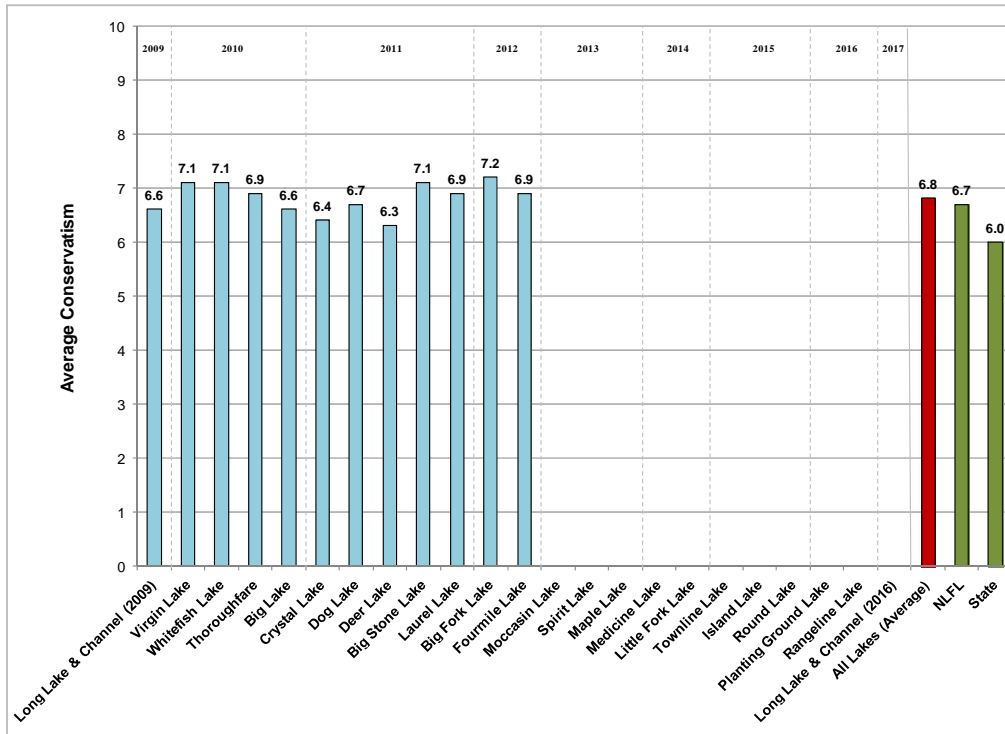


**Figure 3.4-6 Three Lakes Chain species diversity index.** Created using data from summer point-intercept surveys. Ecoregion data provided by WDNR Science Services.

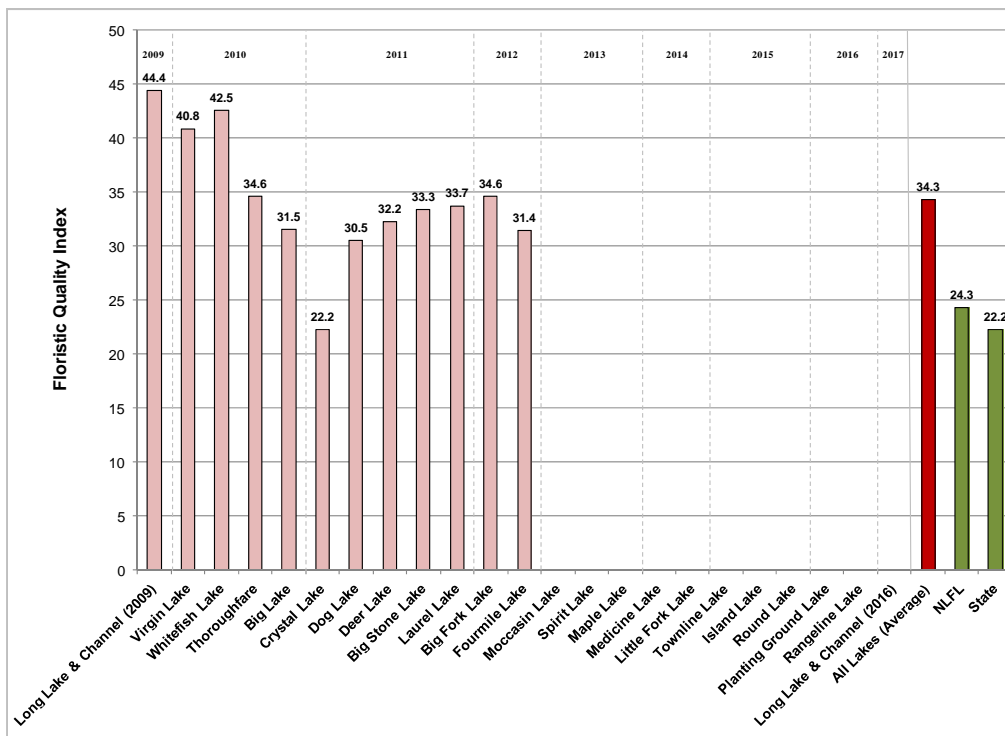
Data collected from the aquatic plant surveys indicated that many of the lakes met or exceed the Northern Lakes Ecoregion median and all project lakes surveyed met or exceeded the state median for average plant species' conservatism values (Figure 3.4-7). This means the majority of the project lakes have plant communities that are more indicative of a pristine condition than those found in most lakes in the state and the ecoregion. The lakes that fell below the ecoregion median had higher nutrient levels and reduced light availability, supporting mainly disturbance-tolerant plant species (e.g., coontail, flat-stem pondweed) and fewer sensitive species.

Combining the species richness and average conservatism values for each project lake to produce the Floristic Quality Index (FQI) resulted in a range of values from 22.2 to 44.4, with an average of 34.3 (equation shown below) (Figure 3.4-8). All of the project lakes but Crystal (Mud) Lake exceed the state and ecoregion median FQI value. Again, this illustrates that the Three Lakes Chain of lakes have high quality plant communities.

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



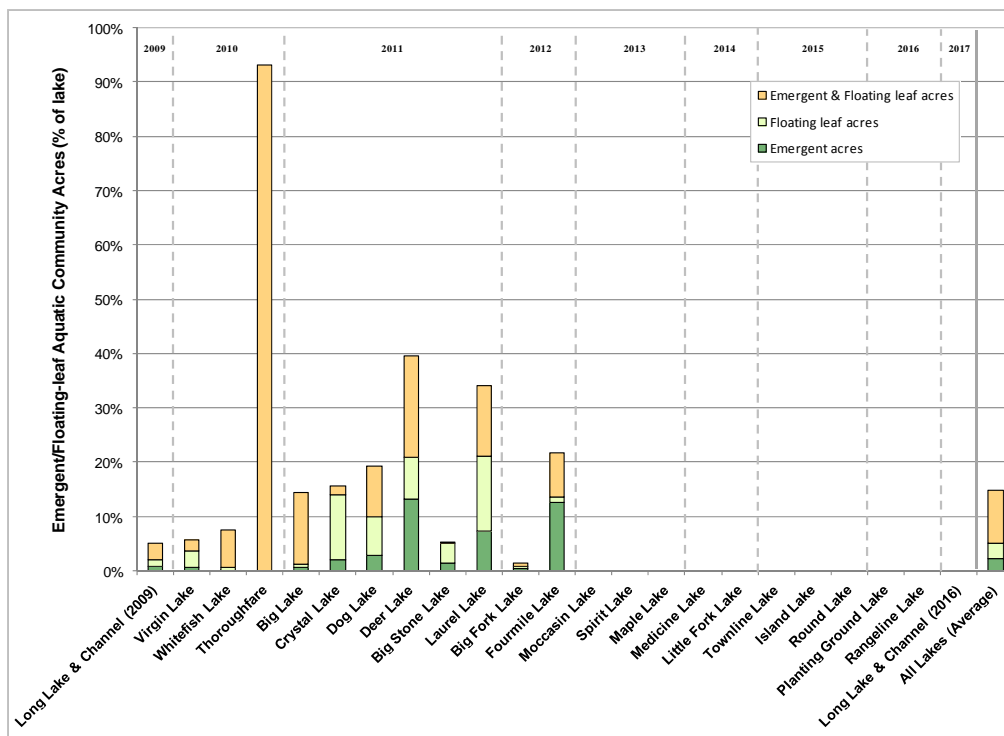
**Figure 3.4-7 Three Lakes Chain average native species’ coefficients of conservatism.** Created using data from summer point-intercept surveys. Note that NLFL is the Northern Lakes and Forests Lakes ecoregion after Nichols (1999).



**Figure 3.4-8. Three Lakes Chain Floristic Quality Assessment.** Created using data from summer point-intercept surveys. Note that NLFL is the Northern Lakes and Forests Lakes ecoregion after Nichols (1999).

As illustrated in the analyses above, the plant communities within the Three Lakes Chain are generally of high quality. One of the biggest advantages of having a healthy plant community in a lake is the habitat value it provides. 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.

Many of the Three Lakes Chain lakes contain large areas of these plant communities. Figure 3.4-9 displays the percent of lake acreage occupied by either emergent, floating-leaf, or a combined emergent and floating-leaf plant communities. The Thoroughfare, a shallow passageway between Virgin and Whitefish Lakes, has an incredible 93% of its total acreage covered by both emergent and floating-leaf plant communities. Big Fork Lake, a large, open waterbody with fairly steeply sloped banks only has 1% of its acreage covered by these community types. Should a community mapping survey be completed again in the future, data may be compared to tell, qualitatively and quantitatively, if any changes in these plant communities have occurred. Currently, Long Lake is scheduled for a management plan update in 2017.



**Figure 3.4-9. Three Lakes Chain emergent and floating-leaf aquatic plant communities.** Created using data from summer community mapping surveys.

### 3.5 Fisheries Data Integration

Fishery management is an important aspect in the comprehensive management of a lake ecosystem; therefore, a brief summary of available data is included here as reference. The following section is not intended to be a comprehensive plan for the lake's fishery, as those aspects are currently being conducted by the numerous fisheries biologists overseeing Three Lakes Chain of Lakes. The goal of this section is to provide an incomplete overview of some of the data that exists, particularly in regards to specific issues (e.g. spear fishery, fish stocking, angling regulations, etc) that were brought forth by the TLWA stakeholders within the stakeholder survey and other planning activities. Although current fish data were not collected, the following information was compiled based upon data available from the WDNR and the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) (WDNR 2012B & GLIFWC 2012A and 2012B).

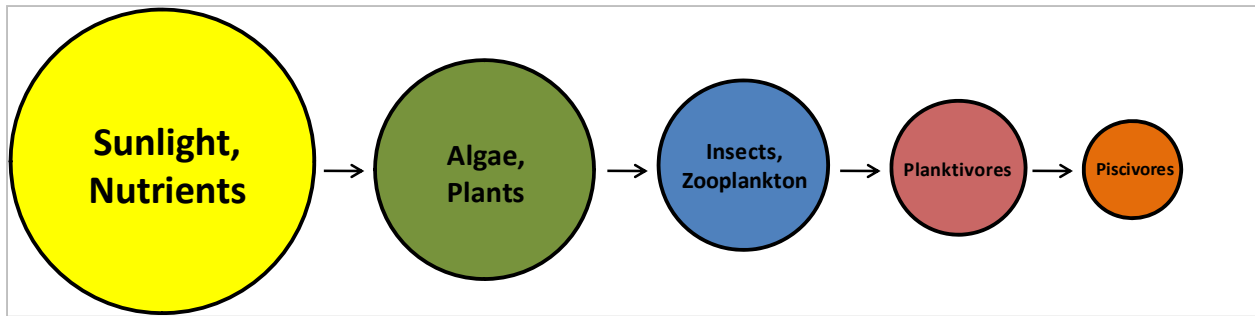
#### Three Lakes Chain of Lakes Fishing Activity

Based on data collected from the stakeholder survey (Appendix B), fishing was the second highest ranked important or enjoyable activity on the Three Lakes Chain of Lakes (Question #10). Approximately 69% of these same respondents believed that the quality of fishing on the lake is fair or good (Question #7); however, approximately 87% believe that the quality of fishing has remained the same or gotten worse since they started fishing the lake (Question #8).

Table 3.5-1 is a list of popular game fish that are present in many northern Wisconsin lakes. The Three Lakes Chain of Lakes is host to many of these species. On some northern Wisconsin lakes, management actions aimed at controlling exotic plant species or excessive native aquatic plant species are utilized and include either herbicide applications or mechanical harvesting. While the Implementation Plan will discuss these specific management actions as they relate to any of the Three Lakes Chain of Lakes, it should be noted that these measures are planned in a manner that reduces their potential impact on the system's fishery. Herbicide applications usually occur in May when the water temperatures are below 65°F, while mechanical harvesting occurs in mid-June and later. The goal is to reduce the impact upon the spawning environment which would be to remove the submergent plants that are actively growing at these low water temperatures. Species that spawn in late spring or early summer may be impacted as water temperatures and spawning locations often overlap, and vital nursery areas for emerged fry could become vulnerable. Yellow perch and muskellunge are examples of species that could potentially be affected by early season herbicide applications, as the treatments could eliminate spawning substrate or nursery areas for the emerged fry.

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

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



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

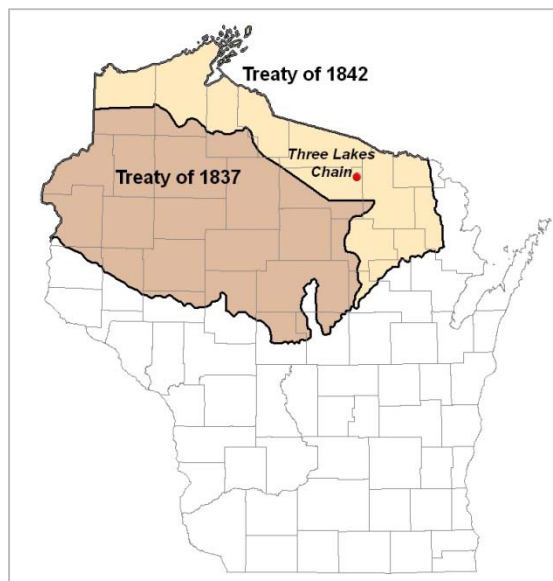
As discussed in the Water Quality section, Three Lakes Chain of Lakes is a mesotrophic to eutrophic system, meaning it has high nutrient content and thus relatively high primary productivity. Simply put, this means Three Lakes Chain of Lakes should be able to support sizable populations of predatory fish (piscivores) because the supporting food chain is relatively robust.

**Table 3.5-1. Common gamefish present in Northern Wisconsin Lakes with biological information** (Becker, 1983).

Common Name	Scientific Name	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Black Bullhead	<i>Ictalurus melas</i>	5	April - June	Matted vegetation, woody debris, overhanging banks	Amphipods, insect larvae and adults, fish, detritus, algae
Black Crappie	<i>Pomoxis nigromaculatus</i>	7	May - June	Near <i>Chara</i> or other vegetation, over sand or fine gravel	Fish, cladocera, insect larvae, other invertebrates
Bluegill	<i>Lepomis macrochirus</i>	11	Late May - Early August	Shallow water with sand or gravel bottom	Fish, crayfish, aquatic insects and other invertebrates
Largemouth Bass	<i>Micropterus salmoides</i>	13	Late April - Early July	Shallow, quiet bays with emergent vegetation	Fish, amphipods, algae, crayfish and other invertebrates
Muskellunge	<i>Esox masquinongy</i>	30	Mid April - Mid May	Shallow bays over muck bottom with dead vegetation, 6 - 30 in.	Fish including other muskies, small mammals, shore birds, frogs
Northern Pike	<i>Esox lucius</i>	25	Late March - Early April	Shallow, flooded marshes with emergent vegetation with fine leaves	Fish including other pike, crayfish, small mammals, water fowl, frogs
Pumpkinseed	<i>Lepomis gibbosus</i>	12	Early May - August	Shallow warm bays 0.3 - 0.8 m, with sand or gravel bottom	Crustaceans, rotifers, mollusks, flatworms, insect larvae (terrestrial and aquatic)
Rock Bass	<i>Ambloplites rupestris</i>	13	Late May - Early June	Bottom of coarse sand or gravel, 1 cm - 1 m deep	Crustaceans, insect larvae, and other invertebrates
Smallmouth Bass	<i>Micropterus dolomieu</i>	13	Mid May - June	Nests more common on north and west shorelines over gravel	Small fish including other bass, crayfish, insects (aquatic and terrestrial)
Walleye	<i>Sander vitreus</i>	18	Mid April - Early May	Rocky, wavewashed shallows, inlet streams on gravel bottoms	Fish, fly and other insect larvae, crayfish
White Crappie	<i>Pomoxis annularis</i>	13	May - June	Within 10 m from shore, over hard clay, gravel, or roots	Crustaceans, insects, small fish
Yellow Bullhead	<i>Ameiurus natalis</i>	7	May - July	Heavy weeded banks, beneath logs or tree roots	Crustaceans, insect larvae, small fish, some algae
Yellow Perch	<i>Perca flavescens</i>	13	April - Early May	Sheltered areas, emergent and submergent veg	Small fish, aquatic invertebrates



Approximately 22,400 square miles of northern Wisconsin was ceded to the United States by the Lake Superior Chippewa tribes in 1837 and 1842 (Figure 3.5-2). The Three Lakes Chain falls within the ceded territory based on the Treaty of 1842. This allows for a regulated open water spear fishery by Native Americans on specified systems. This highly structured process begins with an annual meeting between tribal and state management authorities. Reviews of population estimates are made for ceded territory lakes, and then an “allowable catch” is established, based upon estimates of a sustainable harvest of the fishing stock (age 3 to age 5 fish). This figure is usually about 35% of a lake's fishing stock, but may vary on an individual lake basis. In lakes where population estimates are out of date by 3 years, a standard percentage is used. The allowable catch number is then reduced by a percentage agreed upon by biologists that reflects the confidence they have in their population estimates for the particular lake. This number is called the “safe harvest level”. The safe harvest is a conservative estimate of the number of fish that can be harvested by a combination of tribal spearing and state-licensed anglers. The safe harvest is then multiplied by the Indian communities claim percent, or declaration. This result is called the quota, and represents the maximum number of fish that can be taken by tribal spearers (Spangler, 2009). Daily bag limits for walleye are then reduced for hook-and-line anglers to accommodate the tribal quota and prevent over-fishing. Bag limits reductions may be increased at the end of May on lakes that are lightly speared. The tribes have historically selected a percentage which allows for a 2-3 daily bag limit for hook-and-line anglers (USDI 2007). Tribal spearers may only take two walleyes over twenty inches per nightly permit; one between 20 and 24 inches and one of any size over 20 inches (GLIWC 2012B). This regulation limits the harvest of the larger, spawning female walleye.



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

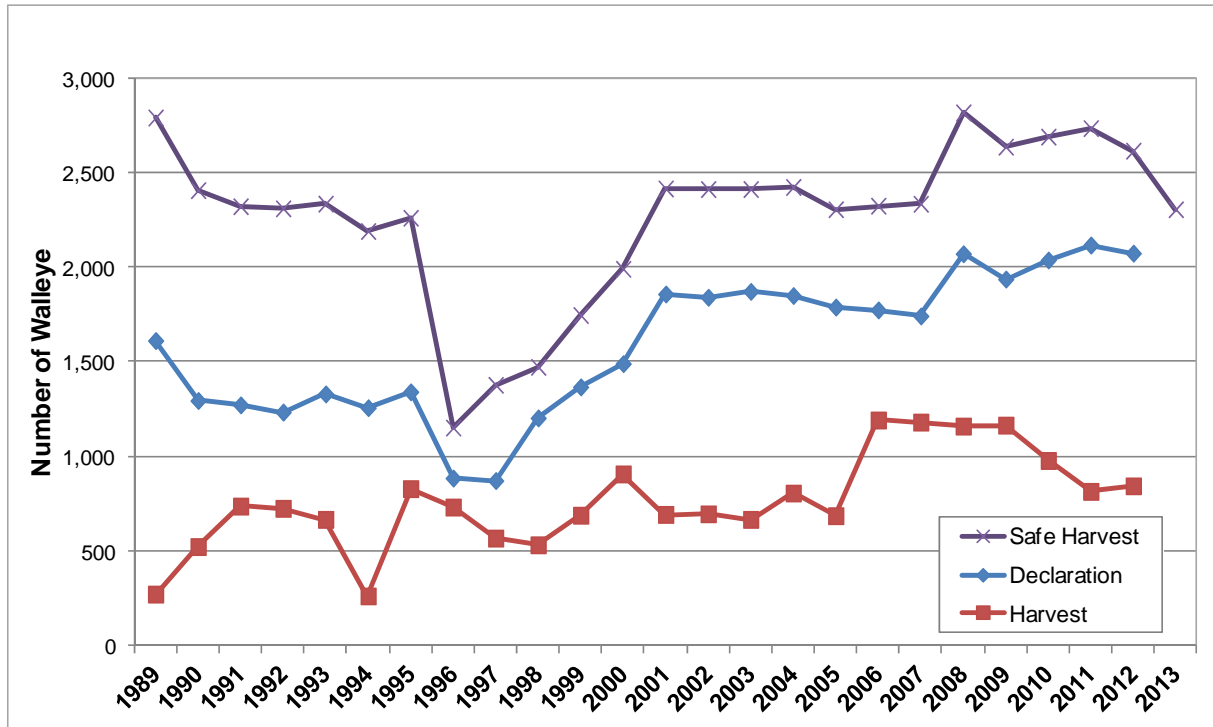
Spearers are able to harvest muskellunge, walleye, northern pike, and bass during the open water season. The spear harvest is monitored through a nightly permit system and a complete monitoring of the harvest (GLIFWC 2012B). Creel clerks and tribal wardens are assigned to each lake at the designated boat landing. A catch report is completed for each boating party upon return to the boat landing. In addition to counting every fish harvested, the first 100 walleye (plus all those in the last boat) are measured and sexed. An updated nightly quota is determined each morning by 9 a.m. based on the data collected from the successful spearers. Harvest of a particular species ends once the quota is met or the season ends. In 2011, a new reporting requirement went into effect on lakes with smaller quotas. Starting with the 2011 spear harvest season, on lakes with a harvestable quota of 75 or fewer fish, reporting of harvests may take place at a location other than the landing of the speared lake.

While a safe harvest level and quota have been established on all lakes at some time between 1989 and present time, not all lakes within the chain have experienced a spearfishing harvest. Lakes with no recorded walleye harvest over this time period include Deer, Dog, Maple, Moccasin, Crystal (Mud), Rangeline and Townline Lakes. Table 3.5-2 displays the walleye and muskellunge harvest frequency during the past 24 years in which data has been recorded. As seen on this table, the lakes that have historically seen a higher spear harvest include most of the larger bodied lakes in the chain – Big, Big Fork, Big Stone, Little Fork, Long, Medicine, and Planting Ground lakes.

**Table 3.5-2. Native American spear harvest frequency on the Three Lakes Chain.** The table summarizes the years in which each lake has experienced a walleye or muskellunge harvest. Data provided by WDNR fisheries staff (T. Cichosz, personal communication).

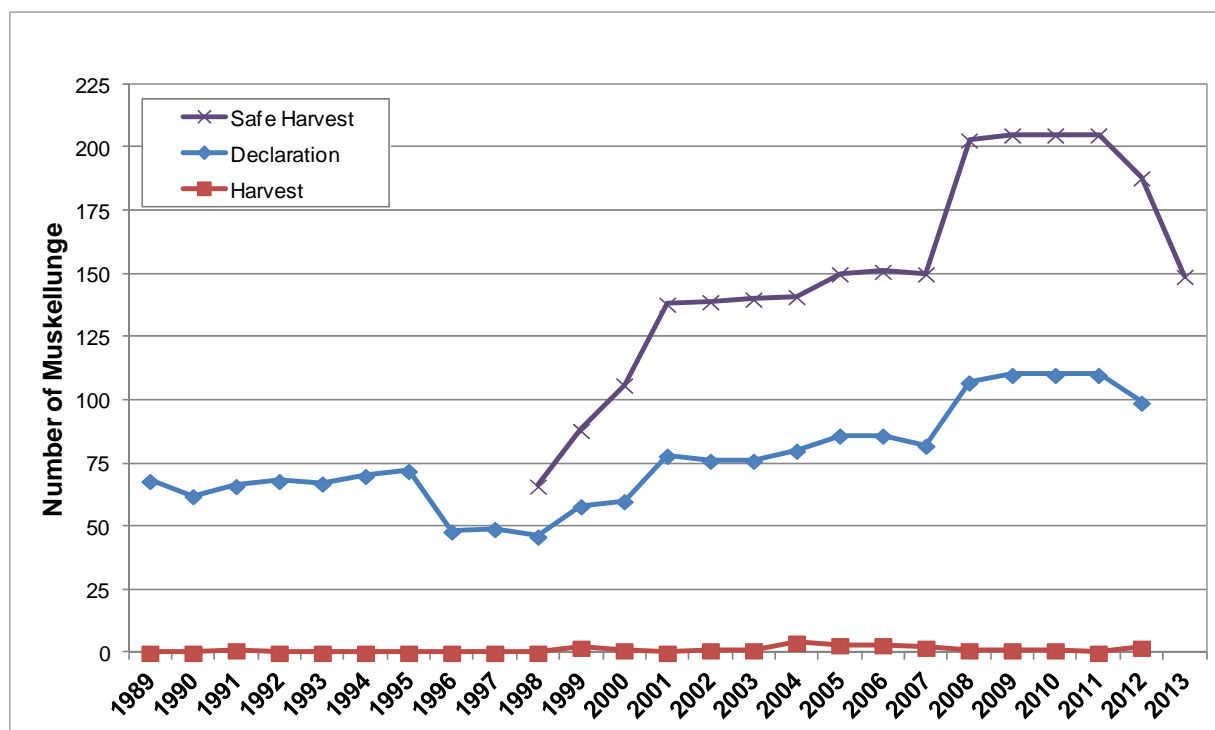
Lake	Years of walleye harvest, 1989-2012	Years of muskellunge harvest, 1989-2012
Planting Ground	23	5
Big Stone	21	
Big	20	2
Big Fork	20	2
Medicine	18	2
Long	13	2
Little Fork	11	
Island	7	2
Laurel	7	2
Whitefish	5	
Spirit	4	1
Fourmile	3	
Virgin	3	1
Round	1	
Deer		
Dog		
Maple		
Moccasin		
Mud (Crystal (Mud))		
Rangeline		
Townline		

Individual lake Native American spearing statistics are displayed in Appendix G. The relationship between the safe harvest number, declaration and actual harvest is displayed on a chain-wide basis for walleye (Figure 3.5-3) and muskellunge (Figure 3.5-4). Once a safe harvest number is set for a given lake, tribal leaders may declare a quota of fish they may spear in the upcoming season. From 1989 to 2012, tribal spearers have claimed a walleye quota that is between 53% and 82% of the safe harvest. On average, Native American spear fishermen have harvested 49% of the declared quota on the Three Lakes Chain of Lakes with respect to walleye.



**Figure 3.5-3. Total chain-wide walleye spear harvest by year.** Annual Native American walleye spear harvest statistics are summarized for 21 lakes in the Three Lakes Chain of Lakes. Data provided by WDNR fisheries staff (T. Cichosz, personal communication).

Figure 3.5-4 displays the Native American open water muskellunge spear harvest since 1989. Muskellunge spear harvests have been minimal on the Three Lakes Chain of Lakes; since 1989 an average of one muskellunge per year has been harvested on the entire chain during the open water spear fishery. This harvest has been as high as four fish (2004) and spear fishermen have rarely surpassed 4% of their allotted declaration (Figure 3.5-4).



**Figure 3.5-4. Total chain-wide muskellunge spear harvest by year.** Annual Native American muskellunge spear harvest statistics are summarized for 21 lakes in the Three Lakes Chain of Lakes. Data provided by WDNR fisheries staff (T. Cichosz, personal communication).

### Three Lakes Chain of Lakes Fishing Regulations

Because Three Lakes Chain of Lakes is located within ceded territory, special fisheries regulations may occur, specifically in terms of walleye. An adjusted walleye bag limit pamphlet is distributed each year by the WDNR which explains the more restrictive bag or length limits that may pertain to Three Lakes Chain of Lakes. In 2011, the daily bag limit remained at three walleyes for every lake on the chain, with the exception of Big Fork and Planting Ground Lakes in which a bag limit of two fish was set. On the Three Lakes Chain of Lakes, recent review of the fishery and its regulations resulted in changes of the minimum length limit for harvesting walleyes. Currently, there is no minimum length limit on walleye, but only one fish over 14" is allowed. WDNR fisheries biologist established this regulation in 2010 to maintain walleye size structure, provide increased opportunity for angler harvest and allow harvest of males over 14" in length (WDNR Correspondence/Memorandum, Appendix G).

For bass species, a catch-and-release season from early May to mid-June exists. Once the regular season begins in mid-June, the minimum length limit is 14" and a daily bag limit is limited to five fish. Three Lakes Chain of Lakes is in the northern half of the muskellunge and northern pike management zone. Muskellunge must be 34" to be harvested, with a daily bag limit of one fish, while no minimum length limit exists for northern pike and only five pike may be kept in a single day. Statewide regulations apply for all other fish species.

### Three Lakes Chain of Lakes Fish Stocking

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

Currently, “maintenance” stocking of muskellunge is done on the Three Lakes Chain of Lakes to maintain this population. Stocking of this species occurs at a rate of 0.25 fish per acre, every other year. Nine of the 18 lakes within the chain have been stocked with muskellunge as recently as 2008 or 2010, and four other lakes within the chain have been stocked historically, but not in recent years. The WDNR does not stock walleye in the Three Lakes Chain of Lakes because the population has high recruitment which has resulted in a high-density fishery. Thus, there is little need to supplement the population with stocking. Stocking summaries for the Three Lakes Chain of Lakes can be viewed in Appendix G.

### Three Lakes Chain of Lakes Creel Surveys

Periodically, the WDNR will conduct creel surveys on Wisconsin lakes to gather information on the fishery. Creel surveys are a series of short, informal interviews with fisherman and are conducted right on the lake of interest. They provide valuable information on sport angler activities and their impacts on the fish populations of a waterbody. From this data, fisheries managers can determine trends in total catch and harvest for the lake, and also estimate the number of hours it takes anglers to catch a particular species of fish.

In 1994, a creel survey was conducted on six of the Three Lakes Chain of Lakes – Big, Big Stone, Laurel, Little Fork, Medicine and Planting Ground Lakes. Creel data shows that anglers targeted walleye and muskellunge the most during the survey period. On Little Fork Lake, anglers spent a combined 2,600 hours pursuing walleye, while a combined 9,800 hours was spent fishing for walleye on Planting Ground Lake. Table 3.5-3 displays data from this 1994 survey for the two species in the Three Lakes Chain of Lakes – muskellunge and walleye.

**Table 3.5-3. Three Lakes Chain WDNR creel survey summary, 1994.** Table display effort for all species, effort directed at either muskellunge or walleye, and catch and harvest numbers as a unit per acre of each lake (WDNR 2012B).

Species	Lake	Total Angler Effort / Acre (Hours)	Directed Effort / Acre (Hours)	Catch / Acre	Harvest / Acre
Muskellunge	Big	20.4	4	0.2	0
	Big Stone	18	5.7	0.2	0
	Laurel	44.7	14.4	0.9	0
	Little Fork	15.4	5	0.2	0
	Medicine	20	9.9	0.4	0.1
	Planting Ground	19	8.1	0.8	0
Walleye	Big	20.4	10.9	3.1	1
	Big Stone	18	8.2	2.8	0.4
	Laurel	44.7	10.9	0.8	0.4
	Little Fork	15.4	7.9	4.6	0.9
	Medicine	20	6.8	2	0.7
	Planting Ground	19	9.7	1.4	0.5

### Three Lakes Chain of Lakes Substrate Type

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

According to the point-intercept survey conducted by Onterra, the lakes within the Three Lakes Chain varied quite a bit in terms of their substrate type. Some of the lakes contained mostly a soft, mucky bottom, while others were dominated by sand (Table 3.5-4). Some of the lakes had a good mixture of both substrates, and incorporated some rocky areas as well.

**Table 3.5-4. Substrate types for the Three Lakes Chain.** Data collected during point intercept surveys by Onterra (2009-2016).

Project Phase	Lake	% Muck	% Sand	% Rock
Long Lake (2009)	Long Lake	66	28	6
	Virgin Lake	34	51	15
Phase I - 2010	Whitefish Lake	24	74	3
	The Thoroughfare	95	5	0
	Big Lake	37	59	4
Phase II - 2011	Laurel Lake	63	36	1
	Big Stone Lake	4	92	5
	Dog Lake	24	75	0
	Crystal (Mud) Lake	91	9	0
Phase III - 2012	Deer Lake	60	39	1
	Fourmile Lake	30	61	10
Phase IV - 2013	Big Fork Lake	10	77	14
	Moccasin Lake			
Phase V - 2014	Spirit Lake			
	Maple Lake			
Phase VI - 2015	Little Fork Lake			
	Medicine Lake			
Phase VII - 2016	Round Lake			
	Island Lake			
	Townline Creek			
Phase VIII - 2016	Townline Lake			
	Planting Ground Lake			
	Range Line Lake			



## 4.0 SUMMARY AND CONCLUSIONS

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

- 1) Collect baseline data to increase the general understanding of the Three Lakes Chain of Lakes ecosystem.
- 2) Collect detailed information regarding invasive plant species within each lake, if any were found.
- 3) Collect sociological information from Three Lakes Chain of Lakes stakeholders regarding their use of the lake and their thoughts pertaining to the past and current condition of the lake and its management.

Completing a comprehensive management plan for a large and diverse ecosystem such as the Three Lakes Chain of Lakes is a tremendous undertaking. By splitting this project into numerous phases, the TLWA, Town of Three Lakes, WDNR, and Onterra ecologists were able to give individualized attention to several lakes of the chain at a time and address specific issues that came about during this planning project. This is important, as during the studies it was learned that each lake has its own unique ecology as well as both positive facets and known challenges. In addressing each lake in a phased manner, a greater understanding was achieved about this ecosystem as a whole also. Though the chain has seen some human disturbance, the lakes are largely in good condition and need protection to ensure that they remain this way.

The large quantity of water the Three Lakes Chain of Lakes holds is the result of a large area of land that drains to these lakes. Over 72,000 acres of land drains towards these lakes. The large watershed consists of primarily natural land cover types, such as forest, forested wetlands, wetlands, etc. These land cover types are the most ecologically beneficial within a lakes watershed, as they allow water to permeate the ground as opposed to allowing more surface water runoff. This creates a naturally occurring filtering process and reduces the amount of nutrients and pollutants entering the lakes. In other watersheds, large amounts of urban and agricultural land reduce this filtration process and increase the amount of surface water pollution a lake receives.

Immediately surrounding each of the Three Lakes Chain of Lakes is the shoreland zone, which serves as an important buffer area for surface water runoff as well as habitat for many terrestrial and aquatic organisms. As the Three Lakes Chain of Lakes is a heavily visited and utilized system, it is not surprising that the shoreland zone shows a large amount of human disturbance. Restoring these disturbed shoreland areas, and protecting the natural shoreland areas that currently exist, may benefit each lake ecosystem and help in creating a natural, picturesque “up north” feel to the Three Lakes Chain of Lakes.

While the watershed is largely responsible for determining the general water quality in a lake or chain of lakes ecosystem, the biological, chemical and physical parameters of the water in a lake may in turn be the largest single factor in determining the health of a lake, including its aquatic plant community, fishery, etc. These components, contributing to the lake’s overall water quality, are an important aspect for recreational activities as well. The water within the Three Lakes Chain of Lakes is moderate to low in terms of its water clarity; however, this is primarily determined by the natural staining color that is derived from the decomposition of plant material in the watershed. So, considering this interesting aspect, the clarity measured on the Three Lakes

Chain of Lakes is not unexpected. Nutrient levels were assessed on the project lakes also, and turned up some interesting results – particularly with phosphorus. Phosphorus concentrations were found to vary amongst the project lakes, and this is partially due to differences in the morphology (deep drainage lakes vs. shallow drainage lakes) and placement of the lakes (higher or lower) in the chain. As eluded to within the Water Quality Section and discussed within the Implementation Plan, there is an unaccounted for nutrient in some of the project lakes that requires additional research if a source of this nutrient input is to be discovered.

A major component of this project’s studies included assessments of the native and if applicable, non-native aquatic species in each project lake. It is interesting to note that although these lakes are interconnected, and very close in proximity to each other, each project lake contains some similar species yet has its own unique aquatic plant community as well. Along with water quality differences, factors such as shoreline condition, substrate type, and lake morphology can determine the amount and type of habitat for aquatic plant species. As described in the Aquatic Plant Section, there is a great diversity of these habitat conditions so it is not surprising that a species rich aquatic plant community exists. Altogether, a total of 88 different plant species were identified from Long Lake as well as the nine Phase I and Phase II lakes associated with this project. The plant communities showed some variance between lakes in terms of their diversity index value and coefficient of conservatism as well. These values are typically used to assess the level of human disturbance.

Another indication of human disturbance is the presence of non-native species. Currently, aquatic invasive species, primarily Eurasian water milfoil, is the largest ecological threat facing the integrity of the Three Lakes Chain of Lakes. An aggressive, ongoing battle has been fought on the Long Lake Burnt Rollways channel targeting this invasive plant. While the plant has largely been kept under control, resurgence has been documented each year since the plant was first discovered (2006). In Virgin Lake, a lake in which native milfoils grow quite prolifically, the Eurasian water milfoil colony that was first discovered in 2010 has become largely unmanageable by passive (hand-harvesting) techniques and in 2012 required an herbicide treatment to reduce fragmentation and spreading of this plant. Moving into the future, these infestations must be monitored diligently to ensure that management efforts are successful in containing the spread to other locations. Additionally, as outlined within the Implementation Plan, continued efforts must be conducted to monitor these lakes for new infestations, as an early infestation is always easier to manage than a previously undetected, advanced-stage infestation.

The Three Lakes Chain of Lakes is a unique resource that many individuals with many different interests utilize. It provides for an outstanding recreational facility that anglers, boaters, swimmers, connoisseurs of nature and others can enjoy. Billed as part of “the largest freshwater chain of lakes in the world”, it is a large and complex ecosystem that inspires one with its picturesque beauty and serene, “up north” feeling. With the knowledge that has been gained through this series of studies, the TLWA and their lake management partner, the Town of Three Lakes, now have a strategic plan in place to maximize the positive attributes of each lake, address the negative attributes, and effectively and efficiently manage the entire ecosystem as a whole. The Chain Wide Implementation Plan that follows is a result of the hard work of many Three Lakes Chain of Lakes stakeholders, and can be applied to each and every lake within the chain. Lakes with added attention or specific issues that were brought forth during this study will have their own Lake Specific Implementation Plan which is located at the end of each individual lake section.

## 5.0 IMPLEMENTATION PLAN

The Implementation Plan presented below was created through the collaborative efforts of the TLWA and ecologist/planners from Onterra. It represents the path the TLWA will follow in order to meet their lake management goals. The goals detailed within the plan are realistic and based upon the findings of the studies completed in conjunction with this planning project and the needs of the Three Lakes Chain of Lakes stakeholders as portrayed by the members of the Planning Committee, the returned stakeholder surveys, and numerous communications between Planning Committee members and the lake stakeholders. The Implementation Plan is a living document in that it will be under continuous review and adjustment depending on the condition of the chain lakes, the availability of funds, level of volunteer involvement, and the needs of the stakeholders. While the TLWA is listed as the facilitator of the majority of management actions listed below, many of the actions may be better facilitated by a sub-committee of the TLWA (e.g. Education & Communication Committee, Water Quality Committee, and Invasive Species Committee). The TLWA will be responsible for deciding whether the formation of sub-committees is needed to achieve the various management goals.

### **Management Goal 1: Continue to Understand, Protect and Enhance the Ecology of the Three Lakes Chain of Lakes Through Stakeholder Stewardship and Science-based Studies**

**Management Action:** Continue the development of comprehensive management plans for the Three Lakes Chain waterbodies.

**Timeframe:** In progress.

**Facilitator:** Board of Directors.

**Grant:** Lake Management Protection Grant in Diagnostic/Feasibility Studies category.

**Description:** The Three Lakes Waterfront Association and Town of Three Lakes have been diligent about protecting the Three Lakes Chain of Lakes and preserving it as a recreational yet natural resource. They realize that the best way to protect the waterbodies in the chain is to fully understand their current level of health so that proper planning and management may occur.

The Three Lakes Waterfront Association, with assistance from their partner the Town of Three Lakes, will continue to develop comprehensive management plans for each lake in the chain. This phased project will continue within the timeframe projected in Map 1. These studies may be completed with the assistance of state funds through the WDNR's Lake Management Protection Grant program.

**Action Steps:**

1. Apply for WDNR grants annually to continue state financial assistance in management planning projects.
2. Retain qualified consultant to conduct science-based studies and facilitate management planning.

## **Management Goal 2: Continue to Control Eurasian Water Milfoil and Prevent Other Aquatic Invasive Species Infestations on the Three Lakes Chain of Lakes**

**Management Action:** Continue Clean Boats Clean Waters watercraft inspections at Three Lakes Chain of Lakes public access locations.

**Timeframe:** In progress.

**Facilitator:** Board of Directors along with TLWA Clean Boats/Clean Waters coordinators.

**Description:** With over 6,100 acres of water, 14 public boat landings (eight more on the Lower Eagle River Chain) one tracked boat-lift system, numerous resorts and several fishing tournaments, the Three Lakes Chain of Lakes provide recreational opportunity for many people. With so many public access opportunities, the threat of the introduction of non-native species is greatly heightened. As outlined in the Table 2.0-1, most of the lakes within the chain hold at least one or two invasive species, such as rusty crayfish, Chinese mystery snail or banded mystery snail. Currently, two waterbodies, the Eagle River below Long Lake and Virgin Lake, are known to hold small populations of Eurasian water milfoil.

The Clean Boats/Clean Waters (CBCW) program of the TLWA supplies both paid and volunteer boat inspectors at 10 public landings on the chain, including focused monitoring at the Burnt Rollways boat lift to assure removal of vegetation from boats coming over the dam from the Lower Eagle River Chain to the Three Lakes Chain of Lakes. The TLWA's efforts include inspecting nearly 12,000 boats and contacting nearly 33,000 people in over 9,500 hours of work during a timespan from 2005 – 2013 (WDNR CBCW website, data accessed November 2013). This is a tremendous effort to coordinate, staff, and carry out but the Town of Three Lakes, TLWA and its dedicated members have proven that monitoring efforts of this scale can be completed efficiently and effectively.

The CBCW boat inspections at these public access points have undoubtedly played a great role in reducing the introduction of invasive species to the Three Lakes Chain of Lakes. Furthermore, opportunities of species from the Three Lakes Chain elsewhere have certainly been diminished. CBCW inspectors cover the landing during the busiest times in order to maximize contact with lake users, spreading the word about the negative impacts of AIS on our lakes and educating people about how they are the primary vector of its spread.

### **Action Steps:**

1. Members of the TLWA periodically attend CBCW training session through CBCW coordinator to update their skills to current standards.
2. Begin inspections during high-risk weekends

3. Report results to WDNR and TLWA.
4. Report results to the WDNR and TLWA.
5. Promote enlistment and training of Three Lakes Chain volunteers to broaden volunteer base and ensure program survival.

**Management Action:** Coordinate monitoring for aquatic invasive species through continuation of Adopt-A-Shoreline program.

**Timeframe:** In progress.

**Facilitator:** TLWA in coordination with Lake Captains and lake residents.

**Description:** In lakes with Eurasian water milfoil or other invasive species, early detection of pioneer colonies commonly leads to successful control. While efforts to control Eurasian water milfoil within Virgin Lake and the Eagle River channel of Long Lake have been successful, eradication of this hearty and resilient invasive plant is very difficult. Therefore, it is crucial for locations of new plants to be promptly identified before they reproduce.

The TLWA has initiated a strategy in which lake residents are coordinated to search the lakeshore area for invasive plant species. These efforts take place on many lakes within the Three Lakes Chain of Lakes. In fact, TLWA volunteers have logged roughly 2,000 hours in this program since 2006. A Lake Captain (a member of the planning committee) is responsible for recruiting riparian property owners to participate in these shoreline patrols. Although most shorelines have been patrolled on an annual basis over the last several years, more volunteers are needed to assure future coverage. Volunteers also intensively cover the area near the Burnt Rollways Dam in the Long Lake channel, as this is a point of special interest due to Eurasian water milfoil being located here.

**Action Steps:**

1. Volunteers from TLWA update their skills by attending a training session conducted by WDNR/UW-Extension through the AIS Coordinator for Oneida County (Michele Sadauskas – 715.365.2750).
2. Trained volunteers recruit and train additional association members.
3. Complete lake surveys following protocols.
4. Report results to WDNR and TLWA.

### **Management Goal 3: Increase the Three Lakes Waterfront Association's Capacity to Communicate with and Educate Lake Stakeholders**

**Management Action:** Support an Education Committee to promote safe boating, water quality, public safety, and quality of life on the Three Lakes Chain of Lakes.

**Timeframe:** Begin Summer 2013.

**Facilitator:** Board of Directors to form Education Committee.

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

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

In addition to creating regularly published association newsletters, a variety of educational efforts will be initiated by the Education Committee. These may include educational materials, awareness events and demonstrations for lake users as well as activities which solicit local and state government support.

#### *Example Educational Topics:*

- Specific topics brought forth in other management actions
- Aquatic invasive species identification & monitoring
- Boating safety and ordinances (slow-no-wake zones and hours)
- Catch and release fishing
- Littering (particularly on ice)
- Noise, air, and light pollution
- Shoreland restoration and protection



- Septic system maintenance
- Fishing Rules
- Water quality topics

**Action Steps:**

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

**Management Goal 4: Facilitate Partnerships with Other Management Entities and Stakeholders**

**Management Action:** Enhance TLWA’s involvement with other entities that have a hand in managing (management units) or otherwise utilizing the Three Lakes Chain of Lakes.

**Timeframe:** Continuation of current effort.

**Facilitator:** Board of Directors to appoint TLWA representatives.

**Description:** As stated on the association website, the purpose of the TLWA is *to preserve and protect our waterways and shorelines...today and for generations to come*. The waters of Wisconsin belong to everyone and therefore this goal of protecting and enhancing these shared resources is also held by other entities. Some of these entities are governmental while other organizations are similar to the TLWA in that they rely on voluntary participation.

It is important that the TLWA engage with all management entities to enhance the association’s understanding of common management goals and to participate in development of those goals. This also familiarizes all management entities with actions that others are taking to reduce the duplication of efforts. The primary management units regarding the Three Lakes Chain of Lakes include governmental units such as the WDNR, or Town of Three Lakes, but also include groups similar to the TLWA such as the Chamber of Commerce. Each entity is specifically addressed on the next page.

**Action Steps:**

1. See table guidelines on the next page.

Partner	Contact Person	Role	Contact Frequency	Contact Basis
<b>Wisconsin Department of Natural Resources</b>	Fisheries Biologist (John Kubisiak – 715.365.8919)	Manages the fishery of the Three Lakes Chain.	Once a year, or more as issues arise.	Stocking activities, scheduled surveys, survey results, volunteer opportunities for improving fishery.
	Lakes Coordinator (Kevin Gauthier – 715.365.5211)	Oversees management plans, grants, all lake activities.	Once a year, or more as necessary.	Information on updating a lake management plans, submitting grants or to seek advice on other lake issues.
	Warden (Patrick Novesky – 715.365.8948)	Oversees regulations handed down by the state.	As needed. May contact WDNR Tip Line (1.800.847.9367) as needed also.	Suspected violations pertaining to recreational activity, including fishing, boating safety, ordinance violations, etc.
	Program Director (Sandra Wickman – 715.365.8951)	Training and assistance on CLMN activities.	Twice a year or more as needed.	Contact to arrange for training as needed, in addition to planning out monitoring and reporting of data.
<b>Oneida County</b>	AIS Coordinator (Michele Saduaskas – 715.365.2750)	Oversees AIS monitoring and prevention activities locally.	Twice a year or more as issues arise.	<u>Spring:</u> AIS training and ID, AIS monitoring techniques <u>Summer:</u> Report activities to Ms. Saduaskas.
<b>Town of Three Lakes</b>	Town Chair (Don Sidlowski - 715.546.331)	Supports TLWA, assists in lake management.	As needed. Visit website ( <a href="http://www.townofthree lakes.com/home">http://www.townofthree lakes.com/home</a> ) often.	Contact regarding grant applications, projects such as CBCW, town events, etc.
<b>Three Lakes Chamber of Commerce</b>	Executive Chamber Director (Skip Brunswick – (715.546.3344)	Coordinates recreational and town-wide events, partner in managing lakes	As needed.	AIS project results may be shared, or displayed at public events, etc. Informative packets available at chamber of commerce.
<b>Oneida County Lakes &amp; Rivers Association</b>	Secretary (Connie Anderson – 715.282.5798)	Protects Oneida Co. waters through facilitating discussion and education.	Twice a year or as needed.	Become aware of training or education opportunities, partnering in special projects, or networking on other topics pertaining to Oneida Co. waterways.
<b>UW-Extension</b>	Program Coordinator (Erin McFarlane – 715.346.4978)	Clean Boats Clean Waters Program	As needed.	May be contacted to set up CBCW training sessions, report data, etc.
<b>Unified Lower Eagle River Chain of Lakes Commission</b>	Commission Chair (Jim Spring – 715.891.1095)	Oversees AIS management of the Lower Eagle River Chain of Lakes	Once a year or as needed. May visit website ( <a href="http://eagleriverchain commission.org/index.htm">http://eagleriverchain commission.org/index.htm</a> ) as needed.	May contact to coordinate Burnt Rollways Dam monitoring. A TLWA representative should attend annual meeting to keep communication flow between organizations.
<b>Wisconsin Valley Improvement Company</b>	Manager of Operations (Peter Hansen – 715.848.2976)	Oversees operation of the Burnt Rollways Dam	As needed.	May be contacted regarding business concerning the Burnt Rollways Dam operation.
<b>Wisconsin Lakes</b>	General staff (800.542.5253)	Facilitates education, networking and assistance on all matters involving WI lakes.	As needed. May check website ( <a href="http://www.wisconsinlakes.org">www.wisconsinlakes.org</a> ) often for updates.	TLWA members may attend WL's annual conference to keep up-to-date on lake issues. WL reps can assist on grant issues, AIS training, habitat enhancement techniques, etc.

## **Management Goal 5: Maintain Current Water Quality Conditions**

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

**Timeframe:** Continuation and expansion of current effort.

**Facilitator:** Planning Committee.

**Description:** Monitoring water quality is an important aspect of every lake management planning activity. Collection of water quality data at regular intervals aids in the management of the lake by building a database that can be used for long-term trend analysis. Early discovery of negative trends may lead to discovering the reason as to why the trend is developing.

The Citizens Lake Monitoring Network (CLMN) is a WDNR program in which volunteers are trained to collect water quality information on their lake. Volunteers trained as a part of the CLMN program begin by collecting Secchi disk transparency data for at least one year, then if the WDNR has availability in the program, the volunteer may enter into the *advanced program* and collect water chemistry data including chlorophyll-a, and total phosphorus. The Secchi disk readings and water chemistry samples are collected three times during the summer and once during the spring. Note: as a part of this program, these data are automatically added to the WDNR database and available through their Surface Water Integrated Monitoring System (SWIMS).

Currently, some of the lakes within the Three Lakes Chain have active volunteers collecting data each year – either within the confines of the initial or advanced program. Ideally, all lakes within the chain would have advanced monitoring occurring each year; however, it is a more realistic goal to push for all lakes monitoring Secchi disk transparency for now. It is important to get volunteers on board with the base Secchi disk data CLMN program so that when additional spots open in the advanced monitoring program, volunteers from interested lakes will be ready to make the transition into more advanced monitoring.

It is the responsibility of the Planning Committee to coordinate new volunteers. When a change in the collection volunteer occurs, it will be the responsibility of the Planning Committee to contact Sandra Wickman (715.365.8951) or the appropriate WDNR/UW Extension staff to ensure the proper training occurs and the necessary sampling materials are received by the new volunteer. It is also important to note that as a part of this program, the data collected are automatically added to the WDNR database and available through their Surface Water Integrated Monitoring System (SWIMS) by the volunteer.

### **Action Steps:**

1. See description above.

**Management Action:** Reduce phosphorus and sediment loads from shoreland watershed to the Three Lakes Chain of Lakes.

**Timeframe:** Continuation of current effort.

**Facilitator:** Board of Directors to appoint Shoreland Representative(s).

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

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

To reduce these negative impacts, the TLWA will initiate an educational initiative aimed at raising awareness among shoreland property owners concerning their impacts on the lake. This will include newsletter articles and guest speakers at association meetings. The Association website is (and has been) a good venue for broadcasting awareness. A good initial educational topic may be a discussion of the Oneida County Private Onsite Wastewater Treatment System Ordinance, which requires septic tanks to be enrolled in the County's Maintenance Program no later than October 1<sup>st</sup> of 2013. Phase II of this initiative requires visual inspections, and, if necessary, pumping of septic tanks every 3 years.

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

**Action Steps:**

1. Recruit a member of the Board of Directors or other interested person to be an advocate and facilitator for shoreline conservation and education.
2. Facilitator gathers appropriate information from WDNR, UW-Extension, Oneida County, and other sources.
3. Facilitator summarizes information for newsletter articles and recruits appropriate speakers for association meetings (development of conservation and restoration education model).
4. Facilitator takes results of Shoreland Assessment and identifies feasible areas for conservation. May visit with new home owners to discuss conservation efforts or restoration possibilities.

**Management Action:** Investigate restoration of urbanized shoreland areas on the Three Lakes Chain of Lakes.

**Timeframe:** Begin 2013.

**Facilitator:** Board of Directors to appoint Shoreland Representative(s).

**Description:** Currently, roughly half (51%) of the Phase I-III project lakes' shorelines are considered to be in a natural/undeveloped or developed-natural state. 18% of shoreline may be classified as urbanized or developed-unnatural, while the remaining 31% of the shoreline is categorized as developed-semi-natural. A priority for the TLWA should be to ensure that undeveloped shorelands are protected. As the Three Lakes Chain of Lakes is a popular destination for tourists and for individuals seeking that quaint "place on a lake up north", this is no easy task. However, it would be worthwhile for the TLWA to investigate restoration of the developed areas of the chain. In particular, Big Stone, Whitefish, Virgin, Big Fork and Deer Lakes had the highest percentage of developed shoreline (Figure 3.3-3).

The Shoreland Condition map for each project lake indicates the locations of these disturbed shorelands. If restoration of the Three Lakes Chain of Lakes shoreland occurs, these areas should be considered a priority. An appointed representative(s) from the TLWA will work with the education initiative volunteer (this may also be the same person) to research grant programs, shoreland restoration techniques, and other pertinent information that will aid the TLWA in making enhancements to applicable shoreline areas. Several valuable resources for this type of conservation work include the WDNR, UW-Extension, etc. Several resources include:

- Wisconsin Lakes website:  
([www.wisconsinlakes.org/shorelands](http://www.wisconsinlakes.org/shorelands))
- Langlade County Land Records and Regulations Department – Shoreland Restoration:  
(<http://lrrd.co.langlade.wi.us/shoreland/index.asp>)
- UW-Extension Shoreland Restoration:  
(<http://www.uwex.edu/ces/shoreland/WhyI/whyres.htm>)
- WDNR Shoreland Zoning website:  
(<http://dnr.wi.gov/topic/ShorelandZoning/>)

**Action Steps:**

1. Recruit facilitator.
2. Facilitator gathers appropriate information from sources described above. This includes biological research as well as grant/funding opportunities.
3. Facilitator assists residents that are interested in shoreland restoration with process of contacting shoreland restoration specialists (public or private) and carrying out restoration plan.
4. Retain potential of having completed projects serve as a "model" for other residents who may be interested in restoration work.

**Management Action:** Investigate sources of phosphorus Big, Crystal (Mud), Rangeline and Townline Lakes.

**Timeframe:** Begin 2013.

**Facilitator:** Planning Committee.

**Description:** During the first Planning Meeting associated with this project, Onterra staff presented water quality results to the planning committee, including higher than expected phosphorus value results which had been obtained from sampling efforts conducted on Crystal (Mud) Lake. Discussions were then held about potential phosphorus sources within the Three Lakes Chain of Lakes watershed. The current level of baseline monitoring that has been conducted on Crystal (Mud) Lake, as well as within other Three Lakes Chain lakes, cannot pinpoint the exact cause of the elevated phosphorus. It is believed by lake stakeholders that elevated nutrients may be present within Big Lake and Townline Lake also, potentially stemming from upstream watershed practices. Though elevated nutrient levels were not captured on Big Lake during these studies, stakeholders presented Onterra staff with photographic evidence of large blue-green algal blooms which had occurred on the lake in the past.

The studies conducted on the Three Lakes Chain thus far are designed to give managers an indication of ecosystem health, and to provide a clue of potential issues that may be occurring. This was achieved during monitoring of Crystal (Mud) Lake. In order to gain an understanding of the source of nutrients to Crystal (Mud) Lake, further studies must be conducted which would consist of higher interval sampling of the lake and tributary stream. These studies are recommended for Big Lake, Rangeline and Townline Lake as well, and will help to determine the source of nutrient contribution to these lakes. Within further grants that will be written as a part of the Three Lakes Chain Management Planning Project, time will be included for Onterra staff to research watershed activities and determine quantitative impacts, if any, to these receiving lakes.

**Action Steps:**

1. See above description.



## **Management Goal 6: Improve Fishery Resource and Fishing**

**Management Action:** Work with fisheries managers to enhance and understand the fishery on the Three Lakes Chain of Lakes.

**Timeframe:** Ongoing.

**Facilitator:** Board of Directors.

**Description:** With over 6,900 acres of water, many residences and visitors and several fishing tournaments, it is safe to say the Three Lakes Chain of Lakes draws much attention from anglers both local and non-local. The ecosystem of the chain is in great shape currently, which is beneficial for producing a quality fishery for anglers to enjoy. However, with the amount of visitors the Three Lakes Chain of Lakes receives it remains important to continuously monitor the fish populations on the chain to ensure that exploitation is not occurring.

During discussions with the planning committees and others involved with the TLWA, it became clear that those who were anglers had concerns over walleye populations in the Three Lakes Chain of Lakes. WDNR biologists proposed a rule change, effective 2011 for the entire Three Lakes Chain of Lakes, which would initiate a no minimum length limit on walleye with a five fish daily bag limit, however only one fish longer than 14" could be kept. This adjustment would allow the fishery, which experiences high recruitment but slow growth, to produce a higher fishable and spawning stock.

Though walleye are at the forefront of anglers concerns, Three Lakes Chain stakeholders must keep in mind that other species as well as other components of the fishery impact walleye population dynamics; therefore, a holistic approach must be considered when looking at the chain's fishery. In other words, education of issues and enhancement of all fish populations must be enacted in order to sustain a quality walleye fishery. In order to keep informed of survey studies and stocking of the Three Lakes Chain of Lakes, a TLWA representative should be selected to contact WDNR fisheries biologist John Kubisiak (715.365.8919) at least once a year for an update, which can be published on the association's website and in periodic newsletter. During this conversation, the TLWA representative may discuss options for improving the fishery, such as collaborating with WDNR staff on habitat enhancement projects or new opportunities with fish stocking as they arise.

### **Action Steps:**

1. See above description.

## 6.0 METHODS

### Lake Water Quality

Baseline water quality conditions were studied to assist in identifying potential water quality problems in the Three Lakes Chain 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 the following:

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

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

### Watershed Analysis

The watershed analysis began with an accurate delineation of the Three Lakes Chain of 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

#### *Curly-leaf Pondweed Survey*

Surveys of curly-leaf pondweed were completed on the Three Lakes Chain of Lakes during mid to late June in order to correspond with the anticipated peak growth of the plant. 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.

## Comprehensive Macrophyte Surveys

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. Based upon advice from the WDNR, the following point spacing and resulting number of points comprised the surveys:

Phase & Field Work Year	Lake	Point-intercept Resolution (meters)	Number of Points	Survey Dates
Phase I - 2010	Virgin Lake	54	361	Aug. 5 & 9, 2010
	Whitefish Lake	42	449	August 10, 2010
	The Thoroughfare	40	439	Aug. 8 & 9, 2010
	Big Lake	68	738	Aug. 5 & 9, 2010
Phase II - 2011	Laurel Lake	48	436	August 10, 2011
	Big Stone Lake	50	981	August 10, 2011
	Dog Lake	45	404	August 9, 2011
	Deer Lake	40	477	August 4 & 9, 2011
	Crystal (Mud) Lake	38	324	August 4 & 5, 2011
Phase III - 2012	Big Fork Lake	56	855	July 17, 2012
	Fourmile Lake	44	437	July 17, 2012

## 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.

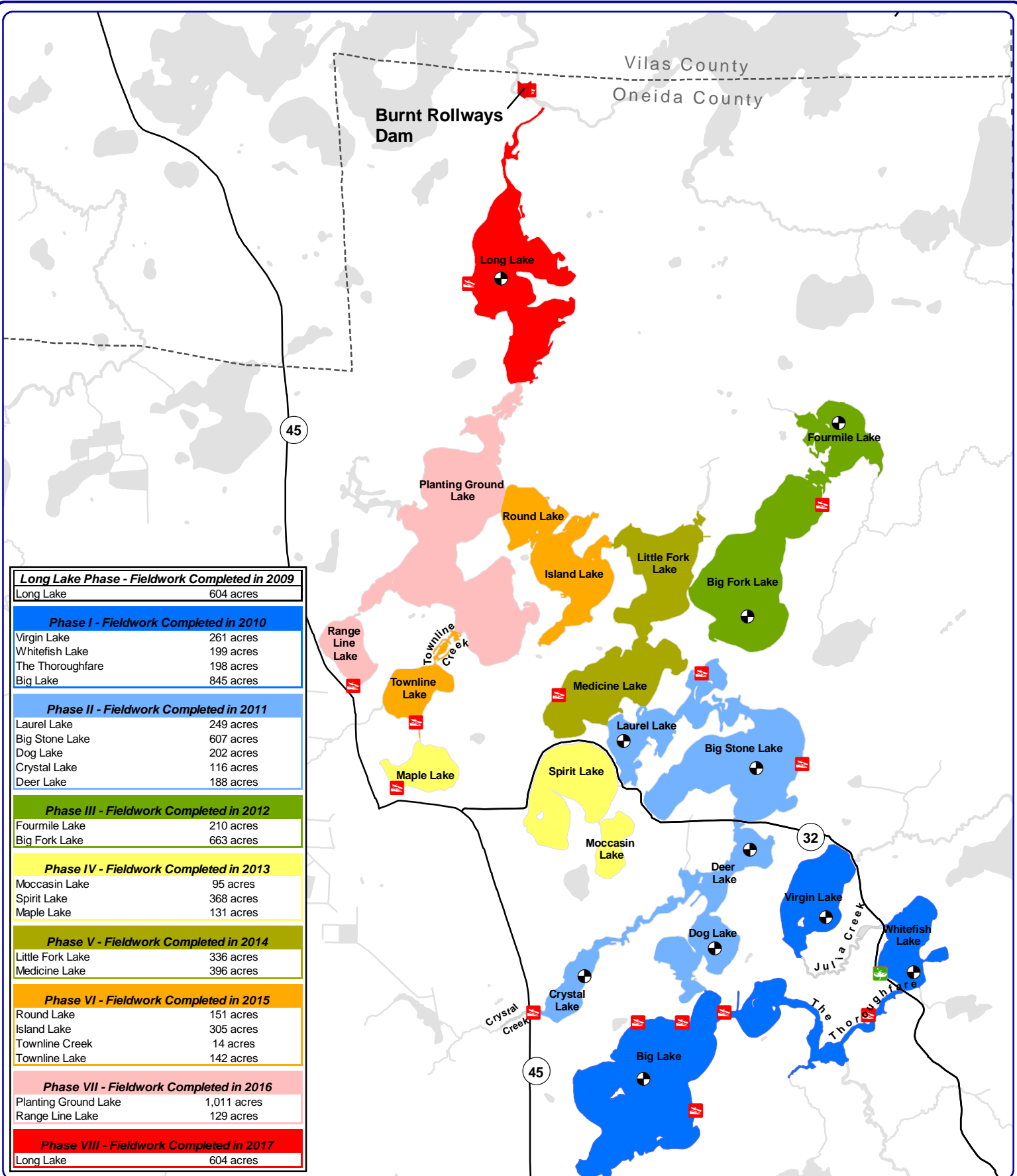
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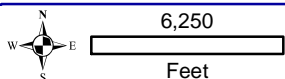
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**Long Lake Phase - Fieldwork Completed in 2009**

Long Lake	604 acres
<b>Phase I - Fieldwork Completed in 2010</b>	
Virgin Lake	261 acres
Whitefish Lake	199 acres
The Thoroughfare	198 acres
Big Lake	845 acres
<b>Phase II - Fieldwork Completed in 2011</b>	
Laurel Lake	249 acres
Big Stone Lake	607 acres
Dog Lake	202 acres
Crystal Lake	116 acres
Deer Lake	188 acres
<b>Phase III - Fieldwork Completed in 2012</b>	
Fourmile Lake	210 acres
Big Fork Lake	663 acres
<b>Phase IV - Fieldwork Completed in 2013</b>	
Moccasin Lake	95 acres
Spirit Lake	368 acres
Maple Lake	131 acres
<b>Phase V - Fieldwork Completed in 2014</b>	
Little Fork Lake	336 acres
Medicine Lake	396 acres
<b>Phase VI - Fieldwork Completed in 2015</b>	
Round Lake	151 acres
Island Lake	305 acres
Townline Creek	14 acres
Townline Lake	142 acres
<b>Phase VII - Fieldwork Completed in 2016</b>	
Planting Ground Lake	1,011 acres
Range Line Lake	129 acres
<b>Phase VIII - Fieldwork Completed in 2017</b>	
Long Lake	604 acres



**Onterra LLC**  
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Sources:  
 Roads & Hydro: WDNR  
 Map Date: December 7, 2012  
 Filename: Map1\_3Lakes\_Location.mxd

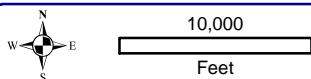
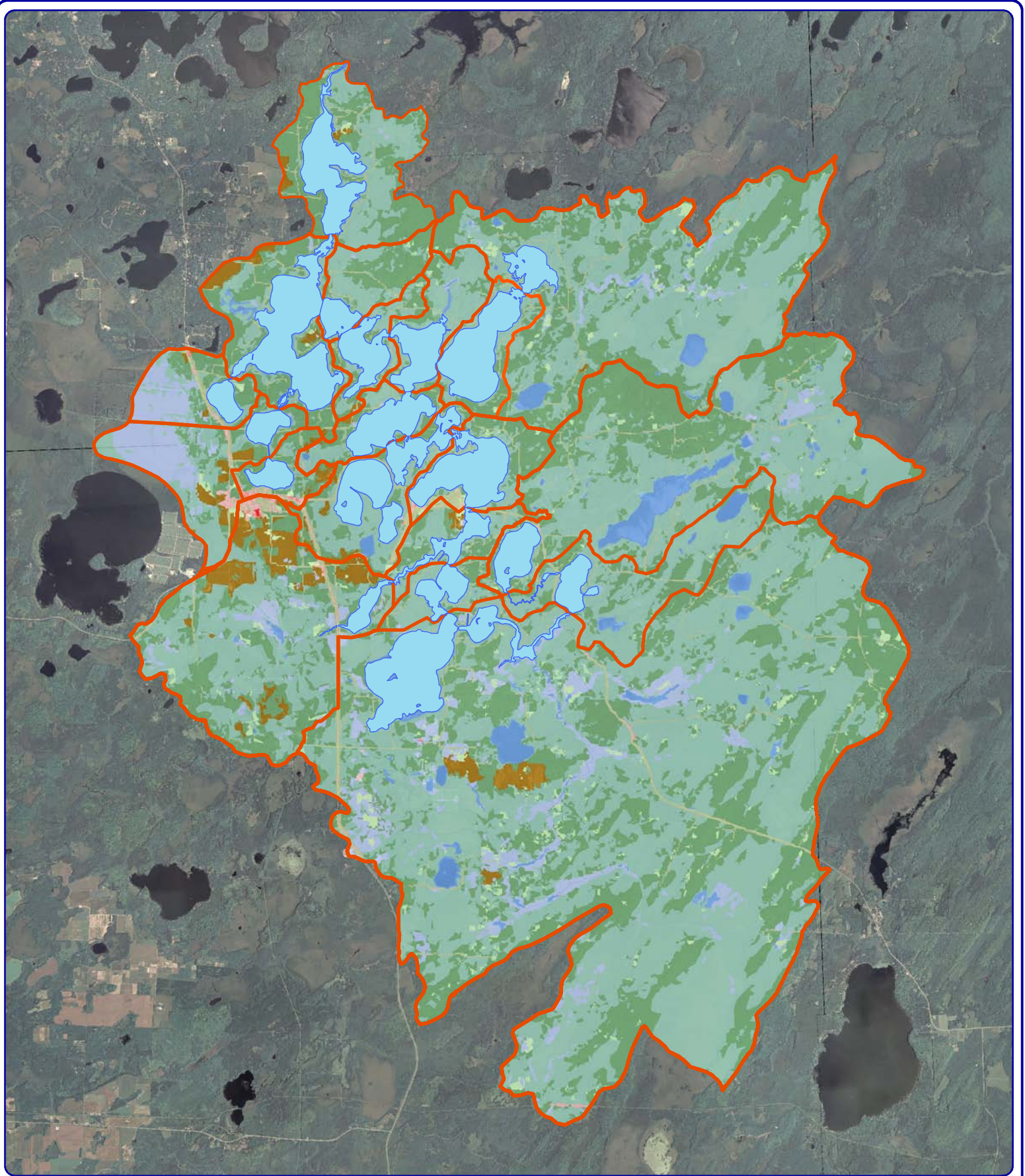


Extent of large map shown in red.

**Legend**

- Public Access - Watercraft Landing
- Public Access - Carry-in
- Water Quality Sampling Location
- Burnt Rollway Dam

**Map 1**  
**Three Lakes Chain**  
 Oneida County, Wisconsin  
**Project Boundaries**  
**and Water Quality**  
**Sampling Locations**



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Source:  
 Watershed: WDNR & Onterra  
 Landcover: WISCLAND  
 Roads & Hydro: WDNR  
 Orthophotography: NAIP, 2010  
 Map Date: March 7, 2011  
 File Name: Map2\_3Lakes\_WS.mxd



Extent of large map shown in red.

- Legend**
- Project Lake
  - Watershed Boundary
- Land Cover Types**
- Forest
  - Forested Wetlands
  - Pasture/Grass
  - Open Water
  - Wetland
  - Row Crop Agriculture
  - Rural Open Space
  - Rural Residential
  - Urban - High Density
  - Urban - Medium Density

Map 2  
 Three Lakes Chain  
 Oneida County, Wisconsin  
**Watershed and  
 Land Cover Types**