The North Lake Adaptive Management Plan

(*A product of the North Lake Stewardship Program*)

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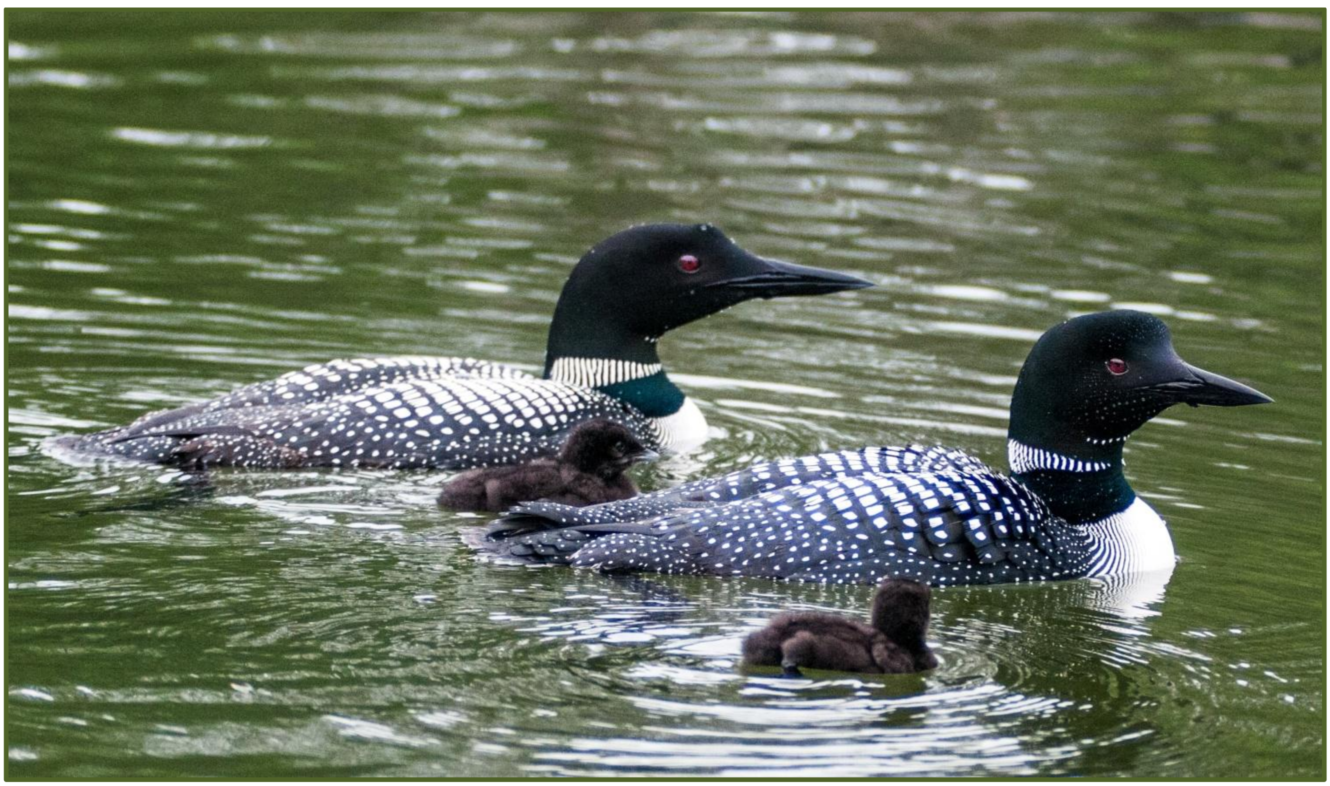

Common Loon family on the Spread Eagle Chain of Lakes 2013 (Ed Patrick photo)

Date: December 2014

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This document is a product of a WDNR Lake Planning Grant awarded to:

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CHAPTER 1

What Is the North Lake Adaptive Management Plan?

The *North Lake Adaptive Management Plan* results from a large-scale project funded by a Wisconsin Department of Natural Resources (WDNR) Lake Planning Grant. The project was sponsored by the Spread Eagle Chain of Lakes Association (SECOLA). White Water Associates, Inc., an independent ecological consulting firm and environmental laboratory, served as consultant to the SECOLA.

Project participants have embraced the concept of "adaptive management" in their approach to North Lake stewardship. Simply stated, adaptive management uses findings from planned monitoring activities to inform future management actions and periodic refinement of the plan. An adaptive management plan accommodates new findings by integrating this information into successive iterations of the comprehensive plan. The plan will therefore be a dynamic entity, successively evolving and improving to fit the needs of North Lake and SECOLA. A central premise of adaptive management is that scientific knowledge about natural ecosystems is uncertain and incomplete. It follows that a practical management plan allows for ongoing adjustments in management designed to "adapt" to changing conditions and new information or understanding. Monitoring the outcomes of plan implementation is essential to the process of adaptive management. It is the goal of the North Lake plan that future monitoring will focus on tangible indicators.

It is appropriate that SECOLA is the lead organization in the implementation of this plan. Success depends on a coalition of participants, each carrying out appropriate tasks and communicating needs and findings to other team members. Future projects and ongoing monitoring results will inspire updates to the plan. The overall vision of the SECOLA is a healthy, sustainable North Lake. This plan is an important tool to realize that vision.

Besides this introductory chapter, this plan is organized in seven additional chapters. Chapter 2 describes the audience for the *North Lake Adaptive Management Plan*. Chapter 3 addresses why there should be a plan and discusses adaptive management and the underlying assumptions of the approach. Chapter 4 details how the plan was created, including the methodology used. Chapter 5 presents the findings from efforts to gather existing and new information about North Lake and its environs by providing summaries of information in thirteen subsections. Chapter 6 (*What Goals Guide the Plan?*) presents the desired future condition and goals established by the Spread Eagle Chain of Lakes Association and the plan writers. Chapter 7 (*What Objectives and Actions Move Us Toward the Goals?*) offers a logical menu of practical management actions ready to be adopted and adapted by those interested in taking an active role in caring for North Lake and its surroundings. Fourteen Appendices complete this document. Appendix A contains literature cited. Appendix B contains the *North Lake Aquatic Plant Management Plan*. Appendix C presents the *North Lake Review of Water Quality*. Appendix D includes the analysis of *Watershed, Water Quality, and WiLMS Modeling*. Appendix E encompasses the *North Lake Conductivity and Sediment Studies*. Appendix F consists of the *North Lake EPA Littoral and Shoreline Survey.* Appendix G is the *Summary of the North Lake Shoreline Survey*. Appendix H includes the *North Lake Fisheries Summary*. The *North Lake Stewardship Program Volunteer Anglers' Journal Report* makes up Appendix I. Appendix J includes the *North Lake Frog and Toad Survey* results. *North Lake Invasive* Species are discussed in Appendix K. Appendix L consists of the *Review of Water Regulations and Planning Relevant to North Lake*. Appendix M is a short summary of *The History of the Spread Eagle Chain of Lakes and its Application to Lake Stewardship.* Finally, Appendix N summarizes the *North Lake User Survey*.

CHAPTER 2

Who Is the Audience for the North Lake Adaptive Management Plan?

The title of Chapter 3 poses the question: "Why Have the *North Lake Adaptive Management Plan*?" The short answer is "Because we care!" We believe that people working together in the stewardship of this lake can make a difference. We can protect and restore a healthy ecosystem if we take a long-term, strategic approach. That approach is presented in this adaptive plan. It is an adaptive plan in the sense that it will grow and evolve. Implemented actions will be monitored. The plan will be evaluated. It will be reviewed and refined as years go by – as new generations take up their stewardship responsibility.

People who care about the North Lake Watershed are the most direct audience for this plan. They will be the implementers and evaluators. They will be the reviewers and future plan writers. Many of them live in or near the watershed. These are the "grassroots" – the constituency most connected to North Lake and its surroundings. People who care are also those who live beyond the watershed boundaries. Some of these people visit North Lake for recreation and enjoyment. But the audience also includes foundations and other funding agencies, resource and regulatory agencies concerned with environmental quality, and other citizens that are working on their watersheds. The more broadly dispersed group of stakeholders is especially apropos to this plan since North Lake is a source lake for zebra mussels (and other aquatic invasive species). Other lakes and streams in the region are at greater risk of invasion because of this source. Because of this fact, those who care about any water resource in the region are an audience for this plan.

For those in the "grassroots" camp, this plan is intended to provide a practical approach to carrying out protection and restoration of North Lake and other regional waters. The plan does not have all the answers (it doesn't even have all the questions). It does not recommend every conceivable rehabilitation or protection action. But the plan does provide plenty with which to get started and it leaves room for ideas and contributions from others. Our recipe mixes a pinch of the theoretical with a cupful of the practical. Those of you who are "hands-on" have plenty to do.

The mixed audience of this plan challenges the authors to present a plan that is scientifically grounded and technically oriented, but at the same time accessible and understandable by the public who will in large part be responsible for its implementation. Although scientists are the primary authors of the plan, the writing is aimed at non-scientists. We define terms where clarity is needed and cite other literature for those interested in the source of a statement, or in learning more about the topic. The SECOLA has interacted with the plan writers throughout the process and reviewed draft components of the plan. The SECOLA has encouraged our practical approach so that applications of the plan are conspicuous.

We will end this chapter with our strongest management recommendation:

Approach lake and watershed management with humility.

Lake and watershed ecosystems are enormously complex. Our understanding of how they work is not complete. This is even truer when aquatic invasive species are part of the mix. Our ability to predict outcomes from specific actions is uncertain. New discoveries are made every day that have important implications for future watershed management. We may never know all we need, but that fact can't stop us from starting work on North Lake today. The fact that ecosystems are inherently resilient is to our great advantage. They are able to rebound from disturbance and repair themselves from injury. In fact, some of today's best watershed managers state that "...successful restoration usually has less to do with skillful manipulation of ecosystems than it does with staying out of nature's way" (Williams et al., 1997). This plan is intended to complement nature's own processes.

CHAPTER 3

Why Have the North Lake Adaptive Management Plan?

Why have the *North Lake Adaptive Management Plan*? The gut-level answer ("because we care") was offered in Chapter 2, but the question deserves more thoughtful reflection – the focus of this chapter. This requires consideration of environment, economy, history, and culture. This chapter also defines some important terms and presents the process and underlying assumptions.

Part 1 - Why Should We Care?

The health of a watershed and the health of local economies like those that exist in the North Lake Watershed are highly integrated. A sustainable economy depends on a healthy environment. In fact all social and economic benefits are based on the biological and physical properties of watersheds (Williams et al., 1997). In fact, our economy should be viewed as being nested inside our environment (Lanoo, 1996).

This link between a healthy environment and the economy is true at several scales. For example, most property owners on North Lake have invested in an ecosystem. The reasons that they have purchased the property are typically linked to the quality of the environment. The economic value of their investment is linked to the health of lake and surroundings. If ecological health declines, so does the value of the property.

At a slightly larger scale, this same principal linking the environment and economy applies to municipalities. The Florence community is caretaker of many ecosystems including North Lake. The long-term economic health of the municipality is tied to the health of North Lake and other lakes and streams in the area. At even larger scales yet, this applies to Florence County, to the State of Wisconsin, and so on.

The SECOLA and this plan aspire to cultivate a deep connection to the lake and its surroundings. It is the people of the watershed that will make the management plan work. Lake and watershed stewardship must be a cultural imperative. In some ways, watershed restoration is about cultural restoration – rejuvenating citizens' civic responsibility to care for the environment in which they live. This is what Aldo Leopold referred to as "...the oldest task in human history: to live on a piece of land without spoiling it" (Leopold, 1948).

People need to feel vital by working to improve, beautify, or build. Sometimes that need is expressed by gardening, caring for a lawn, or volunteering on civic projects. The SECOLA and this plan endeavor to harness that energy and apply it to restoration and protection actions focused on North Lake and its landscape. Education, rehabilitation, and protection become outlets for this creative energy.

Why should you care about creating and implementing a practical resource plan? Because we realize the economy and the economic options available to citizens in the watershed are tied to a healthy environment. Because we are all connected to the North Lake landscape in some way. Because we feel a civic responsibility to care for the lake. Because we realize North Lake potentially affects other lakes. Because we can feel vital by doing meaningful work in the watershed. Because future generations depend on us to hand down a healthy North Lake ecosystem for them to enjoy and use.

The adaptive management plan will be successful if it allows and organizes meaningful stewardship work for North Lake. It needs to make provision for different kinds of approaches and different kinds of people who want to be part of the process. It has to be strategic and integrated so that various actions complement one another, and are consistent with the lake's natural processes. The plan should help avoid management actions that work at cross-purposes or whose outcomes are undesirable.

Part 2 - What Is an Adaptive Management Plan?

An adaptive management process (Walters, 1986) is an appropriate model to use in lake and watershed management. In adaptive management, a plan is made and implemented based on the best available information and well-defined goals and objectives. Outcomes of management actions are monitored to ascertain whether they are effective in meeting stated goals and objectives. Based on this evaluation the plan is adapted (modified) in a process of continuous learning and refining.

Adaptive management concedes and confronts a truth that resource managers are sometimes reluctant to acknowledge – uncertainty. Because natural systems are so diverse, so complex, and so variable, almost all management actions will have uncertain outcomes. An adaptive management approach essentially takes a position that says, "We will make our best attempt and get better as we go along. We'll listen to what the natural system tells us." In adaptive management, monitoring is crucial. Adaptive management uses information from monitoring to continually evaluate and refine management practices. Monitoring measures the success of restoration or management. Well-designed monitoring should indicate how effectively management measures are working and give us new insights into ecosystem structure and function. Monitoring should provide needed information to adapt management goals.

The *North Lake Adaptive Management Plan* can be implemented through five kinds of management actions: protection, rehabilitation, enhancement, education, and research. Research actions have a special subset called "monitoring actions" that serve all of the management actions. Each kind of action is summarized in the following bullets.

- Protection actions are used when high quality areas or ecosystem elements are identified and need to be safeguarded. Since aspects of North Lake and its surroundings are quite pristine, part of the North Lake adaptive management could fall under this kind of action. There are numerous forms that protection actions can take including protecting water quality, conservation easements, buffer zones to prevent runoff into the lake, and so on.
- Rehabilitation actions are those that manipulate site-specific elements of ecosystems in order to repair some past impact. Examples include planting lakeside natural vegetation in areas of erosion, placing fish structures where large woody material has been removed from the lake, or healing an area of active erosion. Individual rehabilitation actions contribute to overall lake and watershed restoration.
- Enhancement actions are intended to improve some function or value of the ecosystem. In some cases, these actions are meant to benefit human users of the lake (for example, enhancing recreation values by planting fish or creating new fish habitat).
- Education actions are those activities that serve to promote lake stewardship and inform people about natural ecosystems. This can include this management plan as an education piece. These actions also include installation of interpretive kiosks or incorporation of North Lake biology in science curriculum of area schools. Every person who visits North Lake is an opportunity for education about healthy ecosystems and impacts to them.
- Research actions are employed to learn about the system being managed. Often we know very little about the plants, animals, habitats, ecosystems, and processes that our management actions are affecting. Research actions on water quality began at North Lake years ago with basic water quality measures and are ongoing today. More recently, research on aquatic plants and zebra mussels have contributed to our understanding of the North Lake ecosystem. Monitoring actions (a subset of research actions) are those that serve to evaluate the outcomes of protection, rehabilitation, enhancement, and education actions. Monitoring actions guide future management.

One word of caution is warranted. Our society typically thinks a long-term planning horizon is twelve months. Unfortunately, this is out of synchrony with the way an ecosystem functions. An ecological clock ticks off time in years, decades, centuries, and even millennia. Lake and watershed management and restoration must be viewed from this perspective. In fact, the final outcomes of some of the good work put in place today might not be apparent until a new generation of lake stewards is on the scene.

Part 3 - What Are the Plan's Underlying Assumptions?

As an adaptive plan, a basic assumption is that the management actions will change over time under the influence of stakeholders. Through iterative refinement, the plan will more closely reflect the needs of the lake and the people who care about it. This plan has assumed a desired condition of sustainable lake health. The plan attempts to reflect the collective vision of the people and organizations that are concerned with the lake and the surroundings. The SECOLA, Florence County Land Conservation Department, the Wisconsin Department of Natural Resources, Florence County Lakes and Rivers Association, and those living and recreating in the Menominee River watershed are among these stakeholders.

The Florence County Land Conservation Department provides a variety of land information and related services including: natural resource and water quality protection information, AIS information and assistance, geographic information, rural addressing, Public Land Survey System and surveying data, property ownership and tax assessment information and mapping products. This office can provide important assistance during subsequent phases of North Lake stewardship.

At a larger geographic scale, the WDNR published the *Headwaters Basin Integrated Management Plan* (WDNR et al., 2002) that provides a snapshot of current conditions of resources in the larger drainage basin that includes North Lake. The Plan outlines nineteen issues of concern to the basin, including control of exotic species, shoreline development, resource inventory and monitoring, habitat loss, user conflicts, and protection of endangered, special concern, or unique species.

The integrating feature of this lake management plan is North Lake and its surroundings. The plan assumes that proper planning in the beginning of the process will save time and money throughout the life of the program and that this can be accomplished by managing the causes rather than (or at least, in addition to) managing the symptoms of any impairments.

CHAPTER 4

How Was the North Lake Management Plan Made?

In this chapter, we describe the methods that were employed to accomplish these tasks and objectives. A team of consulting scientists (White Water) in consultation with the MLA prepared this adaptive management plan. The methods that were used followed closely the goals, objectives, and tasks that were described in the grant proposal submitted to the WDNR. We describe these methods in this section under descriptive paragraph headings.

The effort included gathering, reviewing, and summarizing existing information pertaining to North Lake biota and water quality. Existing information is found in many repositories and forms: anecdotal accounts of residents, resource agency reports and memos, municipal planning and zoning documents, scientific reports, old and new photographs, best guesses of knowledgeable people, and government land office records. Not all of the existing information is of equivalent value in the planning process. Some is not verifiable or the methods by which it was collected are unknown.

Watershed - North Lake watershed analysis included delineating the North Lake watershed area, mapping land cover/use and soils of the watershed; and creating digital elevation models. This information is discussed further in the *North Lake Aquatic Plant Management Plan*. We used existing layers of geographic information available from the WDNR and other sources and manipulated these data using geographical information system technology. We reviewed and summarized existing institutional programs that influence water quality (for example the *Headwaters Basin Integrated Management Plan*, the *Florence County Land & Water Resources Management Plan*, and various township zoning ordinances).

Aquatic Plants – Aquatic plant surveys have been conducted on North Lake by professional consultants in 1995 and 2012. In the 1995 survey, plants were pulled up with a rake in the shallow areas of North Lake. In the deeper areas of North Lake, a device was lowered to the bottom of the lake and dragged along a transect to retrieve plants (MMA, 1996). The 2012 aquatic plant survey was conducted by White Water using the WDNR point-intercept method. The formal WDNR point-intercept survey assesses the plant species composition on a grid of several hundred points distributed evenly over the lake. Using latitude-longitude coordinates and a handheld GPS unit, scientists navigate to the points and use a rake mounted on a pole or rope to sample plants. Plants are identified, recorded and put into a dedicated spreadsheet for storage and data analysis. This systematic survey provides baseline data about the lake that is accurately repeatable in future surveys. The survey area in 1995 included the water body south of Robbins Island, whereas the 2012 survey did not.[1] The data collected by the point-intercept method allow calculation of ecological metrics such as number of sites where a plant species is found, relative percent frequency of species occurrence, frequency of occurrence within vegetated areas, frequency of occurrence at all sites, and maximum depth at which plants are found. The data also allow calculation of metrics such as total number of points sampled, total number of sites with vegetation, total number of sites shallower than maximum depth of plants, frequency of occurrence at sites shallower than maximum depth of plants, Floristic Quality Index, maximum depth of plants (feet), average number of all species per site, average number of native species per site, and species richness. This data and the subsequent analyses were used in the creation of the *Aquatic Plant Management Plan* component of the *North Lake Adaptive Management Plan*.

Aquatic Plant Management Plan - An important component of this project was our objective to prepare an *Aquatic Plant Management Plan* (APMP) for North Lake. This involved interpreting and summarizing the North Lake aquatic plant data for inclusion in the plan. We created an APMP that includes goals, objectives, historical plant management, monitoring, evaluation, plant community, nuisance species or AIS, management alternatives, and recommendations. The North Lake APMP is included as Appendix B of this adaptive management plan.

Water Quality - One of our objectives was to gather, consolidate, assess, and manage information about North Lake water quality and potential risks to water quality. Four tasks were applied to achieving this objective: (1) collect and review existing limnological information about North Lake, (2) analyze and summarize existing North Lake water quality data, (3) assess the existing regimen of water quality sampling for North Lake and determine appropriateness to lake conditions, and (4) revise (if need) the water quality sampling regimen for North Lake as dictated by current information needs. Water quality information was collected from the WDNR

[1] *The WDNR Science Services provide the geographic points (latitude and longitude coordinates) for the point-intercept survey and did not include the area south of Robbins Island as part of North Lake.*

SWIMS database and by White Water Associates, Inc. These data provide insight into lake water quality and are a useful starting point for adaptive lake management.

To develop additional baseline material pertaining to North Lake water quality, we applied the water quality-planning tool known as the *Wisconsin Lake Modeling Suite* (WiLMS). The model is comprised of four parts: the model setup, phosphorus prediction, internal loading and trophic response (Hassett et al., 2003). To view analyses of North Lake's watershed and water quality using the WiLMS modeling, see Appendix D.

In 1996, MMA, Inc. consultants conducted conductivity and sediment studies on North Lake. These were the first studies of their kind on North Lake. With this baseline data, White Water Associates conducted similar conductivity and sediment studies. For results and comparisons of the two studies, see Appendix E, *North Lake Conductivity and Sediment Studies.*

The Spread Eagle Chain water levels are maintained by a dam located at the south end of South Lake. The dam was built in 1956 and has had many evaluations and some repairs (MMA, 05). Glen Johnson, President of SECOLA, has measured the lake level from his dock on East Lake from October, 2012 to September, 2013. His data represent the lake level changes that occur in the Spread Eagle Chain and are presented in the water quality report (Appendix C).

Littoral and Riparian Zones - Two assessments of North Lake's littoral and riparian habitats (one quantitative and one qualitative) were conducted as part of this project. White Water Associates staff conducted a U.S. Environmental Protection Agency (EPA) quantitative littoral zone and shoreline survey in 2012. This survey was augmented with some components of the WDNR protocol for littoral zone and shoreline survey. See Appendix F for results.

With training from White Water staff, North Lake volunteers conducted a qualitative assessment of the entire lake shoreline. This effort included survey of the human development and impacts as well as the natural setting. A photographic documentation of the entire North Lake shoreline was also completed and integrated with other data in order to document the current conditions of the lake. A summary of this information is available in Appendix G. The complete data and photos are available as a CD-ROM.

Fisheries - As part of the adaptive management plan, White Water biologists gathered and summarized information about North Lake fisheries. This objective was fulfilled by reviewing WDNR fisheries reports and interviewing WDNR fisheries biologists. White Water biologists summarized this information for inclusion in this adaptive management plan.

Another component of the adaptive management plan was to create a volunteer angler's journal program. Volunteer anglers' journals can be used to collect meaningful fisheries data to augment WDNR fisheries surveys. It is the objective of the anglers' journal to engage North Lake anglers in collecting fish data and to help understand the dynamics of fish populations. In 2012, 63 angler journals were completed, and 22 people participated. In 2013, 98 angler journals were completed, and 30 people participated. Results of the anglers' journals are in Appendix I.

Wildlife - As part of this project, a frog and toad monitoring program was implemented. Volunteers were trained to monitor for frog and toad species. Design and procedure of the frog and toad monitoring can be read in the *North Lake Frog and Toad Survey* (Appendix J of this plan). Observations on other water-related animals (e.g., common loons and bald eagles) have also been recorded.

Other Related Plans - Because other organizations are involved with water resources planning and management in northern Wisconsin, an objective of the planning component of the project was to review recommendations from existing plans (for example, *Headwaters Basin Integrated Management Plan* and/or *Florence County Land & Water Resources Management Plan*) and review these in the *North Lake Adaptive Management Plan* where appropriate. We also reviewed federal, state, and local regulations and ordinances that serve to protect water quality.

North Lake Historical Context – Human presence in the Spread Eagle Chain of Lakes area has influenced the look of the land and the quality of the lakes. In fact, humans have altered these ecosystems in many ways. As we look toward the future of North Lake and the rest of the Spread Eagle Chain of Lakes, an understanding of the history of the area is important. This gives us perspective as we consider how human stewardship might protect what is best about the lakes and restore aspects that need improvement. For more on *The History of the Spread Eagle Chain of Lakes and its Application to Lake Stewardship*, see Appendix M.

North Lake Attributes and Risks – Another objective was to prepare a catalog of North Lake environmental, cultural, and aesthetic attributes with a qualitative evaluation of the quality and associated potential threats. This objective included three tasks: (1) Through collaboration with the SECOLA and other North Lake area stakeholders, list water-related environmental, cultural, and aesthetic attributes and describe each; (2) qualitatively evaluate each of the attributes; (3) identify and describe potential threats to the North Lake attributes.

Educational Outreach - A planning objective was to support the educational program efforts where related to North Lake zebra mussel and other management elements. Toward this end, White Water staff was available for phone consultation with members of the SECOLA and other stakeholders. We endeavored to increase support, capacity, and involvement of the SECOLA and other stakeholders in long-term stewardship of North Lake through communication of project progress and findings. Finally, White Water staff attended public meetings that report and discuss North Lake planning process and other project-related issues.

Lake User Survey – In June, 1995, a property-owner survey was distributed to North Lake residents to solicit input from lake residents to better understand their needs, knowledge base, concerns and desires.

Adaptive Management Plan – A final project objective called for the creation of this initial adaptive management plan for North Lake that will help ensure high quality lake management and will serve as a firm foundation for future iterations of the plan. The adaptive management plan includes the Aquatic Plant Management Plan with other information about North Lake and its watershed. This objective was guided by two basic tasks. The first task was to develop management recommendations for North Lake. These recommendations include topics such as water quality, fish habitat, special species habitat (rare plants and animals), sensitive areas, non-native species, and ecological threats. The second task was to prepare a practical written plan, grounded in science that includes sections on implementation, monitoring, and adaptive management. The plan will lay the basis for its expansion in future phases. It will identify where more information is required. White Water scientists carried out tasks under this objective.

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CHAPTER 5

What is the State of North Lake and its Watershed?

An understanding of the features and conditions of the North Lake and its landscape is the foundation for developing and implementing strategies that seek to protect and restore the biological health of the area. We have sought information useful to devising the lake's adaptive management plan. Future project phases will collect and incorporate additional information.

This chapter is intended to teach us about North Lake. What is the lake like? What is the surrounding landscape? What organisms live here? How healthy is the lake? How have humans contributed (or detracted) from that health? Do threats to watershed health exist? This chapter identifies and organizes existing information and reports on new findings

If you are new to North Lake and its surroundings, this chapter will make you familiar with features and conditions that exist here and provide some insight as to why things are the way they are. If you are a life-long resident of the North Lake area, you may be familiar with parts of the discussion in this chapter. You may have things to contribute or correct. This would be a welcome response. Become engaged! Improve the understanding of the watershed by adding your knowledge in future iterations of this plan.

We present Chapter 5 in twelve Parts, each part reflecting the following topics: the lake and surroundings, aquatic plants; water quality, littoral and shoreline areas, fisheries, wildlife, aquatic invasive species, regional plans, area history, special attributes, environmental threats, and the lake user survey. Various appendices are referenced from the text.

Part 1. North Lake and the Surrounding Area

North Lake is in Florence County, Wisconsin about 5.5 miles southeast of the town of Florence and about 1.2 miles west of the Michigan-Wisconsin border. Other lakes, both large and small, are in this landscape. This interconnected water landscape is a target for migrating and breeding waterfowl and other birds. North Lake has value and function in this larger landscape as well as its own watershed.

North Lake has a 2.2 mile shoreline and 79 acres surface area. There is no State of Wisconsin or federal ownership on the lake. One improved boat ramp allows public access to North Lake and the entire Spread Eagle Chain of Lakes. The lake is fairly developed with permanent homes and cottages, although areas of more natural riparian area also exist. Exhibit 1 shows the North Lake area and identifies major landmarks.

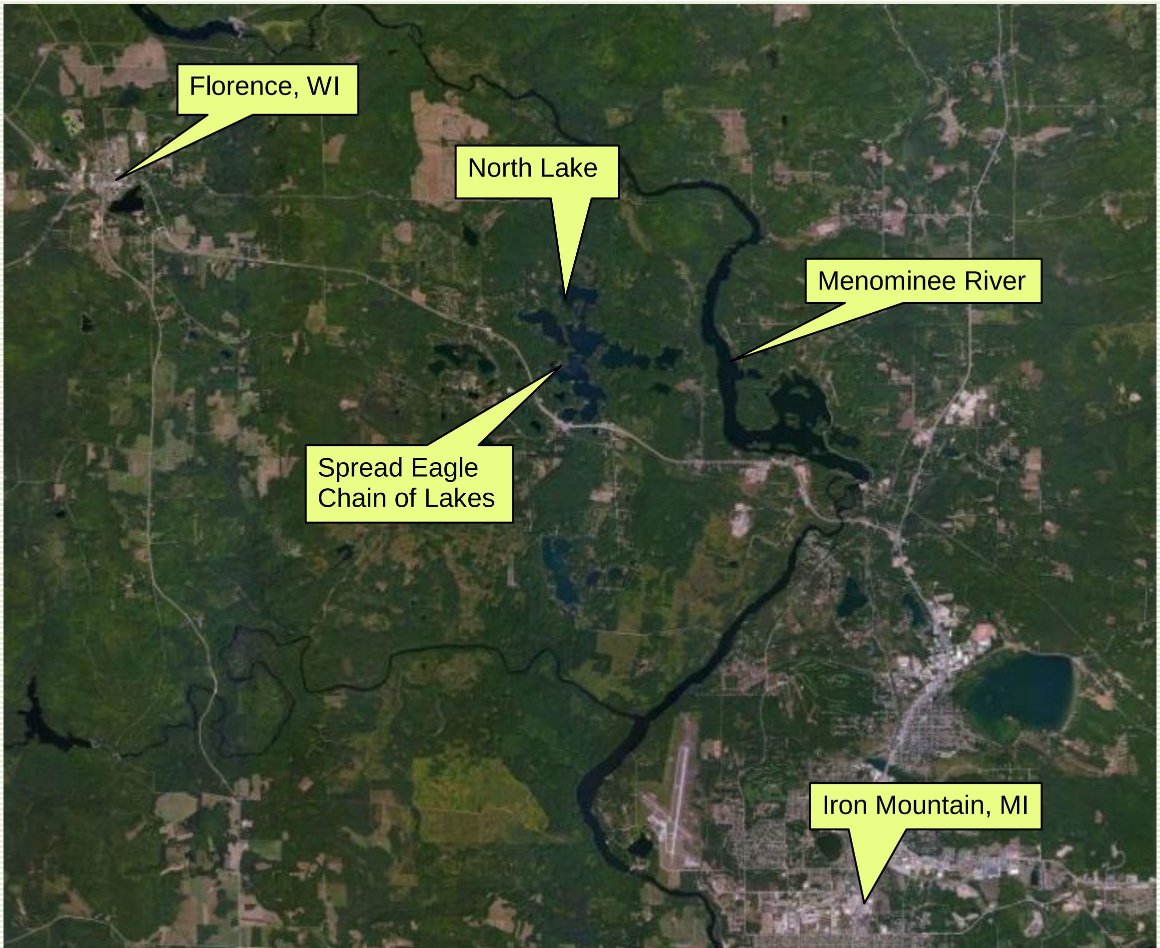

Exhibit 1. Map of North Lake area.

Water from North Lake eventually flows southeastward into the remaining lakes in the chain. The Spread Eagle Outlet finally leaves the Chain of Lakes from South Lake. From here, outflow from the Chain directly enters the Menominee River.

North Lake is within the Menominee River Watershed, an enormously diverse landscape with ecosystems that include boreal forest, diverse northern hardwood forest, oak savanna prairie, pine barrens, southern swamp forest, small and large rivers, lakes of all sizes, streams, and ponds. The biota of this watershed reflects this great diversity of habitats. The watershed has state parks and natural areas, national forests, state forests, county forests, industrial forests, nature preserves, proposed wild and scenic rivers, and recreational areas that range from placid fishing lakes to wild and raging white water rafting. The Menominee River watershed also has a variety of major environmental issues, including a US Environmental Protection Agency designated "Area of Concern" (for chemical contamination), closed iron mines, acid mine drainage, proposed mineral mines, past and present sedimentation from logging practices, wastewater treatment plants, and industrial effluent. The Menominee River is a large system that has numerous public access sites, and has both Eurasian water-milfoil and zebra mussel populations. Appendix B (*North Lake APMP*) contains a thorough treatment of the North Lake watershed, topography, and land-cover types.

Part 2. Aquatic Plants and Aquatic Plant Management Plan

As far as we can determine, no systematic or large-scale plant management activity has ever taken place in North Lake. Over the years, no particular aquatic plant nuisance issues have demanded control action. An aquatic plant survey was conducted in North Lake in 1995. Findings from that survey are discussed in the *North Lake Aquatic Plant Management Plan* (Appendix B). The 2012 point-intercept aquatic plant survey is also discussed in the North Lake APMP including tables and figures that interpret the data. There were twenty-three species of aquatic plants recorded in 2012. The aquatic plant community was diverse and had high floristic quality. These findings indicate that the North Lake plant community is currently healthy and diverse.

Part 3. North Lake Water Quality

Existing water quality data has been collected by the Citizen Lake Monitoring Network (CLMN) on North Lake from 1995 to present and is available in the WDNR SWIMS database. These data supports an oligotrophic classification. North Lake has a maximum depth of 43 feet and a complex bathymetry (Exhibit 2). Water quality information is briefly summarized in this section, but more fully interpreted in Appendix C.

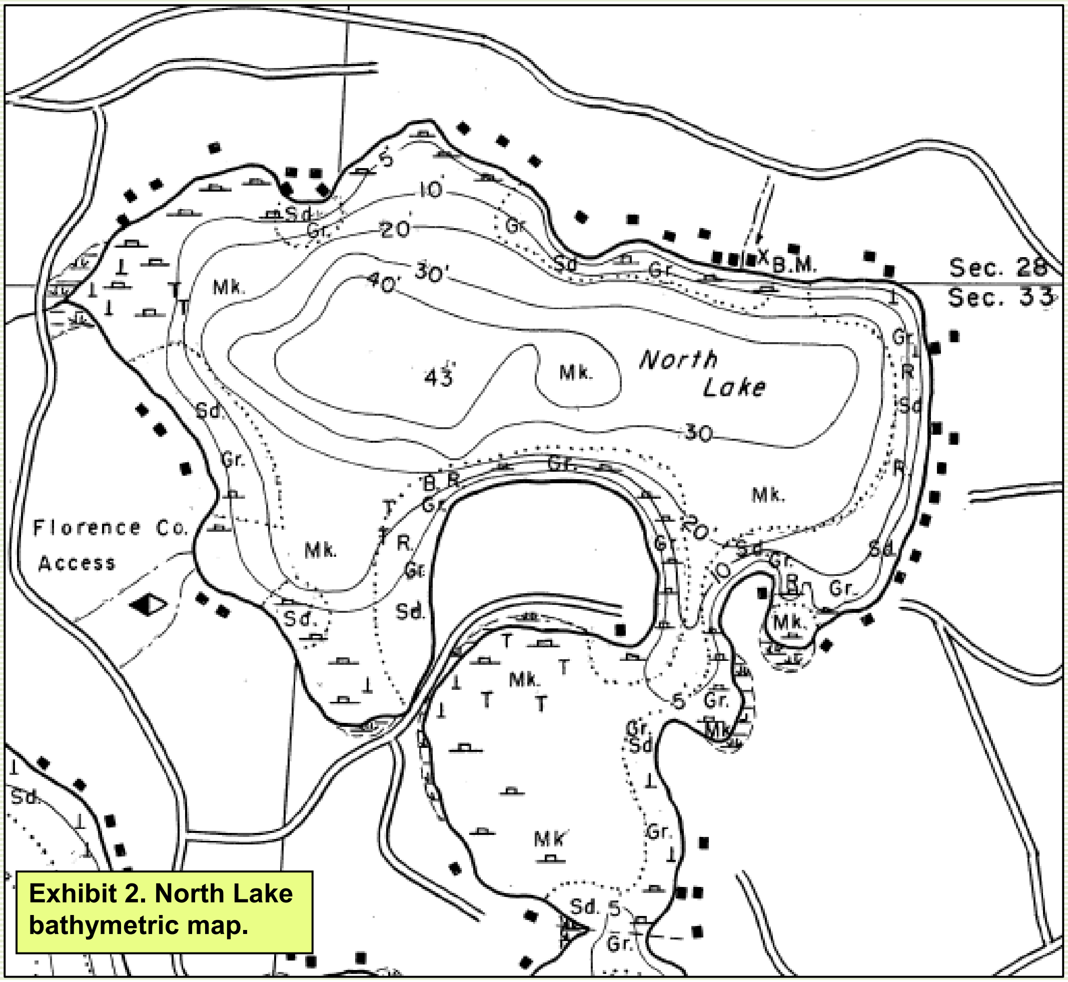

Exhibit 2. North Lake bathymetric map.

Temperature and dissolved oxygen showed stratification in North Lake in the ice-free season. Water clarity is good and in most recent years, user perception of North Lake aesthetic quality is generally regarded as beautiful. Water color is low and turbidity is generally low. The trophic state is oligotrophic. Such lakes (Exhibit 3) typically have low nutrients. They generally cannot support large fish populations, but can develop a food web capable of sustaining a desirable fishery. Oligotrophic lakes are usually clear, deep and free of weeds or large algal blooms. Water quality would be classified as very good with respect to phosphorus concentrations. Chlorophyll *a* (a measure of the relative amount of algae), nitrogen, sodium, and

Exhibit 3. Trophic Status

***Trophic state** of a lake is an indicator of water quality. Lakes are typically divided into three categories of trophic state: oligotrophic, eutrophic, and mesotrophic.*

***Oligotrophic** lakes are clear, deep, and free of weeds or large algal blooms. They are low in nutrients and do not support large fish populations, but they can develop a food web capable of sustaining a desirable fishery.*

***Eutrophic** lakes are high in nutrients and support large biomass (plants and animals). They are usually either weedy or subject to large algal blooms or both. Eutrophic lakes can support large fish populations, but are also susceptible to oxygen depletion. Small, shallow, eutrophic lakes are especially vulnerable to winterkill.*

***Mesotrophic** lakes are intermediate between the oligotrophic and eutrophic. The deepest levels become devoid of oxygen in late summer and limit coldwater fish. Anoxic conditions at the water-sediment interface causes phosphorus to be released from the sediments.*

Over long periods of time, lakes go through natural aging from oligotrophic through mesotrophic to eutrophic. As part of this process, they begin to fill in. This aging process can be sped up by introductions of sediments and nutrients. (Shaw et al., 2004).

potassium levels were considered low. Hardness, calcium, magnesium, chloride and alkalinity (a measure of a lakes buffering capacity against acid rain) were high. The pH of North Lake is slightly alkaline.

As mentioned earlier, the *Wisconsin Lake Modeling Suite (WiLMS)* was used as a planning and education tool for North Lake. WiLMS is a computer program into which the user enters information about the lake (e.g., surface area, depth, and nutrient measures) and the watershed (e.g., acreage and cover types). The model also has information about average rainfall, aerial deposition of materials, and cover type characteristics that it uses to help predict nutrient (phosphorus) loading scenarios. The WiLMS model predicts that most of the phosphorus delivered to North Lake comes from row crop agriculture, even though this cover is not dominant in the watershed. Appendix D provides more results and analyses of the WiLMS on North Lake.

In February, 1996 consultants MMA, Inc. performed conductivity and sediment studies in North Lake. White Water Associates, Inc. performed very similar conductivity and sediment studies in North Lake in 2012.

Lake conductivity studies are conducted to determine if there are any faulty septic systems present which could be leaching excess nutrients into the lake. Low values of conductivity are characteristic of high-quality, oligotrophic (low nutrient) lake waters (GVSU, 2014). High values of conductivity are observed in eutrophic lakes where plant nutrients (fertilizer) are in great abundance (GVSU, 2014). Very high values are indicators of possible pollution sites (GVSU, 2014). A shoreline study compares conductivity levels found along the shoreline with baseline levels measured in the middle of the lake.

Determining lake sediments allows scientists to study past climate and environmental changes, understand the impact of benthic habitat on fisheries and other biological communities, and provide insight about trends in sedimentation (NOAA, 2014). Results and comparisons of the 1996 and 2012 conductivity and sediment studies are provide in Appendix E.

Part 4. North Lake Littoral Zone and Riparian Area

The littoral zone is a critical part in maintaining a healthy lake ecosystem. This zone can be generally defined as the area nearest to a lake's shore in which it is usually shallowest, warmest and where sunlight can penetrate to the bottom. These factors usually allow for aquatic plants to grow. Aquatic plants provide habitat for invertebrates and fish in lakes, provide a food source for wildlife species, dampen the impact of waves, and absorb nutrients that would otherwise be used by algae. Bottom substrates also play an important role in the littoral zone. Substrates can include bedrock, cobble, sand, muck and woody material. These substrates provide habitat for invertebrates, amphibians, crustaceans and fish. The shoreline development index is one calculation used to indicate the amount of potentially productive littoral zone habitat relative to the overall acreage of the lake.

The shoreline development index is a quantitative expression derived from the shape of a lake. It is defined as the ratio of the shoreline length to the length of the circumference of a circle of the same area as the lake. A perfectly round lake would have an index of 1. Increasing irregularity of shoreline development in the form of embayments and projections of the shore is shown by numbers greater than 1. For example, fjord lakes with extremely irregularly shaped shorelines sometimes have SDI's exceeding 5. The Shoreline development index for North Lake is 1.8. This number indicates that the lake has a minimal amount of potentially productive littoral zone habitat relative to the overall acreage of the lake.

Riparian zones make up the area where aquatic ecosystems converge with terrestrial ecosystems. It is one of the most structurally diverse and naturally dynamic ecosystems making it sensitive to environmental or human-cause changes. Like the littoral zone, the riparian zone provides shelter and food sources for wildlife, and improves water quality by retarding runoff, reducing erosion and absorbing pollutants. Riparian areas are so important that the Wisconsin

Administrative Code requires at least 35 feet of land inland from the ordinary high water mark (OHW) be a vegetative buffer (Wisconsin Legislation, 2014).

In a national assessment of lakes, the United States Environmental Protection Agency (USEPA) evaluated hundreds of lakes across the United States assessing water quality, recreational suitability, and ecological integrity (USEPA, 2009). Important findings of that assessment included (1) poor lakeshore habitat (riparian vegetation) is the number one stressor of lake ecosystems nation-wide; (2) poor shallow water (littoral zone) habitat is the number two stressor. For the lake steward, by managing for sound lakeshores (both littoral and riparian components), we can make a difference in lake biological integrity (lake health). This means both development standards (e.g., NR115 and county shoreland ordinances) as well as best management practices (e.g., leave wood in place and minimize clearing of aquatic vegetation).

In 2013, North Lake volunteers conducted a qualitative assessment and photographic documentation of the entire lake shoreline. This information has been integrated and made available as a CD-ROM deliverable of this project. A summary of the qualitative results is provided in Appendix G.

Part 5. North Lake Fisheries

Various fish surveys have been conducted on North Lake by Wisconsin Department of Natural Resources (WDNR) biologists. Because North Lake is a part of the Spread Eagle Chain of Lakes, fisheries reports include information for all lakes in the chain. In 2011, comprehensive fish evaluations of the Spread Eagle Chain lakes were completed by Greg Matzke (2012). Four types of sampling occurred in 2011: early spring fyke netting, early spring electrofishing, late spring fyke netting, and fall electrofishing (Matzke, 2012). For more information on the research conducted on the Spread Eagle Chain in 2011, see Appendix H.

Volunteer Anglers' Journals can be used to collect meaningful fisheries data to augment WDNR fish surveys. North Lake's volunteer angler journal program was designed so that anglers can systematically record their fishing experiences. It is hoped that this activity will engage anglers in collecting fish data and understanding the dynamics of fish populations. The objectives for the angler journal program include providing information on:

- Species of fish caught while angling on North Lake;
- Size distribution of fishes caught on North Lake;
- Fishing emphases of North Lake anglers (time spent on panfish, walleyes, bass, etc.);
- Fishing techniques used on North Lake (trolling, bait fishing, spin fishing, etc.);

- Relative amount of catch and release fishing; and
- Catch-per-effort (CPE) for various North Lake fish species.

A field data form was provided for North Lake anglers to fill out. In 2012, 63 angler journals were completed, and 22 people participated. In 2013, 98 angler journals were completed, and 30 people participated. Results of the anglers' journals are in Appendix I. Participants also recorded fishing data in 2014 and these data are archived for future analysis.

Part 6. North Lake Wildlife

For many reasons, lakes attract a variety of wildlife species. Some of these species require a lake as a prime habitat component. Some live in or near the lake permanently, while others visit only at times in order to obtain crucial resources. Lakes provide food in the form of plants, insects, fishes, and other organisms. Lakes provide breeding and nesting sites. Lakes provide shelter and protection. Some of the wildlife species that use lakes are common (for example, green frogs, painted turtles, tree swallows, belted kingfishers, mink, and raccoons). In contrast, other lake-dependent wildlife species are relatively rare (for example, common loons, bald eagles, and osprey). In this section, we focus on two species (common loon and bald eagle) that in many ways represent the quintessential image of a northern Wisconsin lake. These species, when present also provide a strong indication of a healthy lake. This section also references the frog and toad survey conducted by North Lake volunteers.

The common loon (*Gavia immer*) has one of the most distinct plumages of North American birds. It is a large bird with spotted black and white body, and a black/iridescent green head. The loon has many distinct calls for guarding territories, communicating with other loons, and warding of threats. Loons spend most of their life in the water. Unlike most birds, loons have solid bones allowing them to dive as deep as 250 feet in search of food (MNDNR, 2014). With legs positioned fairly far back on their body, loons are good swimmers. The position of the legs, however, means that walking on land is difficult for a loon. Perhaps because of their awkwardness on land, loon nests are built close to shore (Cornell). Loon nests are made of grasses, rushes, and twigs. Loons are quite territorial. A small lake (5-50ha) can accommodate one pair of breeding loons. Larger lakes may have more than one pair, with each pair occupying a bay or different section of the lake (Loon Pres. Comm., 2014). LoonWatch, a program of the Sigurd Olson Environmental Institute, has hundreds of volunteers monitoring loon nests and territories throughout Wisconsin. In 2010, volunteers observed approximately 3,373 adult loons and 805 chicks throughout surveyed Wisconsin lakes (LoonWatch). Common loons are frequently observed feeding on North Lake, despite fairly heavy boat traffic. According to SECOLA member Ed Patrick, a pair of common loons successfully hatched chicks on the Spread Eagle Chain of Lakes in 2013 (the picture of this loon family adorns the cover of this plan). This pair nested in East Lake and according to Mr. Patrick's sources ("a few old-timers"), these are the first common loon chicks on the Chain in over thirty years. Attempted nests have failed in the past few years. Mr. Patrick also reports that a decade ago sighting a common loon on the Spread Eagle Chain of Lakes was a rarity. In recent summers it was an everyday occurrence.

The bald eagle (*Haliaeetus leucocephalus*) is listed as a Special Concern species in Wisconsin, and is federally protected by the Bald & Golden Eagle Act (WDNR, 2013). Bald eagles live near water and eat small animals, carrion, and fish (preferring fish). They are believed to mate for life. Eagles create their nests in tall trees, using sticks and other debris. Eagle territories can be 1 to 2 square miles. In Wisconsin, bald eagle nest and territory surveys are conducted by plane. In 2013, there were 1,344 known bald eagle nest territories occupied by breeding adults (NHI, 2014). This was an increase of 57 pairs from 2011, and an increase of 7 from 2012 (NHI, 2014). North Lake, located in Florence County, has no known nests or territories (Ron Eckstein, email), however, foraging bald eagles use North Lake and the Spread Eagle Chain of Lakes. The Wisconsin Natural Heritage Inventory (NHI) assesses the rarity of species by using State and Global ranks. The State and Global ranks of the bald eagle can be described as: "Apparently secure in Wisconsin, with many occurrences (Breeding and Non-breeding)," and "Demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery."

North Lake riparian owner Darlin Verley spent nearly sixteen hours observing water related birds in 2013 with twenty-nine observation days spaced during April, May, June, July, August, and September. She recorded seeing Great Egrets (on four days), Great Blue Herons (on seven days), Common Loons (on 15 days) and Bald Eagle (on one day). She also observed loon chicks. She says that these were the first loon chicks she has observed on North Lake since building there in 1956. Mrs. Verley also reports that Bald Eagles have been more frequently observed in recent years.

Other rare species and communities live and are near to North Lake. The Wisconsin Natural Heritage Inventory (NHI) lists these rare species and communities. Exhibit 4 shows the rare species and communities found in the same township(s) as North Lake.

Exhibit 4. Rare Species and Communities located near North Lake.			
Common Name	*Scientific Name*	*State Status**	*Group Name*
Bald eagle	*Haliaeetus leucocephalus*	SC/P	Bird
Common nighthawk	*Chordeiles minor*	SC/M	Bird
Upland sandpiper	*Bartramia longicauda*	SC/M	Bird
Black spruce swamp		NA	Community
Bracken grassland		NA	Community
Lake-deep, soft, seepage		NA	Community
Northern dry-mesic forest		NA	Community
Northern sedge meadow		NA	Community
Northern wet forest		NA	Community
Pine barrens		NA	Community
Pickerel frog	*Lithobates palustris*	SC/H	Frog
Northern flying squirrel	*Glaucomys sabrinus*	SC/P	Mammal
Woodland jumping mouse	*Napaeozapus insignis*	SC/N	Mammal
Elktoe	*Alasmidonta marginata*	SC/P	Mussel
Autumnal water-starwort	*Callitriche hermaphroditica*	SC	Plant
Missouri rock-cress	*Arabis missouriensis*	SC	Plant
Intrepid forestfly	*Shipsa rotunda*	SC/N	Stonefly
Wood turtle	*Glyptemys insculpta*	THR	Turtle

***END**=Endangered; **THR**=Threatened; **SC**=Special Concern; **SC/P**=fully protected; **SC/N**=no laws regulating use, possession or harvesting; **SC/H**=take regulated by establishment of open/closed seasons; **SC/FL**=federally protected as endangered or threatened, but not so designated by DNR; **SC/M**=fully protected by federal and state laws under Migratory Bird Act (WDNR, 2014).

(NHI, 2013)

As part of the North Lake Stewardship Program, a frog and toad monitoring route was established in wetlands surrounding North Lake. A description of the sites and the monitoring results are reported in Appendix J.

Part 7. North Lake Aquatic Invasive Species

In the past five years, five aquatic invasive species (AIS) with significant populations have been recorded in North Lake: (1) rusty crayfish (*Orconectes rusticus*) discovered in 2008, (2) banded mystery snail (*Viviparus georgianus*) discovered in 2009, (3) freshwater jellyfish (*Craspedacusta sowerbii)* discovered in 2009, (4) zebra mussels (*Dreissena polymorpha*) discovered in 2012, (5) and Eurasian water-milfoil (*Myriophyllum spicatum)* discovered in 2012. One wetland/terrestrial invasive species, European marsh thistle (*Cirsium palustre*), was observed in the 2012 point-intercept study. It was also noted that pink water lily (*Nymphaea odorata*) was observed in that study. This is a colored variation of the native white water lily. It is not invasive, however, it is not native to northern Wisconsin lakes, and was likely planted by someone into the lake. For more information about the invasive species present in North Lake, see Appendix K, *North Lake Invasive Species.*

Part 8. Water Resource Regulations and Planning Relevant to North Lake

For the purposes of this plan we reviewed documents of other organizations involved with water resources regulations, planning, and management in northern Wisconsin. Appendix L contains our documentation of these reviews and provides substantive information on (1) federal, state, and county regulations and ordinances that influence water quality, (2) WDNR programs that strive to preserve and restore land and water resources (including Fisheries Management and Habitat Protection, Watershed, Wastewater, Nonpoint Source Pollution Abatement, Drinking and Groundwater, Wildlife, Endangered Resources, and Forestry), and (3) a review of the *Florence County Land & Water Resource Management Plan* (Florence County Land Conservation Department, 2011). These reviews discuss federal, state, and local agencies and the mechanisms by which they protect water resources. The discussion ranges from the federal Clean Water Act of 1972 to Wisconsin's NR115 to Florence County ordinances.

Part 9. Historical Review

Humans have had a variety of influences on North Lake and the rest of the Spread Eagle Chain of Lakes. Euro-Americans over the past 150 years have had the most dramatic and longlasting influence on the look of the landscape surrounding North Lake and the quality of the water. A summary of the pertinent surrounding North Lake and the Spread Eagle Chain of Lakes is provided as Appendix M (*The History of the Spread Eagle Chain of Lakes and its Application to Lake Stewardship).*

Part 10. North Lake Area Special Attributes

One of the objectives of the North Lake Aquatic Invasive Species Control Grant was to prepare a description of North Lake environmental, cultural, and aesthetic attributes with an assessment of quality and potential threats. Environmental quality attributes can be organized in three categories: (1) environmental (ecological), (2) cultural and (3) aesthetic (Redding, 1973). Some resources may display all three conditions and others may contain only one. More complete definitions (Redding, 1973) of the three categories are as follows:

1. Environmental (ecological) attributes are components of the environment and the interactions among all its living and nonliving components that directly or indirectly sustain dynamic, diverse, and viable ecosystems. Included are functional and structural aspects of the environment.
2. Cultural attributes are evidence of past and present habitation that can be used to reconstruct or preserve human lifeways. Included are structures, sites, artifacts, and environments.
3. Aesthetic attributes are perceptual stimuli that provide diverse and pleasant surroundings for human annulment and appreciation. Included are sights, sounds, scents, tastes, and tactile impressions.

The first two attributes (ecological and cultural) are more tangible than the third but aesthetic attributes are important when it comes to how people feel about a feature and are compelled to protect a feature or otherwise act as stewards. The importance of preserving aesthetic resources is emphatically expressed in the National Environmental Policy Act 1969 that requires the “Federal Government to use all practicable means ….. (to) …. assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings… and to… preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity and variety of individual choice” (NEPA Sec. 101 (b) (2, 4)). Aesthetic quality is a subjective attribute. Something that has high aesthetic value for one person may not receive the same consideration from another. Some hold high aesthetic value in a manicured lawn where others prefer a more natural ground cover. Aldo Leopold (1948) expresses his love for nature and its beauty and the need for a land ethic to protect natural beauty and “quality of life.” In its promotional effort, the Florence County website states the following questions:

- *Looking for more natural, less commercial?*
- *Searching for a real wilderness experience?*
- *Getting crowded where you stalk game?*

These all reflect a context of aesthetic attributes. In the stewardship of North Lake, it will be important to consider the environmental, cultural, and aesthetic attributes that are part of the lake and its surroundings. It is useful to evaluate how these attributes are threatened and how they might be protected and maintained.

Florence County is located in northeastern Wisconsin. It covers 488 sq miles and has 4023 permanent residents (US Census, 2010). About 50% of Florence County land is publically owned and few places seem crowded. There are 265 lakes and 165 miles of rivers, including two state- designated “Wild Rivers” (the Pine and Popple Rivers). The county is 80% forested with miles of scenic trails. There are many waterfalls in the county: LaSalle, Meyers, and Bull Falls on the Pine River and Washburn, Little Bull, Big Bull and Jennings Falls on the Popple River (Florence County, 2013). The Pine and Popple Rivers are among Wisconsin’s most remote river systems. The entire 89 mile length of the Pine River and 62 miles of its major tributary, the Popple River, were designated by the Wisconsin legislature as State Wild Rivers in 1965 to be protected from development and kept in natural, free flowing condition (Florence County, 2013). There are fourteen public and private camping areas. Many parks are located in Florence County: Lake Emily Park, West Bass Lake Park, Fisher Lake Park, Kenneth Thompson Memorial Park, Keyes Lake Park, Loon Lake Park, Popple River Park, and Vagabond Park. There are many opportunities for hiking as Florence County maintains more than 27 miles of hiking trails throughout a variety of habitats ranging in length and difficulty, including a mile long path through a variety of woodland vegetation and diverse topography to the banks of the Pine River for a view of majestic LaSalle Falls. The Chequamegon-Nicolet National Forest features a number of trails through six distinctly different areas of the forest including the Whisker Lake Trail and Lauterman National Recreation Trail (Florence County, 2013). In 1978, Congress and President Carter officially declared 7,500 acres of the former Nicolet National Forest a federally designated wilderness. Whisker Lake Wilderness, the second largest national forest wilderness area in the state, is located in northern Florence County. Southeast of Florence lies 8500 acre Spread Eagle Barrens State Natural Area. It is the largest expanse of pine barrens and bracken grasslands that remain in northeast Wisconsin. The Nicolet National Forest is located in northern Wisconsin, where towering pine and hardwood forest are interspersed with hundreds of crystal clear lakes and streams. The Chequamegon Nicolet National Forest covers approximately 83,000 acres in Florence County (Explore Florence County, 2012).

In winter, Florence County also boasts many cross country ski trails and also Keyes Peak Ski Hill which provides downhill skiing, snow tubing, snowshoeing and cross country skiing. The Florence County Snowmobile Club, established in 1960, has approximately 180 miles of trail. Club members work with Florence County, State of Wisconsin, Federal Government and private landowners and they state it is the best trail system in the state. Ice fishing is a popular activity on Florence County lakes.

Among the cultural resources, is the historical Florence County Courthouse Jail which was constructed in 1889. There are many organizations within the North Lake community involved in protecting the environment. One of the organizations is The Florence County Lakes and Rivers Association (FCLARA), founded in 2000. Their statement of purpose is "To develop a partnership among lake and river concerned citizens, to increase support and education, to maintain and improve high quality water, fish, animal, bird, air, and associated wetland resources, thereby maintaining the aesthetic values of Florence County lakes and rivers as public recreational facilities today and for future generations" (FCLARA, 2008). There are many lake and river organizations that take part in this group: The Spread Eagle Chain of Lakes (SECOLA), Keyes Lake Improvement Association (KLIA), Lake Ellwood Association, Lake Emily Association, Patton Lake Association, Halsey Lake Association, Fay Lake Association, Long Lake Association, Frog-Bass Lake Association, Wild Rivers Association, and the Menominee River Association. These various organizations collectively assemble an impressive number of environmental stewards and concerned citizens.

Cary Anderson (Florence County Lakes and Streams Association, personal communication 12/17/2012) holds that the aesthetics of lakes and rivers in the Menominee River Watershed are the same as they have always been. People need to be constantly educated in tactful, entertaining, and non-threatening ways. That's what lake associations should be and are doing. People on lakes and rivers will respond more to the effects of invasives like Eurasian water-milfoil and blue-green algae than zebra mussels, simply because they can see and maybe smell the mess it makes. We expect the water clarity to increase with zebra infestation, but I doubt that would bother people who live on water, until the infestation interferes with their physical use. One of the biggest threats we have to water quality is basic shoreline habitat destruction.

Florence County's lakes, streams, and forests are outstanding and unique. Residents and visitors alike feel an imperative to protect and to maintain the environmental, cultural, and aesthetic attributes. As more and more people realize what a great place the County is to visit and to live, the threats from development and related activities may increase. We all need to do our part in helping protect our natural resources and to follow FCLARA's statement, "…. to increase support and education, to maintain and improve high quality water, fish, animal, bird, air, and associated wetland resources, thereby maintaining the aesthetic values of Florence County lakes and rivers as public recreational facilities today and for future generations."

As has been outlined in various parts of this Adaptive Management Plan, North Lake is a high quality ecosystem with respect to components of water quality, aquatic plants, fish community, and wildlife habitat. These attributes combine to influence a high aesthetic quality. The next part outlines some of the potential threats to this high quality.

Part 11. Environmental Threats to North Lake

North Lake and its surroundings are subject to environmental threats from a variety of sources. We outline some of these threats in this part of the North Lake plan.

Recreational pressure – North Lake is a well-known and much-loved fishing and water recreation lake for people from near and far. It is the gateway through which recreationists access the entire Spread Eagle Chain of Lakes. An expanding base of admirers will result in increasing recreational pressures. Increased traffic in and out of the lake increases opportunities for additional AIS introductions and puts other area water bodies at risk from zebra mussels and other AIS from North Lake.

Development pressure – North Lake has some areas of fairly high residential development as well as areas with predominantly natural vegetation and broad and diverse riparian areas. In some areas of the lake, conventional lawns, cropped short and in close proximity to the shore indicate a need for educational effort to inform residents about more ecologically friendly waterfront vegetation. Likewise, well-intended activities meant to "clean up" the shoreline or shallow water zone of the lake diminishes the habitat quality for invertebrates and fish.

Water quality inputs – The water quality and aquatic ecosystem functioning of North Lake is affected by all inputs of water (groundwater, precipitation, streams, and overland runoff). All of these sources have potential to carry pollutants of various kinds to North Lake. North Lake has excellent water quality and a long record of water quality monitoring. Non-point source pollution, however, remains an important threat to North Lake water quality. That is the subject of the next paragraph.

Non-point source pollution – Surface runoff from the land, roadways, parking lots and other surfaces flows into North Lake. This runoff carries with it sediment, nutrients (for example, from fertilizers) and contaminants (for example, oils and herbicides) that can have detrimental effects on the North Lake ecosystem. Known as non-point source pollution (because it does not emanate from a discrete point like an effluent pipe from a paper mill), this kind of runoff can come from lawns, agricultural fields, clear-cuts, and impervious surfaces (for example, roads and paved parking lots). Sometimes the impact is physical, such as sediment covering gravel spawning areas. Sometimes it is chemical such as excess phosphorus from lawn fertilizers that might invoke an algal bloom. This type of pollution can be best controlled through education and protection of riparian buffers (natural vegetation near the waterways that absorb the pollutants before they reach the water).

Invasive aquatic species – Non native plant and animal species have become a grave concern for aquatic, wetland, and terrestrial ecosystems. The discovery of zebra mussels in North Lake is worthy of such concern. The threat remains for other AIS introductions as well. When it comes to non-native aquatic plant invaders, the best defense against establishment is a healthy community of native plants. A diverse native plant community presently exists. Effective education and diligent monitoring are important factors in avoiding establishment of aquatic invasive species.

Riparian ecosystem integrity – Healthy riparian areas (the naturally vegetated land near the water) provide numerous important functions and values to North Lake. For example, they serve as habitat for many species, contribute important habitat to the lake (e.g., large wood), filter out non-point source pollution from entering the lake, and armors the shores against erosion. Educating riparian owners around North Lake as to the importance of riparian areas is crucial to the maintenance of these critical areas.

Littoral zone ecosystem quality – Much of the productivity of a lake comes from the shallow water areas known as the littoral zone. This is where plants grow, invertebrates live, fishes spawn, and aquatic birds and mammals spend much of their time. The presence of good aquatic vegetation, diverse substrate, and dead woody material (logs and branches) is crucial to this littoral zone ecosystem. Sometimes the human temptation is to “clean up” these areas, but in fact this process diminishes the habitat quality greatly. It is important to educate landowners and others about how to protect the littoral zone from degradation. Piers and swimming areas impact the littoral zone as well, but can coexist with a quality shallow water habitat if kept to a reasonable level.

Habitat degradation of nearby aquatic and wetland habitats (ponds, streams) – The wetland habitats, streams, small lakes, and ponds in the vicinity of North Lake all contribute to the high quality of the lake. These smaller ecosystems can be overlooked in terms of their importance and therefore deserve some special attention. One of the first protective measures to take is to identify where these features are and characterize their size and ecological composition. This informs future protection and restoration efforts.

Part 12. Lake User Survey

In June, 1995, a property-owner survey was distributed to North Lake residents. That survey solicited input from lake residents to better understand the needs, knowledge base, concerns and desires of the various water body users. Responses and analysis of that 1995 survey can be viewed in the *Lake Planning Study for North Lake* (MMA, 1996). A summary of the survey results can be viewed in Appendix N of this Adaptive Management Plan.

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CHAPTER 6

What Goals Guide the North Lake Adaptive Management Plan?

"Protect the Best and Restore the Rest" has become the credo of successful watershed managers across the country. This simple phrase acknowledges that watershed management is more than identifying the worst areas and trying to rehabilitate them. It recognizes that of equal or greater importance is identifying those areas that are of high or moderate quality in the watershed and establishing mechanisms to maintain that quality. "Protect the Best and Restore the Rest" also implies the importance of identifying imminent threats to watershed health and working to eliminate them. This simple principal is founded on the restoration ecology fact that the most certain way to successfully restore the structure and function of part of a broken watershed ecosystem is to rely on intact areas of the watershed to serve as the donors of healthy "parts" (such as aquatic insect species or good quality water). "Protecting the Best" allows us to "Restore the Rest" more effectively and economically. But, protecting the best is prerequisite.

The primary goal of the *North Lake Adaptive Management Plan* is to perpetuate the quality of North Lake and its watershed ecosystem into the future. Sometimes this will mean protecting what is good about the lake and its surroundings and sometimes it may mean restoring some feature that has been degraded. Restoration is reestablishment of the structure and function of an ecosystem including its natural diversity (Cairns, 1988; National Research Council, 1992). It implies rehabilitating and protecting sufficient components of the ecosystem so that it functions in a more or less natural way, provides habitat for native plants and animals, and supports reasonable human uses.

The *North Lake Adaptive Management Plan* offers several supporting goals. In an adaptive plan, new goals can be adopted as the plan evolves. We conclude this chapter by presenting these goals organized under topical headings.

Restoration – Apply rehabilitation, protection, and education actions under the direction of specific objectives directed at specific areas in the North Lake watershed.

Research – Gather information that is useful in planning and monitoring restoration actions and devising education programs.

Monitoring – Establish a monitoring system in the North Lake watershed that will provide data that reveals the quality of the system and establishes methods to evaluate the effectiveness of management efforts.

Cultural Climate – Encourage a cultural and political atmosphere that allows and promotes good watershed stewardship including cooperation between citizens, businesses, public agencies, and municipalities.

Sustainable Economy – Foster an environment that promotes a sustainable economy, provides a diversity of economic options for the residents of the watershed, and does not diminish opportunities for future generations of watershed residents.

Recreation – Promote a sustainable recreation in North Lake where all citizens (now and in the future) can enjoy the opportunities of the natural and human-sustained environment while respecting the environment and the rights of fellow citizens.

Program Maintenance – Foster a stewardship culture that engages people to donate time, talent, and money sufficient to support the implementation and periodic update of the *North Lake Adaptive Management Plan*.

In the final chapter of this plan, we present possible objectives and actions that will serve to move toward these goals. This is not an exhaustive treatment, but a starting point, integrated with monitoring so that adaptive management can take place in subsequent years. This *Adaptive Management Plan* also contains the *North lake Aquatic Plant Management Plan* with its own set of objectives and actions.

CHAPTER 7

What Objectives and Actions Move Us Toward Our Goals?

The North Lake watershed is healthy, diverse, and productive. The lake has been colonized by several aquatic invasive species that potentially impact the aquatic ecosystem and animals that use it. Perhaps of greatest concern among these AIS is the zebra mussel as it has potential to influence the entire North Lake food web extending from algae up to common loons and bald eagles. Our challenge through this adaptive management plan is to perpetuate the healthy characteristics of North Lake (including the native biodiversity) into the future. The challenge will be met by a capable set of program partners that are prepared to devote themselves to North Lake stewardship. These partners include the members of the Spread Eagle Chain of Lakes Association, the Florence County Land Conservation Department, the Wild Rivers Invasive Species Coalition, the ecological scientists of White Water Associates, Inc., the WDNR, Florence County Lakes and Rivers Association, and others who care about North Lake and the Spread Eagle Chain of Lakes.

Abraham Lincoln is attributed with the following wisdom: "If I had an hour to cut down a tree, I'd spend the first 45 minutes sharpening my ax." Planning and preparation are important for any task, but especially when working with a system as complex as a lake or watershed. The vision and goals described in the previous chapter provide the basis for developing objectives and actions to achieve the desired future for the North Lake watershed. In keeping with the spirit of an adaptive management plan, we present several actions and associated objectives that can be undertaken as human and financial resources allow in subsequent phases of the program. Desired outcomes of each action are also stated. The actions, objectives, and outcomes each need to be further developed so that appropriate methodology and accurate estimates of required effort can be described. The Spread Eagle Chain of Lakes Association is in control of the plan. The plan is flexible and allows the insertion of new actions at any point along the path of lake management. The pace of implementation of the plan is also flexible and will be influenced by availability of volunteer time, financial resources, and other factors.

Recommended Actions for the North Lake Adaptive Management Plan

Action (Education): Work with WDNR to understand and manage the North Lake fishery.

Objective: To support scientific and effective perpetuation of a quality North Lake fishery.

Outcome: Document meetings and other contacts made to the WDNR and others.

Status: Action included in *Adaptive Management Plan*. This is an ongoing activity.

Action (Monitoring): Continue with the volunteer angler's journal program in North Lake.

Objective: To augment fisheries data collected by the WDNR and monitor the North Lake fish community on an ongoing basis.

Outcome: Periodic updates of the data considered by SECOLA and provided to WDNR..

Status: Action included in *Adaptive Management Plan*. This is an ongoing activity.

Action (Education): Maintain kiosk and/or other education structure at the public boat launch that provides information on the threats of aquatic invasive species introductions to North Lake and outline how such introductions can be minimized.

Objective: Prevent new introductions of aquatic invasive species to North Lake.

Outcome: Creates more informed and responsible recreational users of North Lake. The SECOLA should document that updated educational material is maintained.

Status: Action included in *Adaptive Management Plan*. This is an ongoing activity.

Action (Education): Provide educational material at the boat landing that emphasizes the threat of carrying zebra mussels and other AIS from North Lake to other water bodies and outlines how such inadvertent transport of AIS can be minimized.

Objective: Prevent new introductions of aquatic invasive species to regional lakes.

Outcome: Creates more informed and responsible recreational users of North Lake. SECOLA should document that updated educational material is maintained.

Status: Action included in *Adaptive Management Plan*. This is an ongoing activity.

Recommended Actions for the North Lake Adaptive Management Plan

Action (Research): Conduct a second point-intercept plan survey in 2017 (5 years after the first survey). Analyze and compare data to the 2012 survey to determine changes in the aquatic plant community.

Objective: To understand the diversity and abundance of the native aquatic plant community in North Lake and understand how this community changes over time. To determine whether zebra mussels are influencing composition and distribution of the aquatic plant community in North Lake.

Outcome: Updated *Aquatic Plant Management Plan* for North Lake.

Status: Action included in *Adaptive Management Plan* and would be conducted in a future phase of the North Lake stewardship effort.

Action (Research): Conduct periodic assessments of North Lake for aquatic invasive plant and animal species.

Objective: To provide an early warning of new introductions of aquatic invasive species to allow rehabilitation actions to occur when populations are still small.

Outcome: Document the number and timing of surveys and maintain record of findings.

Status: This is an ongoing activity with more specific guidance provided in the *Aquatic Plant Management Plan*.

Action (Education): Establish an award or recognition of riparian owners that preserve or rehabilitate "natural shoreline" habitat on their property. This could be recognized in the SECOLA newsletter along with an article about the ecological benefits of natural shorelines.

Objective: To encourage good shoreline stewardship by riparian owners and improve the riparian area quality of North Lake.

Outcome: Monitor by general awareness of landowners and changes in shoreline maintenance behaviors.

Status: Action included in *Adaptive Management Plan*.

Recommended Actions for the North Lake Adaptive Management Plan

Action (Education): Create periodic updates of the adaptive management plan.

Objective: To incorporate most up-to-date information regard North Lake and application of best stewardship practices.

Outcome: An up-to-date management plan is available for ongoing implementation and stewardship of North Lake.

Status: Action included in *Adaptive Management Plan*. This document is the first version of the adaptive management plan.

Action (Protection): Adopt and implement the *Aquatic Plant Management Plan* prepared as result of the current project.

Objective: To protect and maintain a high quality aquatic plant community in North Lake, and reduce opportunities for introduction of aquatic invasive plant species.

Outcome: A healthy, diverse North Lake aquatic plant community and a human community that is actively engaged in monitoring and protecting native aquatic plants.

Status: Action included *Adaptive Management Plan*. The *Aquatic Plant Management Plan* is intended for adoption in 2014.

Action (Research): Every 3-5 years (more often if interest allows), repeat the frog-toad survey.

Objective: To understand the diversity and abundance of the frog-toad community in wetlands in the watershed and determine how this community changes over time.

Outcome: Updated report in Adaptive Management Plan.

Status: Action included in *Adaptive Management Plan* and would be conducted in a future phase of the North Lake stewardship effort.

Action (Research): Continue Clean Lakes Monitoring of North Lake water quality.

Objective: To monitor lake water quality and detect changes over time.

Outcome: Updated report in Adaptive Management Plan for North Lake.

Status: Action included in *Adaptive Management Plan* and would be conducted in a future phases of the North Lake stewardship effort and preferably on an annual basis.

Recommended Actions for the North Lake Adaptive Management Plan

Action (Education): Conduct a formal lake users' survey.

Objective: To update information about North Lake users' knowledge base, concerns, and goals for North Lake. The previous survey was conducted nearly 20 years ago. The formal survey would also serve as an educational vehicle to inform lake users about the SECOLA, the *Adaptive Management Plan*, and the *Aquatic Plant Management Plan.*

Outcome: A knowledgeable population of North Lake users and a better informed SECOLA. New information and understanding can be applied in North Lake stewardship.

Status: Action included in *Adaptive Management Plan*. Planned for a future phase.

Action (Restoration): Investigate the possibility of application of the WDNR Fish Sticks program for North Lake (see Fish Sticks Best Management Practices at http://dnr.wi.gov/topic/fishing/documents/outreach/FishSticksBestPractices.pdf.

Objective: To restore and improve large woody structure in the North Lake littoral zone to enhance fish habitat.

Outcome: A possible future WDNR planning grant project to plan and install "fish sticks."

Status: Action included in *Adaptive Management Plan*. Planned for a future phase.

Future phases of North Lake Stewardship will build on the foundation established in this *Adaptive Management Plan*. Additional aspects of the North Lake watershed ecosystem will be explored. Future phases will include revisions to the lake management plan and the aquatic plant management plan.

North Lake and its watershed serve the human residents well. But, in order for future generations to enjoy all that the watershed can provide, this adaptive plan should be embraced, developed, and implemented. It may seem slow at first, but considerable momentum already exists because of the hard work that has already occurred.

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Appendix A
Literature Cited

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WHITE WATER ASSOCIATES, INC.

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Appendix B
North Lake Aquatic Plant Management Plan

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North Lake Stewardship Program:

Aquatic Plant Management Plan

Prepared for:
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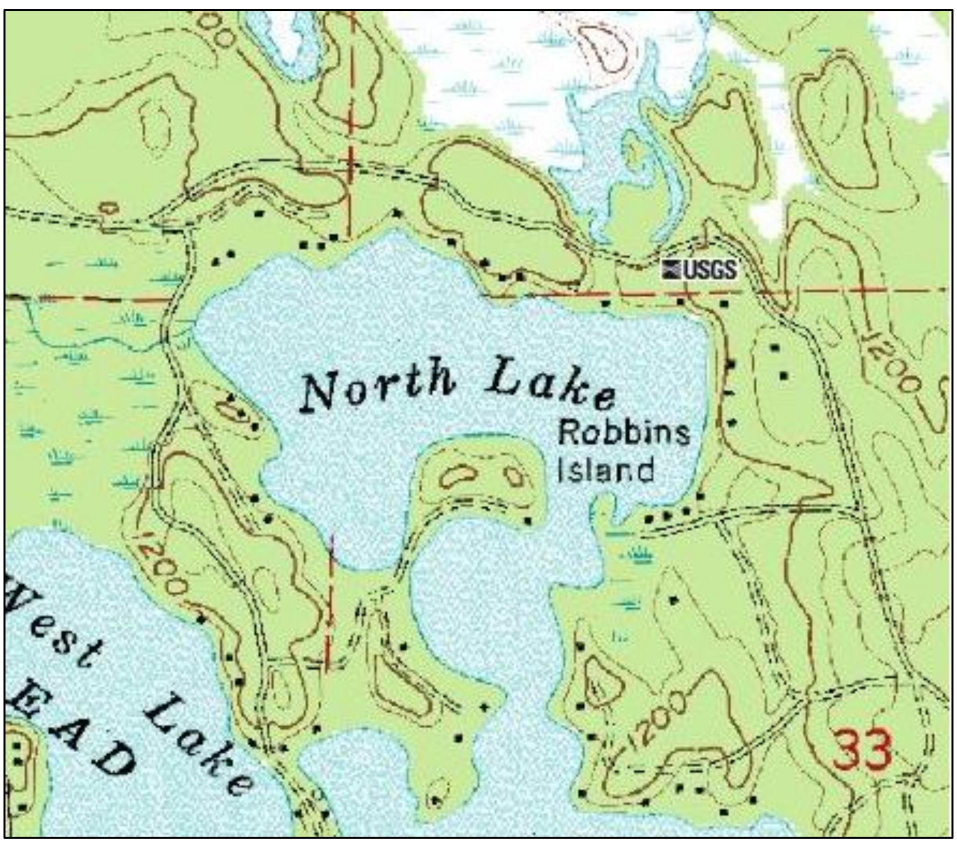

Date: December 2014

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North Lake Stewardship Program:
Aquatic Plant Management Plan

This plan is a product of a WDNR Lake Planning Grant awarded to:

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Cite as: *Premo, Dean, Angie Stine, Caitlin Clarke and Kent Premo. 2014. North Lake Stewardship Program: Aquatic Plant Management Plan (Florence County, Wisconsin). White Water Associates, Inc.*

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TABLE OF CONTENTS

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CHAPTER 1

Introduction

This *North Lake Aquatic Plant Management* (APM) Plan results from the broader efforts undertaken by the Spread Eagle Chain of Lakes Association (SECOLA). That effort, entitled ***The North Lake Stewardship Program***, was funded by the Wisconsin Department of Natural Resources (WDNR) Lake Planning Grant Program. As project sponsor, the SECOLA submitted the proposal and administered the project. Several work products result from this project, including this *APM Plan*.

The SECOLA has committed to lake stewardship by way of an integrated adaptive management plan. This *APM Plan* is a component of the *North Lake Adaptive Management Plan* (Premo et al., 2014). After review and approval of the management plan, the SECOLA will formally adopt the plan. The SECOLA views stewardship of lakes as an ongoing endeavor that requires integration of new information and understanding as time goes on. This long-range perspective accommodates the appropriate range of geographic scales from which to approach lake stewardship: a discrete "lake specific" focus that goes hand-in-hand with waterscape-wide awareness.

This *Aquatic Plant Management Plan* addresses North Lake in northeast Wisconsin (Florence County). Despite this specificity, it maintains the waterscape perspective crucial to effective lake stewardship. This is especially important when it comes to preventing introduction and establishment of aquatic invasive species (AIS). The closely related *Adaptive Management Plan* provides additional overarching waterscape level examination that allows greater opportunity and efficiency in water resource management and education.

A systematic survey of aquatic plants using the WDNR "point-intercept" method was an important underpinning of this *Aquatic Plant Management Plan*. An analysis of the plant data along with water quality and other lake information allowed preparation of the APM Plan.

Aquatic plants rarely get the respect they merit, although this is slowly changing. We still call an aquatic plant bed a "weed bed." Many aquatic plants have "weed" in their names (e.g., duckweed, pondweed, or musky weed). Likely this term was borrowed from "seaweed" and not intended as derogatory, but in today's use, "weed" connotes an unwanted, aggressively growing plant. Such is not the case for the vast majority of aquatic plants. In fact, aquatic plants are a vital part of a lake ecosystem, recycling nutrients, providing vertical and horizontal structure, and creating habitat for animal life. Invertebrates, including crustaceans and insects, live on or within this "aquatic forest." Fish find food and shelter within aquatic plant beds. Waterfowl eat parts of plants directly as well as feed on invertebrates associated with the plants. Muskrats eat aquatic plants and particularly love cattails and bulrushes. Otter and mink hunt invertebrates and small vertebrates within the shelter of submergent and emergent beds. In shallow water, great blue herons find fishes among the plants.

In lakes that receive an excess of nutrients (particularly from fertilizers or leaking septic tanks), plant growth can become too lush or dominated by only a few species. As these abundant plants die, their decomposition can depress dissolved oxygen levels and diminish suitability for fish. Algae can respond rapidly to nutrient influxes and create nuisance conditions. These phenomena can cause humans to view all aquatic plants in a negative light.

On another negative front, non-native plant species, transported on boats and trailers or dumped from home aquariums, private ponds and water gardens may come to dominate a water body to the exclusion of a healthy diversity of native species. Eurasian water-milfoil (*Myriophyllum spicatum*) is one of the better known examples of these so-called aquatic invasive plant species.

For most lakes, native aquatic plants are an overwhelmingly positive attribute, greatly enhancing the aesthetics of the lake and providing good opportunities for fishing, boating, swimming, snorkeling, sight-seeing, and hunting. In fact a healthy and diverse native aquatic plant community is the best defense against an aquatic invasive plant species.

When it comes to aquatic plant management, it is useful to heed the mantra of the medical profession: "First, do no harm." It is both a social and scientific convention that aquatic plant management is more effective and beneficial when a lake is considered as an entire and integrated ecosystem. Anyone involved in aquatic plant management should be aware that a permit may be required to remove, add, or control aquatic plants. In addition, anyone using Wisconsin's lakes must comply with the "Boat Launch Law" that addresses transport of aquatic plants on boat trailers and other equipment. A good review of the laws, permits, and regulations that affect management and behavior surrounding aquatic plants can be found in the WDNR guidelines called ***Aquatic Plant Management in Wisconsin***.[1]

In preparing this plan, we followed guidelines in ***Aquatic Plant Management in Wisconsin***. The resulting plan is an adaptive plan (Walters, 1986). Simply put, it will be

[1] *http://www4.uwsp.edu/cnr/uwexlakes/ecology/APM/APMguideFull2010.pdf*

modified as new information becomes available. The WDNR guidance document outlines three objectives that may influence preparation of an aquatic plant management plan:

- ***Protection*** - preventing the introduction of nuisance or invasive species into waters where these plants are not currently present;
- ***Maintenance*** - continuing the patterns of recreational use that have developed historically on and around a lake; and
- ***Rehabilitation*** - controlling an imbalance in the aquatic plant community leading to the dominance of a few plant species, frequently associated with the introduction of invasive non-native species.

Currently, the motivation for this plan lies in the first two objectives. North Lake is a high quality resource with good water quality and a diverse and interesting community of aquatic plants. It has a recreational history and current human use that has caused some moderate degradation to the ecosystem. North Lake has aquatic invasive species (AIS) that influence the health of the ecosystem in a variety of ways. Perhaps chief among these AIS, in terms of potential impacts, is the zebra mussel (*Dreissena polymorpha*) that was discovered in North Lake in 2012. Another AIS (Eurasian water-milfoil, *Myriophyllum spicatum*) was found at the same time. The zebra mussel population is growing quite rapidly in North Lake and spreading to other lakes in the Spread Eagle Chain. In contrast, Eurasian water-milfoil seems to be under control by way of simple hand-pulling of individual plants. Likely the robust native plant community in North Lake has played a role in keeping the Eurasian water-milfoil in check.

During the course of this project and through earlier efforts, SECOLA and its consultant White Water Associates, Inc. (White Water) have followed the first five steps in the seven-step plan outlined in the WDNR Guidance Document for developing an aquatic plant management plan guidance document:

1. Goal setting – Getting the effort organized, identifying problems to be addressed, and agreeing on the goals;
2. Inventory – Collecting baseline information to define the past and existing conditions;
3. Analysis – Synthesizing the information, quantifying and comparing the current conditions to desired conditions, researching opportunities and constraints, and setting directions to achieving the goals;
4. Alternatives – Listing possible management alternatives and evaluating their strengths, weaknesses and general feasibility;

5. Recommendations – Prioritizing and selecting preferred management options, setting objectives, drafting the plan;
6. Implementation – Formally adopting the plan, lining up funding, and scheduling activities for taking action to achieve the goals;
7. Monitor & Modify – Developing a mechanism for tracking activities and adjusting the plan as it evolves.

Besides this introductory chapter, this plan is organized in six Chapters. The study area is described in Chapter 2. Chapter 3 states the purpose and goals for the plan. Chapter 4 presents an inventory and analysis of information that pertain to the plan including the results of the aquatic plant survey. Chapter 5 provides recommendations that support the overall goals and establish the stewardship component of plan. Finally, Chapter 6 presents actions and objectives for implementing the plan. Three appendices complete this document. Appendix 1 contains Literature Cited, Appendix 2 contains tables and figures for the 2012 aquatic plant survey in North Lake, and Appendix 3 contains the *North Lake Review of Water Quality*.

CHAPTER 2

Study Area

North Lake is in Florence County, Wisconsin about 5.5 miles southeast of the town of Florence and about 1.2 miles west of the Michigan-Wisconsin border. The water body identification code (WBIC) is 703000. Other lakes and streams are in this landscape. Exhibit 1 is an aerial view of the North Lake landscape showing a few of the other water features. This interconnected water landscape is a target for migrating and breeding waterfowl and other birds. North Lake has value and function in this larger landscape as well as its own watershed.

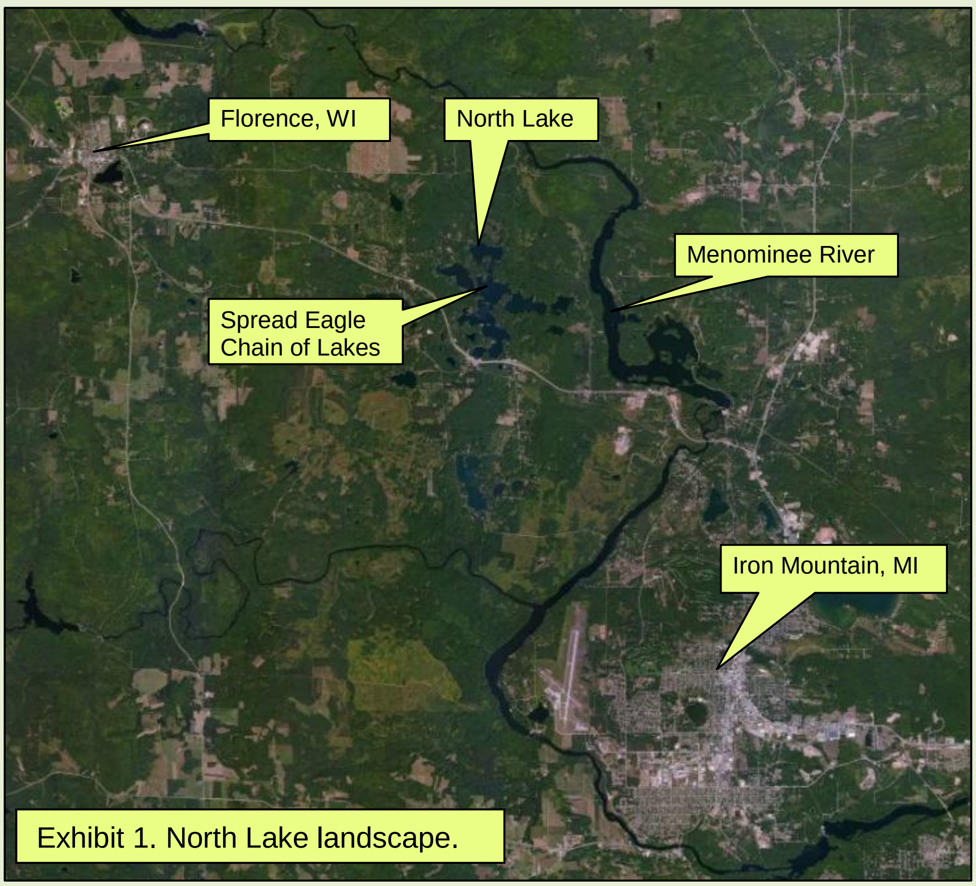

Exhibit 1. North Lake landscape.

North Lake has a 2.2 mile shoreline and 79.2 acres surface area. There is no state or federal land surrounding the lake. North Lake comprises the northern-most lake of the Spread Eagle Chain of Lakes, an eight lake chain totaling 548 acres in surface area. The single improved boat ramp located on the west shore of North Lake allows public access to the entire Spread Eagle Chain of Lakes. North Lake is fairly developed with permanent homes and cottages, although areas of more natural riparian area also exist. North Lake is classified as oligotrophic, and has a complex bathymetry (Exhibit 2).

North Lake connects to Middle Lake (of the Spread Eagle Chain) by way of a broad channel. The last link in the Chain of Lakes is South Lake. A concrete compensation dam on the south end of South Lake controls the water level of the Chain of Lakes. A small stream (the Spread Eagle Outlet) flows from South Lake and travels about two miles before emptying into the Menominee River.

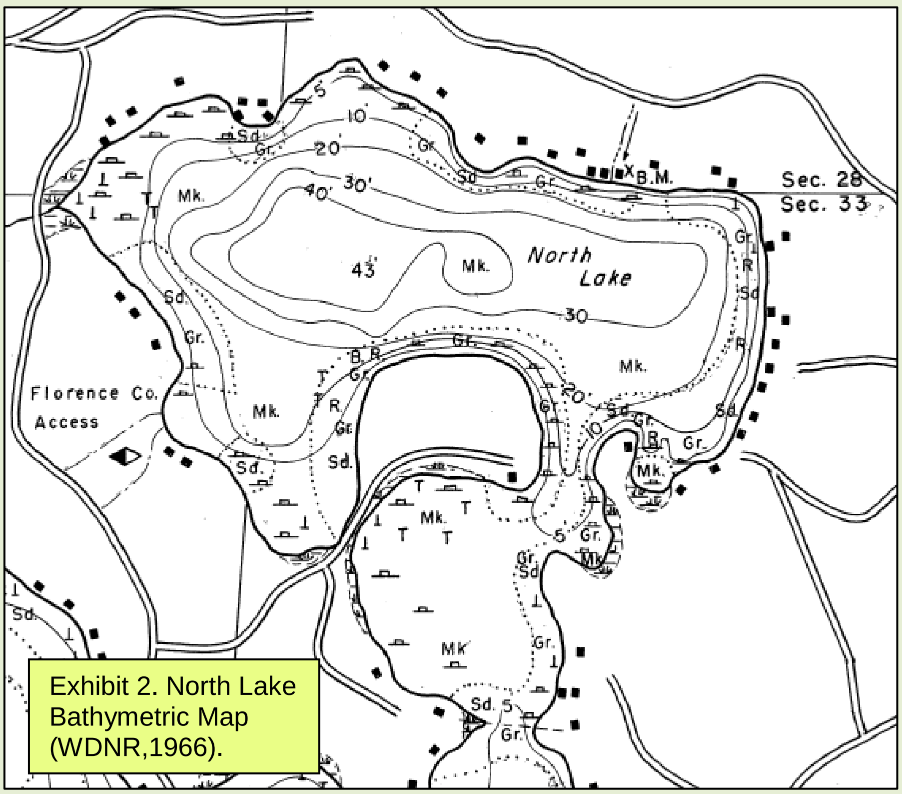

Exhibit 2. North Lake Bathymetric Map (WDNR,1966).

Descriptive water body parameters for North Lake are in Exhibit 3. It is a drainage lake of 79 acres and maximum depth of 43 feet. It has a low shoreline development index. The shoreline development index is a quantitative expression derived from the shape of the lake. It is defined as the ratio of the shoreline length to the length of the circumference of a circle of the same area as the lake. A perfectly round lake would have a shoreline development index of 1. Increasing irregularity of shoreline development in the form of bays and projections of the shore is shown by numbers greater than 1. For example, fjord lakes with extremely irregularly shaped shorelines sometimes have SDI's exceeding 5. A higher shoreline development index indicates that a lake has relatively more productive littoral zone habitat.

Exhibit 3. Water Body Parameters.

Water Body Name	North Lake
County	Florence
Township/Range/Section	T40N-R19E-S28,28,32,33
Water Body Identification Code	703000
Lake Type	Drainage
Surface Area (acres)	79.2
Maximum Depth (feet)	43
Maximum Length (miles)	0.4
Maximum Width (miles)	0.5
Shoreline Length (miles)	2.2
Shoreline Development Index	1.8
Total Number of Piers (EPA survey)	45
Number of Piers / Mile of Shoreline	20.5
Total Number of Homes (2009 aerial)	33
Number of Homes / Mile of Shoreline	15.0

We observed a total of 45 piers on the shoreline of North Lake (counted during one of the shoreline assessments). This translates to 20.5 piers per mile of shoreline. The riparian area consists of both upland and wetland areas (Exhibit 4).

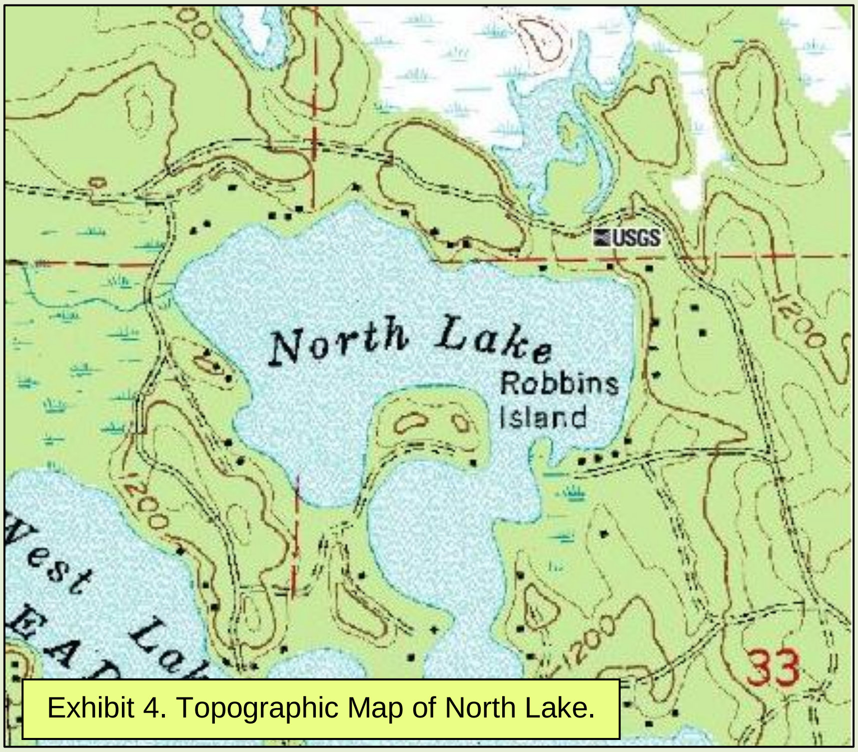

Exhibit 4. Topographic Map of North Lake.

CHAPTER 3

Purpose and Goal Statements

This plan approaches aquatic plant management with a healthy dose of humility. We do not always understand the causes of environmental phenomena or the effects of our actions to manage the environment. With that thought in mind, we have crafted a statement of purpose and goals for this plan:

> ***North Lake has a healthy and diverse aquatic plant community that was documented by a point-intercept aquatic plant survey. This plant community is essential to, and part of, a high quality aquatic ecosystem that benefits the human community with its recreational and aesthetic features. The purpose of this aquatic plant management plan is to maintain the aquatic plant community in its present high quality state.***

Supporting this purpose, the goals of this aquatic plant management plan are:

> ***(1) Monitor and protect the native aquatic plant community;***
> ***(2) Prevent establishment of AIS and nuisance levels of native plants;***
> ***(3) Promote and interpret APM efforts; and***
> ***(4) Educate riparian owners and lake users on preventing AIS introduction, reducing nutrient inputs that potentially alter the plant community, and minimizing physical removal of native riparian and littoral zone plants.***

The purpose and goals are the foundation for the *North Lake Aquatic Plant Management Plan* presented in this document. They inform the objectives and actions outlined in Chapter 5 and are the principal motivation of North Lake stewards.

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CHAPTER 4

Information and Analysis

Our efforts in this project have compiled information about historical and current conditions of the North Lake ecosystem and its surrounding watershed. Of particular importance to this *Aquatic Plant Management Plan* is the aquatic plant survey that was conducted using the *WDNR Protocol for Aquatic Plant Survey, Collecting, Mapping, Preserving, and Data Entry* (Hauxwell et al., 2010). The results of this comprehensive "point-intercept" survey along with relevant components of other information are presented in this chapter under nine respective subheadings: watershed, aquatic plant management history, aquatic plant community description, fish community, water quality and trophic status, water use, riparian area, wildlife, and stakeholders.

Part 1. Watershed

North Lake and its watershed are very small components of a large-scale watershed landscape. The continental United States is divided into 18 watershed regions (Exhibit 5). Two watershed regions lie within Wisconsin: the Upper Mississippi and Great Lakes regions. North Lake is located in the Great Lakes watershed region. The Great Lakes region is also made up of many sub-regions. The Lake Michigan sub-region (more specifically the Northwest Lake Michigan basin) (HUC#040301) is where North Lake is found (Exhibit 6). The Northwest Lake Michigan basin includes the Menominee sub-basin, where North Lake is located (Exhibit 7). The Menominee sub-basin (HUC#04030108) covers parts of Florence (including North Lake), Forest, and Marinette counties in Wisconsin, and parts of Dickinson, Iron, and Menominee counties in Michigan (Exhibit 8). As you can see in Exhibit 8, the Menominee sub-basin is divided into numerous watersheds and sub-watersheds (designated by 10 and 12-digit HUC codes). In the exhibit, the numbers represent the 4 digit suffixes of the 12-digit HUC code. Suffixes beginning with "07" are part of the Squaw Creek-Menominee River watershed (example: 04030108-07XX). North Lake is enclosed within the Twin Falls Dam-Menominee River sub-watershed labeled "0701" (HUC#040301080701). Exhibit 9 displays the watershed boundary specific to North Lake, which eventually flows into all the watersheds listed above.

Exhibit 5. United States watershed regions (USGS, 2013).

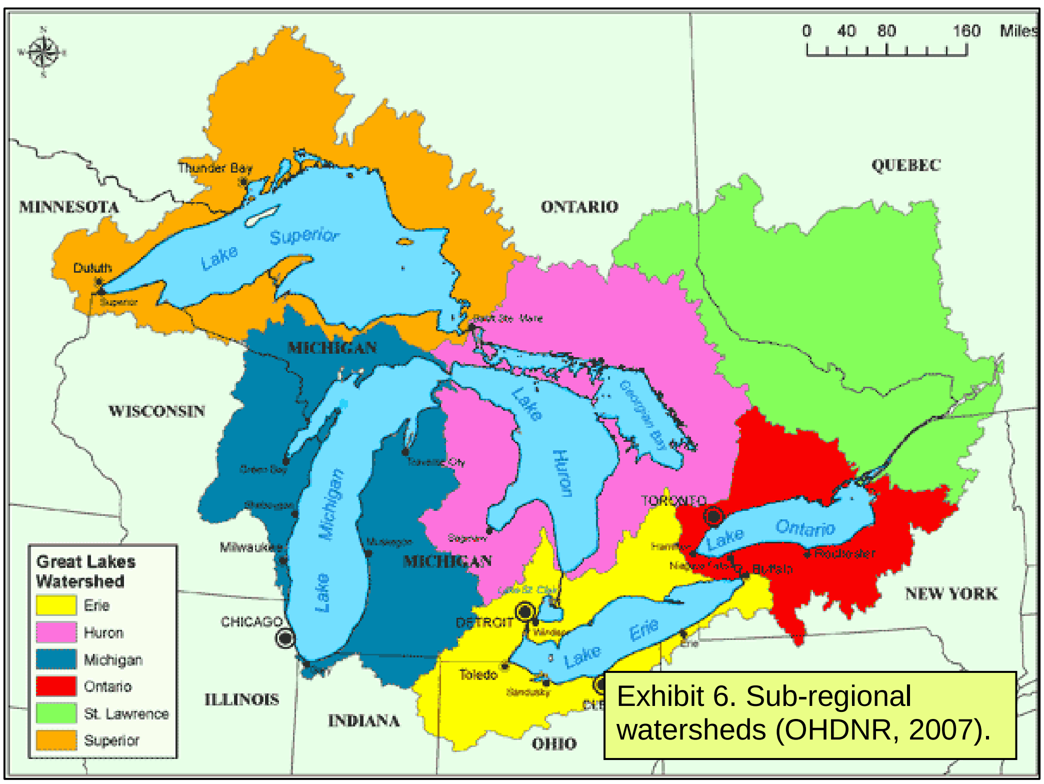


Exhibit 6. Sub-regional watersheds (OHDNR, 2007).

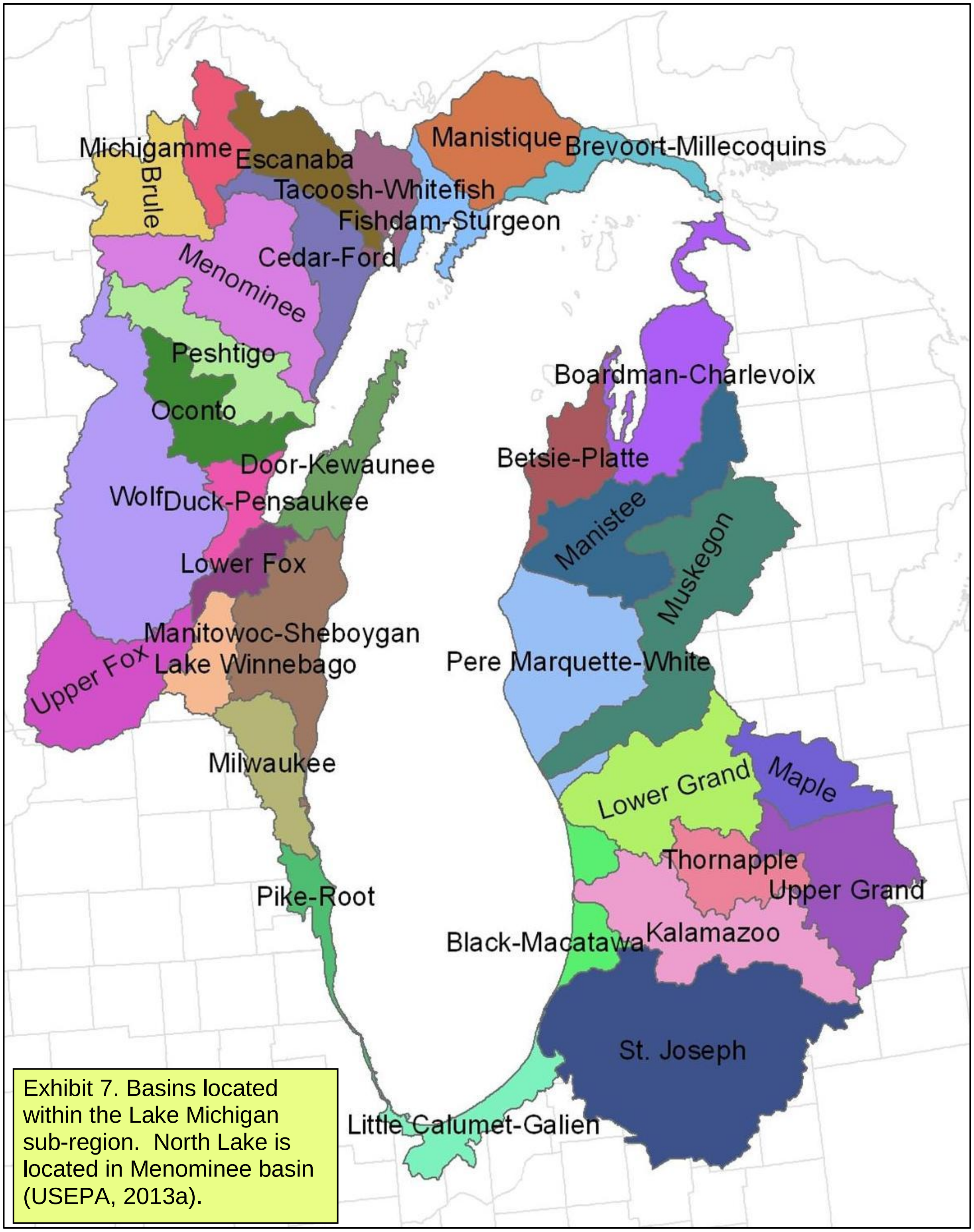


Exhibit 7. Basins located within the Lake Michigan sub-region. North Lake is located in Menominee basin (USEPA, 2013a).

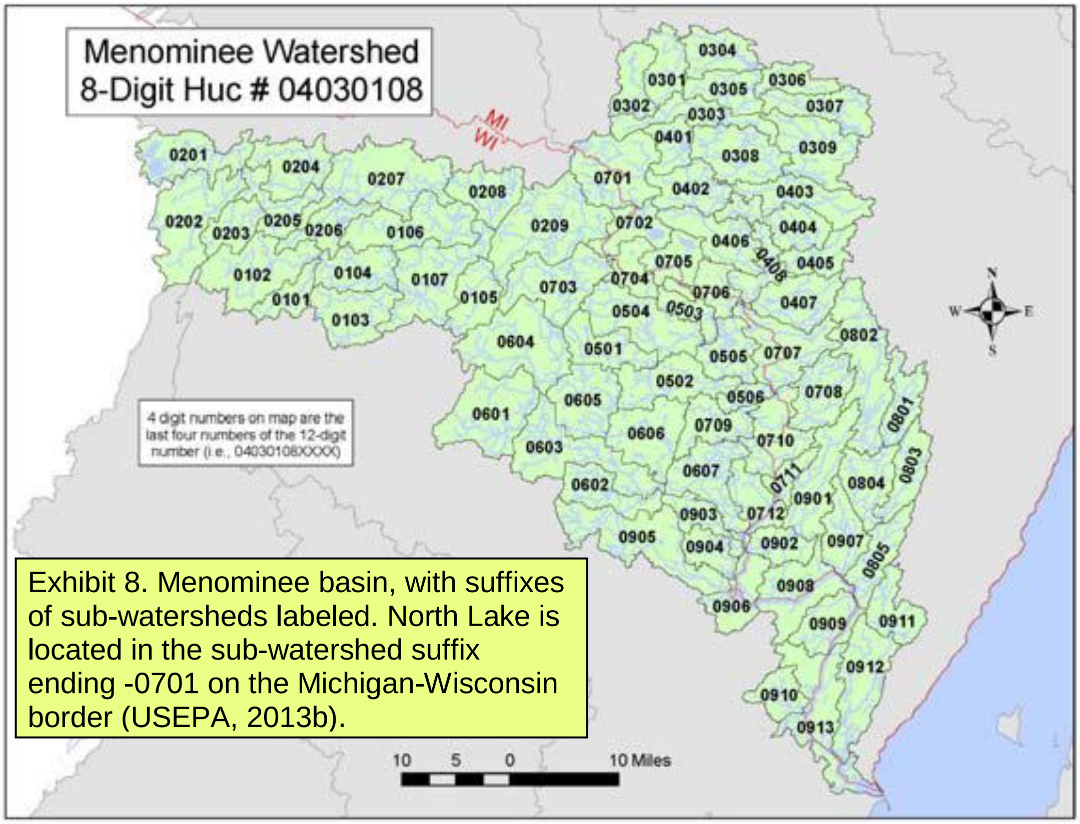


Exhibit 8. Menominee basin, with suffixes of sub-watersheds labeled. North Lake is located in the sub-watershed suffix ending -0701 on the Michigan-Wisconsin border (USEPA, 2013b).

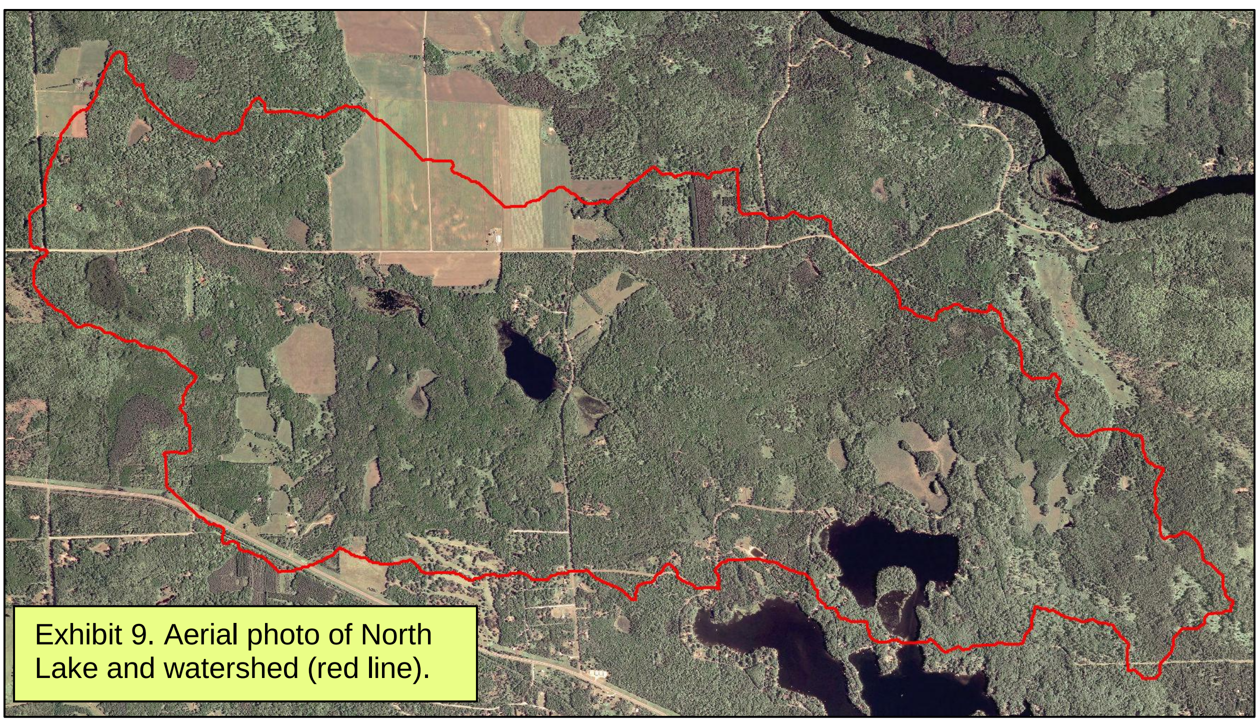


Exhibit 9. Aerial photo of North Lake and watershed (red line).

The elevation of the North Lake watershed ranges from around 1,269 feet above sea level to 1,561 feet above sea level. A digital elevation model, shown in Exhibit 10, displays the relative elevations for the North Lake watershed. Orange and red areas of the landscape are the highest elevations, and greens and blues are the lowest elevations.

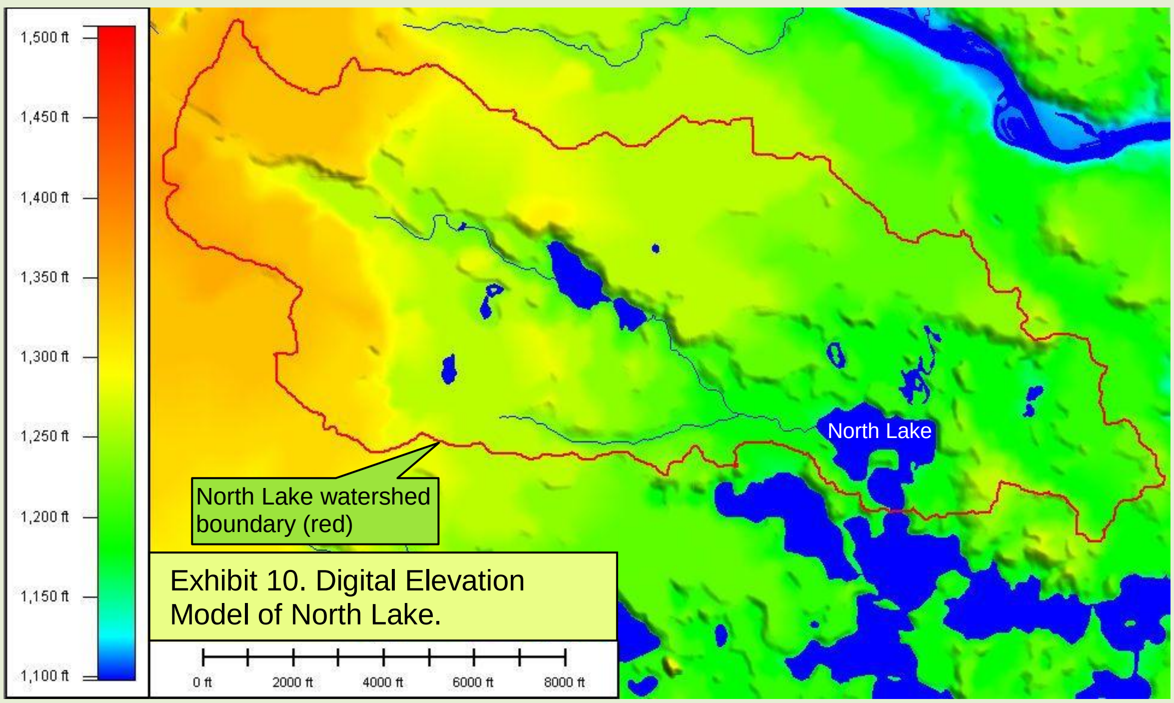


Exhibit 10. Digital Elevation Model of North Lake.

The watershed (drainage basin) is all of the land and water areas that drain toward a particular river or lake. A water body is greatly influenced by its watershed. Watershed size, topography, geology, land use, soil fertility and erodibility, and vegetation are all factors that influence water quality. The North Lake watershed is about 3,035 acres. The land uses in the watershed are shown in Exhibit 11. Forest and surface water comprise the largest components.

All soil groups (A, B, C and D) are present in the North Lake watershed (Exhibit 11). Soil group B covers 56% of the watershed, group A makes up 26%, and groups C and D together make up about 18%. Infiltration rates rank from highest to lowest, with A having the highest and D having the lowest. The watershed to lake area ratio is 38:1. Water quality often decreases with an increasing ratio of watershed area to lake area because there are more sources and amounts of runoff. In larger watersheds, runoff water can leach more minerals and nutrients and carry them to the lake. The runoff to a lake (such as after a rainstorm or snowmelt) differs greatly among land uses. Forest cover is the most protective as it exports much less soil (through erosion) and nutrients (such as phosphorus and nitrogen) to the lake than agricultural or urban land use.

Exhibit 11. Cover Types and Soil Groups of the North Lake Watershed.

Cover Type	Acres	Percent
Agriculture	243.4	8.0
Commercial	0	0
Forest	2281.2	75.2
Grass/Pasture	26.9	0.9
High-density Residential	4.2	0.1
Low-density Residential	122.3	4.0
Water	356.8	11.8
Total	3034.8	100.0

Soil Group	Acres	Percent	**Hydrologic Soil Groups** - Soils are classified by the Natural Resource Conservation Service into four Hydrologic Soil Groups* based on the soil's runoff potential. The four Hydrologic Soils Groups are A, B, C and D. Where A has the smallest runoff potential and D the greatest.
A	792.5	26.1	**Group A** is sand, loamy sand or sandy loam types of soils. It has low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission.
B	1683.0	55.5	**Group B** is silt loam or loam. It has a moderate infiltration rate when thoroughly wetted and consists chiefly or moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.
C	42.5	1.4	**Group C** soils are sandy clay loam. They have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.
D	5156.9	17.0	**Group D** soils are clay loam, silty clay loam, sandy clay, silty clay or clay. This soil has the highest runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material.

*(*USDA, Natural Resources Conservation Service, 1986*)

Part 2. Aquatic Plant Management History

Aquatic plant surveys have been conducted in North Lake in 1995 and 2012. The former survey was conducted along transects in the lake, the latter was conducted using the point-intercept method. Findings from the 1995 and 2012 surveys are discussed in the next section (Part 3). As far as we can determine, no large-scale plant management activity has ever taken place in North Lake. As previously stated, hand-pulling has been used on the AIS Eurasian water-milfoil. Other than the Eurasian water-milfoil, no particular aquatic plant nuisance issues have warranted control action in North Lake.

Part 3. Aquatic Plant Community Description

Why do lakes need aquatic plants? In many ways, they are underwater forests. Aquatic plants provide vertical and horizontal structure in the lake just like the many forms and variety of trees do in a forest. Imagine how diminished the biodiversity of a forest stand becomes after a clear-cut. Similarly, a lake's biodiversity in large part depends on a diversity of plants.

Aquatic plants are beneficial in many ways. Areas with plants produce more food for fish (insect larvae, snails, and other invertebrates). Aquatic vegetation offers fish shelter and spawning habitat. Many submerged plants provide food for waterfowl and habitat for insects on which some waterfowl feed. Aquatic plants further benefit lakes by producing oxygen and absorbing nutrients (phosphorus and nitrogen) from runoff. Aquatic plants also protect shorelines and lake bottoms by dampening wave action and stabilizing sediments.

The distribution of plants within a lake is generally limited by light availability, which is, in turn, controlled by water clarity. Aquatic biologists often estimate the depth to which rooted aquatic plants can exist as about two times the average Secchi clarity depth. For example, if the average Secchi depth is eight feet then it is fairly accurate to estimate that rooted plants might exist in water as deep as sixteen feet. At depths greater than that (in our hypothetical example), light is insufficient for rooted plants to grow. In addition to available light, the type of substrate influences the distribution of rooted aquatic plants. Plants are more likely to be found in muddy or soft sediments containing organic matter, and less likely to occur where the substrate is sand, gravel, or rock. Finally, water chemistry influences which plants are found in a body of water. Some species prefer alkaline lakes and some prefer more acidic lakes. The presence of nutrients like phosphorous and nitrogen also influence plant community composition.

As mentioned earlier, non-native invasive plant species can reach high densities and wide distribution within a lake. This diminishes the native plant community and the related habitat. At times, even a native plant species can reach nuisance levels with respect to certain kinds of human recreation. These cases may warrant some kind of plant management.

Aquatic plant surveys have been conducted on North Lake by professional consultants in 1995 and 2012. In the 1995 survey, plants were pulled up with a rake in the shallow areas of North Lake. In the deeper areas of North Lake, a device was lowered to the bottom of the lake and dragged along a transect to retrieve plants (MMA, 1996). The 2012 aquatic plant survey was conducted by White Water and used the WDNR point-intercept method. The formal WDNR point-intercept survey assesses the plant species composition on a grid of several hundred points distributed evenly over the lake. Using latitude-longitude coordinates and a handheld GPS unit, scientists navigate to the points and use a rake mounted on a pole or rope to sample plants. Plants are identified, recorded and put into a dedicated spreadsheet for storage and data analysis. This systematic survey provides baseline data about the lake that is accurately repeatable in future surveys. The survey area in 1995 included the water body south of Robbins Island, whereas the 2012 survey did not.[2]

Because North Lake has been surveyed twice, we are able to identify differences in the plant community that have resulted over the course of the 17 year interval. Changes in a lake environment might manifest as loss of species, change in species abundance or distribution, difference in the relative composition of various plant life forms (emergent, floating leaf, or submergent plants), and/or appearance of an AIS or change in its population size. Monitoring can track changes and provide valuable insight on which to base management decisions. In the case of the North Lake aquatic plant data, comparisons must be made with some reservations because of the different sampling methods. In the remainder of this section (Part 3) we provide a report of the findings of the 2012 point-intercept aquatic plant survey, and provide a summary of the aquatic plant survey conducted in 1995. Supporting tables and figures for the aquatic plant surveys are provided in Appendix 2.

Species richness refers to the total number of species recorded. It is a basic measure of biological diversity. Twenty-three aquatic plant species were recorded in the 2012 survey. Of these, twenty-one were collected at sampling sites and the others were observed from the boat while on route between sampling points. Table 1 displays summary statistics for the survey. Table 2 provides a list of the species encountered, including common and scientific name along

[2] *The WDNR Science Services provide the geographic points (latitude and longitude coordinates) for the point-intercept survey and did not include the area south of Robbins Island as part of North Lake.*

with summarizing statistics.[3] The number of species encountered at any given sample point ranged from 0 to 8 and 111 sample points were found to have aquatic vegetation present. The average number of species encountered at these vegetated sites was 2.36. The actual number of species encountered at each of the vegetated sites is graphically displayed on Figure 1. Plant density is estimated by a "rake fullness" metric (3 being the highest possible density). These densities (considering all species) are displayed for each sampling site on Figure 2.

The maximum depth of plant colonization was 21 feet in the 2012 survey (Table 1 and Figure 3). Rooted vegetation was found at 111 of the 134 sample sites with depth ≤ the maximum depth of plant colonization (82.8% of sites). These sites are displayed as a black dot within a circle on Figure 4. This indicates that although availability of appropriate depth may limit the distribution of plants, it is not the only habitat factor involved. Substrate is another feature that influences plant distribution (e.g., soft substrate often harbors more plants than hard substrate). Figure 5 presents the substrates encountered during the aquatic plant survey (mud, sand, or rock).

Table 2 provides information about the frequency of occurrence of the plant species recorded in the lake in the 2012 survey. Several metrics are provided, including total number of sites in which each species was found and frequency of occurrence at sites ≤ the maximum depth of rooted vegetation. This frequency metric is standardized as a "relative frequency" (also shown in Table 2) by dividing the frequency of occurrence for a given species by the sum of frequency of occurrence for all plants and multiplying by 100 to form a percentage. The resulting relative frequencies for all species total 100%. The relative frequencies for the plant species collected with a rake are graphically displayed in descending order on Figure 6. This display shows that muskgrasses (*Chara* sp.) had the highest relative frequency followed by nitella (*Nitella* sp.). The lowest relative frequencies are at the far right of the graph. Figure 7 displays the distribution sampling sites where plants classified as "emergent" or "floating" were recorded. As examples of individual species distributions, we show the occurrences of a few of the most frequently and least frequently encountered plants in Figures 8-14.

Species richness (total number of plants recorded for the lake) is a measure of species diversity, but it doesn't tell the whole story. As an example, consider the plant communities of two hypothetical ponds each with 1,000 individual plants representing ten plant species (in other words, richness is 10). In the first pond, each of the ten species populations is comprised of 100

[3] *If you are interested in learning more about the plant species found in the lake, visit the University of Wisconsin Steven Point Freckmann Herbarium website at: http://wisplants.uwsp.edu/ or obtain a copy of "Through the Looking Glass (A Field Guide to the Aquatic Plants in Wisconsin)."*

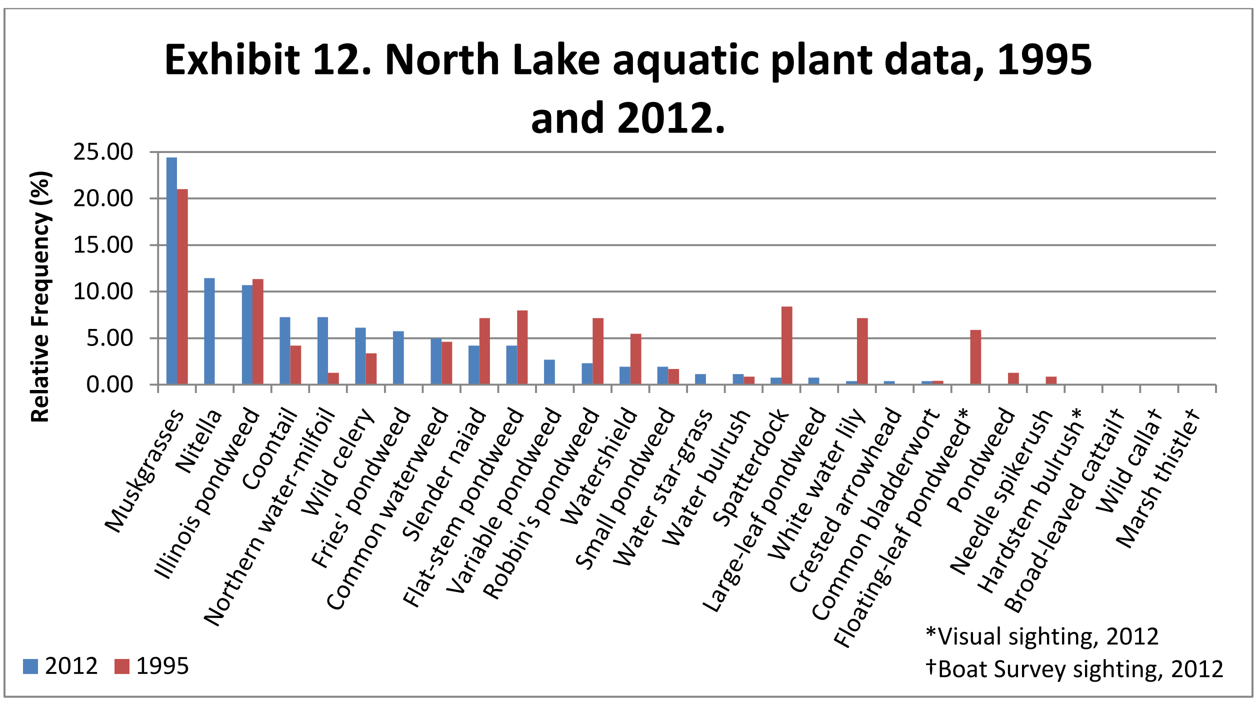
individuals. In the second pond, Species #1 has a population of 991 individuals and each of the other nine species is represented by one individual plant. Intuitively, we would say that first pond is more diverse because there is more "even" distribution of individual species. The "Simpson Diversity Index" (SDI) takes into account both richness and evenness in estimating diversity. It is based on a plant's relative frequency in a lake. The closer the Simpson Diversity Index is to 1, the more diverse the plant community. The SDI for North Lake is 0.89 (Table 1), which indicates a diverse aquatic plant community.

Another measure of floristic diversity and quality is the *Floristic Quality Index* (FQI). Floristic quality is an assessment metric designed to evaluate the closeness that the flora of an area is to that of undisturbed conditions (Nichols, 1999). Among other applications, it forms a standardized metric that can be used to compare the quality of different lakes (or different locations within a single lake) and monitor long-term changes in a lake's plant community (an indicator of lake health). The FQI for a lake is determined by using the average *coefficient of conservatism* times the square root of the number of native plant species present in the lake. Knowledgeable botanists have assigned to each native aquatic plant a *coefficient of conservatism* representing the probability that a plant is likely to occur in pristine environments (relatively unaltered from presettlement conditions). The coefficients range from 0 to 10, with 10 being assigned to those species most sensitive to disturbance. As more environmental disturbance occurs, the less conservative species become more prevalent.

Nichols (1999) analyzed aquatic plant community data from 554 Wisconsin Lakes to ascertain geographic (ecoregional) characteristics of the FQI metric. This is useful for considering how the North Lake FQI (28.4) compares to other lakes and regions. The statewide medians for number of species and FQI are 13 and 22.2, respectively. North Lake values are high compared to these statewide values. Nichols (1999) determined that there are four ecoregional-lake types groups in Wisconsin: (1) Northern Lakes and Forests lakes, (2) Northern Lakes and Forests flowages, (3) North Central Hardwoods and Southeastern Till Plain lakes and flowages, and (4) Driftless Area and Mississippi River Backwater lakes. North Lake is located in the Northern Lakes and Forests lakes group. Nichols (1999) found species numbers for the Northern Lakes and Forests lakes group had a median value of 13. The 2012 North Lake data is consistent with that find. Finally, the North Lake FQI (28.4) was higher than the median value for the Northern Lakes and Forests lakes group (24.3). These findings support the contention that the North Lake plant community is healthy and diverse.

Eighteen aquatic plant species were recorded in the 1995 survey. The maximum depth of plants was between 16 and 20 feet deep. The three most dominant species were muskgrasses (*Chara* sp.), Illinois pondweed (*Potamogeton illinoensis)*, and spatterdock (*Nuphar variegata*). In the 1995 aquatic plant study report, "% Occurrence" was used to rate plant findings. The WDNR point-intercept protocol does not have this same metric, but instead calculates a relative frequency (calculated by dividing the frequency of occurrence for a given species by the sum of frequency of occurrence for all plants and multiplying by 100). The resulting relative frequencies for all species total 100%. We have since estimated a relative frequency for the 1995 plant survey based on the % Occurrence values reported. Because sampling procedure was different in 1995, we cannot estimate the SDI or the FQI for North Lake at that time. A comparison of 1995 and 2013 aquatic plant statistics can be viewed in Appendix 2.

Exhibit 12 displays the relative frequency of plants found in 1995 and 2012. There are differences in the relative frequencies of several species has change while others are quite comparable. Some species are unique to one survey or the other. It is possible that different sampling techniques are responsible for some of these differences.



During the point intercept survey, no aquatic plants were observed in North Lake that would be considered a nuisance-level population density or distribution. It was noted that pink water lily (*Nymphaea odorata*) was observed in the point-intercept study. It is a variation of the native white water lily. It is not invasive, however, it is not native to northern Wisconsin lakes, and was likely planted by someone into the lake. As has been stated previously, Eurasian water-milfoil has been found in North Lake, but removed by hand-pulling (discussed below). On-going monitoring efforts check North Lake for recurrence of this AIS. European marsh thistle (*Cirsium palustre*) was seen in the boat survey in 2012. This thistle is considered a *Restricted* wetland/terrestrial species in Wisconsin. A *Restricted* species is one that has already been established in the state and causes or has the potential to cause significant environmental or economic harm or harm to human health (WDNR, 2012). Yellow iris (*Iris pseudacorus*) was observed at two locations in North Lake: on the northeast shore (45.90497, -88.13528) and on the northwest shore (45.904846, -88.143467). The Yellow Iris is a non-native aquatic plant species that is currently proposed as restricted in the State of Wisconsin. All parts of this plant are poisonous and therefore not valuable as a wildlife food source. When flowers are present it is easily identified. During non-flowering periods it is difficult to distinguish from the native Blue flag (*Iris versicolor*). No state or federally listed aquatic plant species have been recorded in North Lake.

Eurasian water-milfoil was discovered in North Lake in fall of 2012 by a WDNR biologist who hand-pulled the specimens he observed. This discovery (and the simultaneous discovery of zebra mussel) motivated the SECOLA to obtain a rapid response grant to monitor and contain these AIS species. White Water Associates biologists working in conjunction with SECOLA volunteers undertook this monitoring and containment project. In the case of the Eurasian water-milfoil, hand-pulling has been employed to control the population. A discovery of additional Eurasian water-milfoil plants south of Robbins Island in 2013 brought about a second rapid response grant that extended monitoring to the entire Spread Eagle Chain of Lakes. A more thorough report of the monitoring and hand-pulling efforts of Eurasian water-milfoil is presented in Appendix K of the *North Lake Adaptive Management Plan*.

Part 4. Fish Community

Various fish surveys have been conducted on North Lake by Wisconsin Department of Natural Resources (WDNR) biologists. Because North Lake is a part of the Spread Eagle Chain of Lakes, fisheries reports include information for all lakes in the chain. In 2011, comprehensive fish evaluations of the Spread Eagle Chain lakes were completed by Greg Matzke (2012). Four types of sampling occurred in 2011: early spring fyke netting, early spring electrofishing, late spring fyke netting, and fall electrofishing (Matzke, 2012). For more fisheries information, see Appendix H of the *North Lake Adaptive Management Plan*.

Part 5. Water Quality and Trophic Status

North Lake is a 79 acre drainage lake with a maximum depth of 43 feet. Existing water quality data has been collected by the Citizen Lake Monitoring Network (CLMN) on North Lake from 1995 to present and is available in the WDNR SWIMS database. North Lake water quality information is briefly summarized in this section and is more fully interpreted in Appendix 3 of this plan.

Temperature and dissolved oxygen showed stratification in North Lake in the ice-free season. Water clarity is good and in most recent years, user perception of North Lake aesthetic quality is generally regarded as beautiful. Water color is low and turbidity is generally low. The trophic state is oligotrophic. Water quality is classified as very good with respect to phosphorus concentrations. Chlorophyll *a* (a measure of the amount of algae), nitrogen, sodium, and potassium levels are low. Hardness, calcium, magnesium, chloride and alkalinity (a measure of a lakes buffering capacity against acid rain) are high. The pH of North Lake is slightly alkaline.

Part 6. Water Use

North Lake has a single public access site that is the sole access for the entire Spread Eagle Chain of Lakes. Because of its proximity to fairly populated areas and its recreational desirability, the Spread Eagle Chain receives a great deal of recreational traffic. The great majority of that boat traffic launches at the North Lake boat landing. North Lake is also used by riparian owners and their guests for a variety of recreational activities. There is no State of Wisconsin or federal ownership on the lake.

Part 7. Riparian Area

Part 1 (Watershed) describes the larger riparian area context of North Lake. The near shore riparian area can be appreciated by viewing Exhibit 4. The lake is moderately developed with a fairly intact forested riparian zone that extends for hundreds of feet back from the lake. A paved road nearly circumscribes the lake and is set back from the lake from 150 feet to several hundred feet. The forest is a mixture of coniferous and deciduous trees and shrubs. Our review of 2009 aerial photography reveals 33 houses on the lake. This intact riparian area provides numerous important functions and values to the lake. It effectively filters runoff to the lake. It provides excellent habitat for birds and mammals. Trees that fall into the lake from the riparian zone contribute important habitat elements to the lake. Educating riparian owners as to the value of riparian areas is important to the maintenance of these critical areas.

Part 8. Wildlife

Eagle and loon studies have been conducted by the Wisconsin Department of Natural Resources and by many volunteers as part of programs such as LoonWatch. Rare species and communities have also been identified by the WDNR. A frog and toad survey was conducted as part of the planning grant project and is reported in the *North Lake Adaptive Management Plan* along with other information on area wildlife.

In the future it would be desirable to monitor other wetland and water oriented wildlife such as waterfowl, fish-eating birds, aquatic and semi-aquatic mammals, and invertebrate animals. It would be particularly important to monitor the populations of aquatic invasive animal species that already exist in the lake (rusty crayfish, banded mystery snail, zebra mussel, and freshwater jellyfish). Finally, it is essential to monitor North Lake for the presence of new aquatic invasive animal species (for example, rainbow smelt and common carp).

Part 9. Stakeholders

At this juncture in the ongoing aquatic plant management planning process, members of SECOLA have represented the North Lake stakeholders. Additional stakeholders and interested citizens are invited to participate as the plan is refined and updated in order to broaden input, build consensus, and encourage participation in stewardship. No contentious direct plant management actions (for example, harvesting or use of herbicides) are a component of the current plan. In June, 1995, a property-owner survey was distributed to North Lake residents. That survey solicited input from lake residents to better understand the needs, knowledge base, concerns and desires of the various water body users. Responses and analysis of that 1995 survey can be viewed in the *Lake Planning Study for North Lake* (MMA, 1996). A summary of the survey results can be viewed in Appendix N of the *North Lake Adaptive Management Plan*.

CHAPTER 5

Recommendations, Actions, and Objectives

In this chapter we provide recommendations for specific objectives and associated actions to support the *APM Plan's* goals stated in Chapter 3 and re-stated here for convenient reference:

(1) Monitor and protect the native aquatic plant community;
(2) Prevent establishment of AIS and nuisance levels of native plants;
(3) Promote and interpret APM efforts; and
(4) Educate riparian owners and lake users on preventing AIS introduction, reducing nutrient inputs that potentially alter the plant community, and minimizing physical removal of native riparian and littoral zone plants.

Since North Lake is a healthy and diverse ecosystem with regard to its aquatic plant community, we could simply recommend an alternative of "no action." In other words, North Lake continues without any effort or intervention on part of lake stewards. Nevertheless, we consider the "no action" alternative imprudent. Many forces threaten the quality of the lake, and members of SECOLA feel great responsibility to minimize the threats. In addition to the possible continued presence of Eurasian water-milfoil, the relatively new addition of zebra mussels to the lake ecosystem may have repercussions to aquatic plants. This dynamic process warrants careful monitoring. We therefore outline in this section a set of actions and related management objectives that will actively engage lake stewards in the process of management.

The actions are presented in tabular form. Each "action" consists of a set of four statements: (1) a declarative "action" statement that specifies the action (2) a statement of the "objective" that the action serves, (3) a "monitoring" statement that specifies the party responsible for carrying out the action and maintaining data, and (4) a "status" statement that suggests a timeline/calendar and indicates status (not yet started, ongoing, or completed).

Recommended Actions for the North Lake APM Plan

Action #1: Formally adopt the *North Lake Aquatic Plant Management Plan*.

Objective: To provide foundation for long-term native plant community conservation and stewardship and to be prepared for response to new AIS introductions.

Monitoring: SECOLA oversees activity and maintains the plan.

Status: Planned for 2014.

Action #2: Monitor water quality.

Objective: Continue with collection and analysis of water quality parameters to detect trends in parameters such as nutrients, chlorophyll *a*, and water clarity.

Monitoring: SECOLA oversees activity and maintains data.

Status: Ongoing.

Action #3: Monitor the lake for aquatic invasive plant species with particular emphasis on Eurasian water-milfoil.

Objective: To understand the lake's biotic community, provide for early detection of AIS and continue monitoring any existing populations of AIS.

Monitoring: SECOLA oversees activity and maintains data (with assistance from a consultant as needed).

Status: Ongoing.

Action #4: Monitor the lake for aquatic invasive animal species.

Objective: To understand the lake's biotic community, provide for early detection of AIS and continue monitoring any existing populations of AIS.

Monitoring: SECOLA oversees activity and maintains data (with assistance from a consultant as needed).

Status: Ongoing.

Recommended Actions for the North Lake APM Plan

Action #5: Monitor the populations of zebra mussels, Chinese mystery snail, and Rusty Crayfish in North Lake.

Objective: Determine potential effects of these aquatic invasive animals.

Monitoring: SECOLA oversees activity.

Status: Undertake as capacity and funding allows.

Action #6: Form an Aquatic Invasive Species Rapid Response Team and interface with the WDNR Lakes Management Coordinator and County AIS staff.

Objective: To be prepared for new AIS discovery and efficient response.

Monitoring: SECOLA coordinates this activity.

Status: Planned for 2014.

Action #7: Monitor North Lake's shoreline and littoral zone for European marsh thistle (*Cirsium palustre*), Yellow iris (*Iris pseudacorus*), and pink water lily (*Nymphaea odorata*) and investigate approach to controlling the existing populations.

Objective: To limit the population of these species.

Monitoring: SECOLA oversees activity and maintains record of monitoring and control (with assistance from a consultant as needed).

Status: Anticipated in 2016.

Action #8: Continue to control the population of Eurasian water-milfoil through hand-pulling. If monitoring shows this to be ineffective consult with WDNR and consultants as to other feasible approaches.

Objective: To limit the population expansion of this aquatic invasive species.

Monitoring: SECOLA oversees activity and maintains record of monitoring and control (with assistance from a consultant as needed).

Status: Anticipated in 2015.

Recommended Actions for the North Lake APM Plan
Action #9: Monitor for nuisance algal blooms (especially blue-green algae) and filamentous algae (in the near-shore area) and report occurrences to the WDNR. ***Objective:*** To identify changes in the North Lake ecosystem that might result from excessive nutrients or changes brought about by the presence of zebra mussels. ***Monitoring:*** SECOLA oversees activity and maintains record of monitoring (with assistance from a consultant as needed). ***Status:*** Anticipated in 2015.
Action #10: Conduct quantitative plant surveys at regular intervals (at least, every 5 years) using WDNR point-intercept methodology. ***Objective:*** To watch for changes in native species diversity, floristic quality, plant abundance, distribution and the occurrence of non-native, invasive plant species. ***Monitoring:*** SECOLA oversees activity and maintains data (with assistance from a consultant as needed). ***Status:*** Anticipated in 2017 or 2018.
Action #11: Update the APM plan approximately every five years or as needed to reflect new plant information from plant surveys and monitoring. ***Objective:*** To have current information and management science included in the plan. ***Monitoring:*** SECOLA oversees and maintains data with assistance from a consultant as needed; copies to WDNR. ***Status:*** Ongoing.
Action #12: Develop a Citizen Lake Monitoring Network to monitor for invasive species and develop strategies including education and monitoring activities (see http://www.uwsp.edu/cnr/uwexlakes/clmn for additional ideas). ***Objective:*** To create a trained volunteer corps to monitor aquatic invasive species and to educate recreational users regarding AIS. ***Monitoring:*** SECOLA oversees activity and reports possible introductions of AIS. ***Status:*** Anticipated to begin in 2014.

Recommended Actions for the North Lake APM Plan

Action #13: Become familiar with and recognize the water quality and habitat values of ordinances and requirements on boating, septic, and property development.

Objective: To protect native aquatic plants, water quality, and riparian habitat.

Monitoring: Lake residents and other stakeholders.

Status: Ongoing.

Action #14: Create an education plan for the property owners and other stakeholders that will address issues of healthy aquatic and riparian plant communities.

Objective: Educate stakeholders on topics that affect the lake's aquatic and riparian plant communities, including: (1) the importance of aquatic plants; (2) no or minimal manual or mechanical removal of plants along the shoreline is desirable and that any plant removal should conform to Wisconsin regulations; (3) the value of a natural shoreline in protecting lake health; (4) nutrient sources and the role excess nutrients play in degradation of the aquatic plant community; (5) the importance of reducing or eliminating use of fertilizers on lake front property; (6) the importance of minimizing transfer of AIS to the lake by having dedicated watercraft and cleaning boats that visit the lake.

Monitoring: SECOLA oversees activity and assesses effectiveness.

Status: Anticipated to begin in 2015.

Action #15: Monitor the lake watershed for purple loosestrife.

Objective: Identify purple loosestrife populations before they reach large size.

Monitoring: SECOLA oversees activity.

Status: Anticipated in 2014.

Action #16: Through education, signage, and sanitation of boats and equipment limit the dispersal of North Lake AIS to other bodies of water in the region.

Objective: To protect regional water bodies from AIS introduction. North Lake is a source water for AIS. As good landscape citizens, SECOLA members should act to minimize dispersal of AIS to other bodies of water through education, signage and sanitation.

Monitoring: SECOLA oversees activity.

Status: Anticipated in 2014.

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CHAPTER 6

Contingency Plan for AIS

Unfortunately, sources of aquatic invasive plants and other AIS are numerous in Wisconsin and Michigan. Some infested lakes are quite close to North Lake. Despite serious and dedicated efforts applied to stopping transport of AIS, there is an increasing likelihood of accidental introduction of additional AIS to North Lake through conveyance of life stages by boats, trailers, and other vectors. It is important for SECOLA and other concerned lake stewards to be prepared for the contingency of aquatic invasive plant species colonization.

For riparian owners and users of a lake ecosystem, the discovery of AIS is an event that elicits an immediate desire to “fix the problem.” Although strong emotions may be evoked by such a discovery, a deliberate and systematic approach is required to appropriately and effectively address the situation. An aquatic plant management plan (one including a contingency plan for AIS) is the best tool by which the process can be navigated. In fact the APM plan is a requirement in Wisconsin for some kinds of aquatic plant management actions. One of the actions outlined in the previous chapter was to establish an Aquatic Invasive Species Rapid Response Team. This team and its coordinator are integral to the management process. It is important for this team to be multi-dimensional (or at least have quick access to the expertise that may be required). AIS invade not just a single lake, but an entire region since the new infestation is an outpost from which the AIS can more easily colonize other nearby water bodies. For this reason it is strategic for the Rapid Response Team to include representation from regional stakeholders.

Exhibit 13 provides a flowchart outlining an appropriate rapid response to the suspected discovery of an aquatic invasive plant species. The response will be most efficient if an AIS Rapid Response Team has already been established and is familiar with the contingency plan. In the remainder of this chapter we further describe the approach.

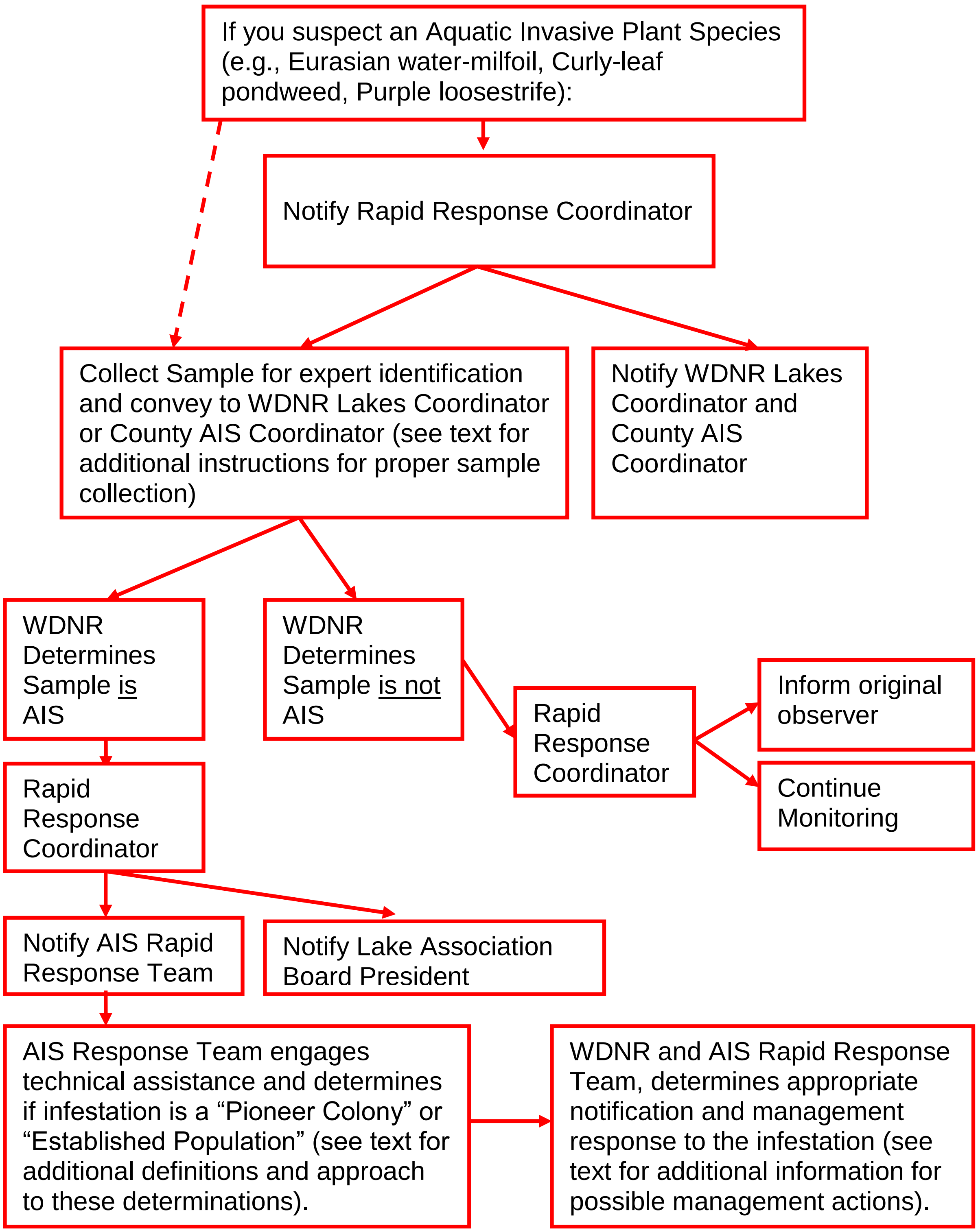
When a suspect aquatic invasive plant species is found, either the original observer or a member of the Rapid Response Team (likely the coordinator) should collect an entire plant specimen including roots, stems, and flowers (if present). The sample should be placed in a sealable bag with a small amount of water to keep it moist. Place a label in the bag written in pencil with date, time, collector’s name, lake name, location, town, and county. Attach a lake map to the bag that has the location of the suspect AIS marked and GPS coordinates recorded (if GPS is available). The sample should be placed on ice in a cooler or in a refrigerator. Deliver the sample to the WDNR or the County AIS Coordinator as soon as possible (at least within three days). The WDNR or their botanical expert(s) will determine the species and confirm whether or not it is an aquatic invasive plant species.

If the suspect specimen is determined to be an invasive plant species, the next step is to determine the extent and density of the population since the management response will vary accordingly. The Rapid Response Team should conduct (or have its consultant conduct) a survey to define the colony's perimeter and estimate density. If less than five acres (or <5% of the lake surface area), it is designated a "Pioneer Colony." If greater than five acres (or >5% of the lake surface area) then it is designated an "Established Population." Once the infestation is characterized, "at risk" areas should also be determined and marked on a map. For example, nearby boat landing sites and areas of high boat traffic should be indicated.

When "pioneer" or "established" status has been determined, it is time to consult with the WDNR Lakes Coordinator to determine appropriate notifications and management responses to the infestation. Determining whether hand-pulling or chemical treatment will be used is an important and early decision. Necessary notifications of landowners, governmental officials, and recreationists (at boat landings) will be determined. Whether the population's perimeter needs to be marked with buoys will be decided by the WDNR. Funding sources will be identified and consultants and contractors will be contacted where necessary. The WDNR will determine if a further baseline plant survey is required (depending on type of treatment). A post treatment monitoring plan will be discussed and established to determine the efficacy of the selected treatment.

Once the Rapid Response Team is organized, one of its first tasks is to develop a list of contacts and associated contact information (phone numbers and email addresses). At a minimum, this contact list should include: the Rapid Response Coordinator, members of the Rapid Response Team, County AIS Coordinator, WDNR Lakes Management Coordinator, Lake Association President(s) (or other points of contact), local WDNR warden, local government official(s), other experts, chemical treatment contractors, and consultant(s).

Exhibit 13. Aquatic Invasive Plant Species Rapid Response



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Appendix 1
Literature Cited

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Appendix 2

Aquatic Plant Survey Tables and Figures

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WHITE WATER ASSOCIATES, INC.

Table 1. Summary statistics for the 2012 point-intercept aquatic plant surveys for North Lake.

Summary Statistic	Value	Notes
Total number of sites on grid	246	Total number of sites on the original grid (not necessarily visited)
Total number of sites visited	238	Total number of sites where the boat stopped, even if much too deep to have plants.
Total number of sites with vegetation	111	Total number of sites where at least one plant was found
Total number of sites shallower than maximum depth of plants	134	Number of sites where depth was less than or equal to the maximum depth where plants were found. This value is used for Frequency of occurrence at sites shallower than maximum depth of plants.
Frequency of occurrence at sites shallower than maximum depth of plants	82.8	Number of times a species was seen divided by the total number of sites shallower than maximum depth of plants.
Simpson Diversity Index	0.89	A nonparametric estimator of community heterogeneity. It is based on Relative Frequency and thus is not sensitive to whether all sampled sites (including non-vegetated sites) are included. The closer the Simpson Diversity Index is to 1, the more diverse the community.
Maximum depth of plants (ft.)	21.00	The depth of the deepest site sampled at which vegetation was present.
Number of sites sampled with rake on rope	62	
Number of sites sampled with rake on pole	99	
Average number of all species per site (shallower than max depth)	1.96	
Average number of all species per site (vegetated sites only)	2.36	
Average number of native species per site (shallower than max depth)	1.96	Total number of species collected. Does not include visual sightings.
Average number of native species per site (vegetated sites only)	2.36	Total number of species collected including visual sightings.
Species Richness	21	
Species Richness (including visuals)	23	
Floristic Quality Index (FQI)	28.4	

Table 2. Plant species recorded and distribution statistics for the 2012 North Lake aquatic plant survey.

Common name	Scientific name	Frequency of occurrence at sites less than or equal to maximum depth of plants	Frequency of occurrence within vegetated areas (%)	Relative Frequency (%)	Number of sites where species found	Number of sites where species found (including visuals)	Average Rake Fullness
Muskgrasses	*Chara* sp.	47.76	57.66	24.43	64	64	1.61
Nitella	*Nitella* sp.	22.39	27.03	11.45	30	30	1.90
Illinois pondweed	*Potamogeton illinoensis*	20.90	25.23	10.69	28	33	1.11
Coontail	*Ceratophyllum demersum*	14.18	17.12	7.25	19	19	1.11
Northern water-milfoil	*Myriophyllum sibiricum*	14.18	17.12	7.25	19	19	1.79
Wild celery	*Vallisneria americana*	11.94	14.41	6.11	16	16	1.00
Fries' pondweed	*Potamogeton friesii*	11.19	13.51	5.73	15	15	1.20
Common waterweed	*Elodea canadensis*	9.70	11.71	4.96	13	13	1.15
Slender naiad	*Najas flexilis*	8.21	9.91	4.20	11	11	1.00
Flat-stem pondweed	*Potamogeton zosteriformis*	8.21	9.91	4.20	11	12	1.00
Variable pondweed	*Potamogeton gramineus*	5.22	6.31	2.67	7	8	1.00
Fern pondweed	*Potamogeton robbinsii*	4.48	5.41	2.29	6	6	1.33
Watershield	*Brasenia schreberi*	3.73	4.50	1.91	5	7	1.00
Small pondweed	*Potamogeton pusillus*	3.73	4.50	1.91	5	5	1.00
Water star-grass	*Heteranthera dubia*	2.24	2.70	1.15	3	3	1.00
Water bulrush	*Schoenoplectus subterminalis*	2.24	2.70	1.15	3	3	1.00
Spatterdock	*Nuphar variegata*	1.49	1.80	0.76	2	10	1.00
Large-leaf pondweed	*Potamogeton amplifolius*	1.49	1.80	0.76	2	2	1.00
White water lily	*Nymphaea odorata*	0.75	0.90	0.38	1	4	1.00
Crested arrowhead	*Sagittaria cristata*	0.75	0.90	0.38	1	1	1.00
Common bladderwort	*Utricularia vulgaris*	0.75	0.90	0.38	1	1	1.00
Floating-leaf pondweed	*Potamogeton natans*				Visual	8	
Hardstem bulrush	*Schoenoplectus acutus*				Visual	1	
Wild calla	*Calla palustris*				Boat Survey		
Broad-leaved cattail	*Typha latifolia*				Boat Survey		
European marsh thistle	*Cirsium palustre*				Boat Survey		

Frequency of occurrence within vegetated areas (%): Number of times a species was seen in a vegetated area divided by the total number of vegetated sites.

European marsh thistle is considered a *Restricted* species in Florence County.

Figure 1. Number of plant species recorded at North Lake sample sites (2012).

Figure 2. Rake fullness ratings for North Lake sample sites (2012).

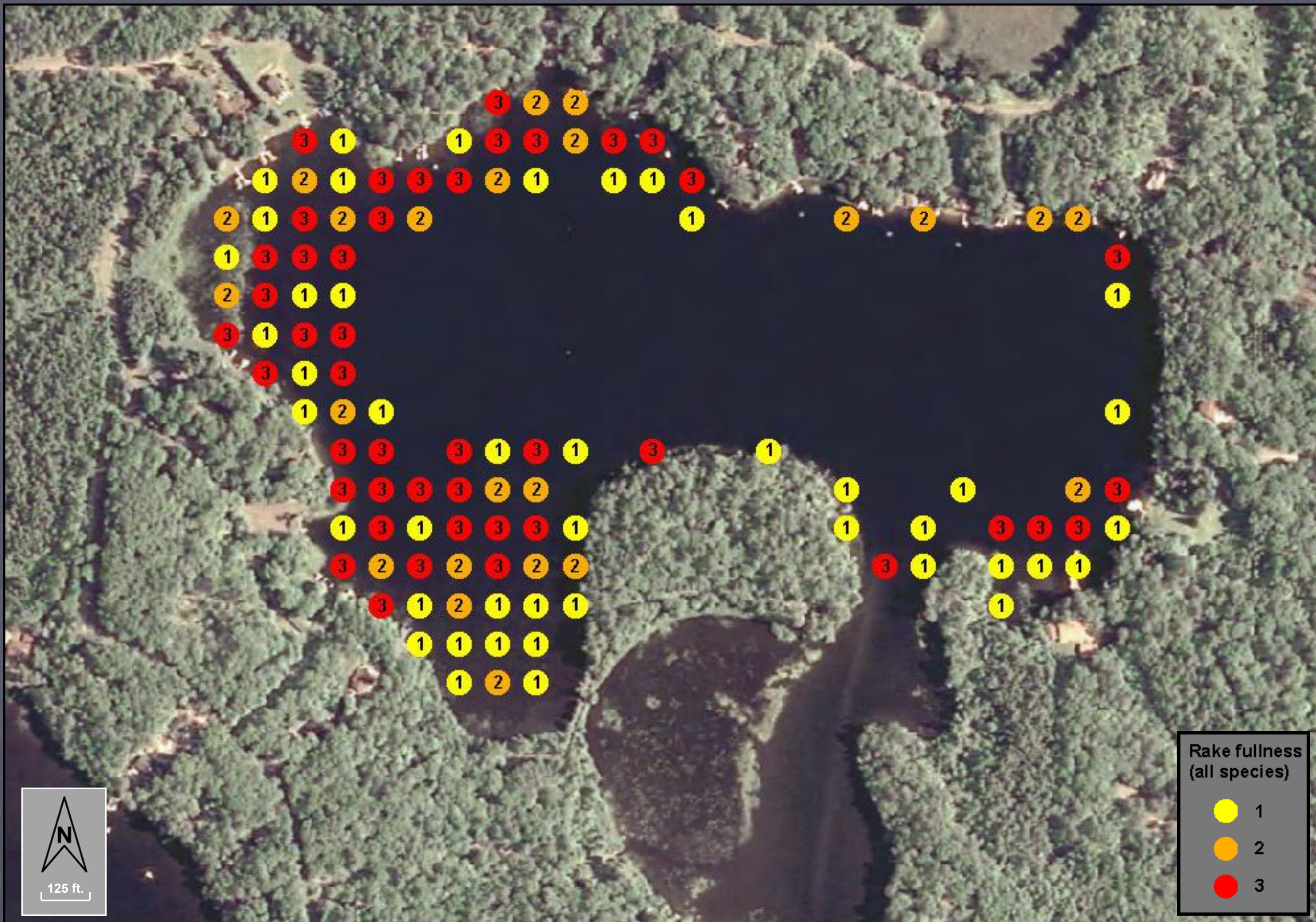

Figure 3. Maximum Depth of Plant Colonization in North Lake.

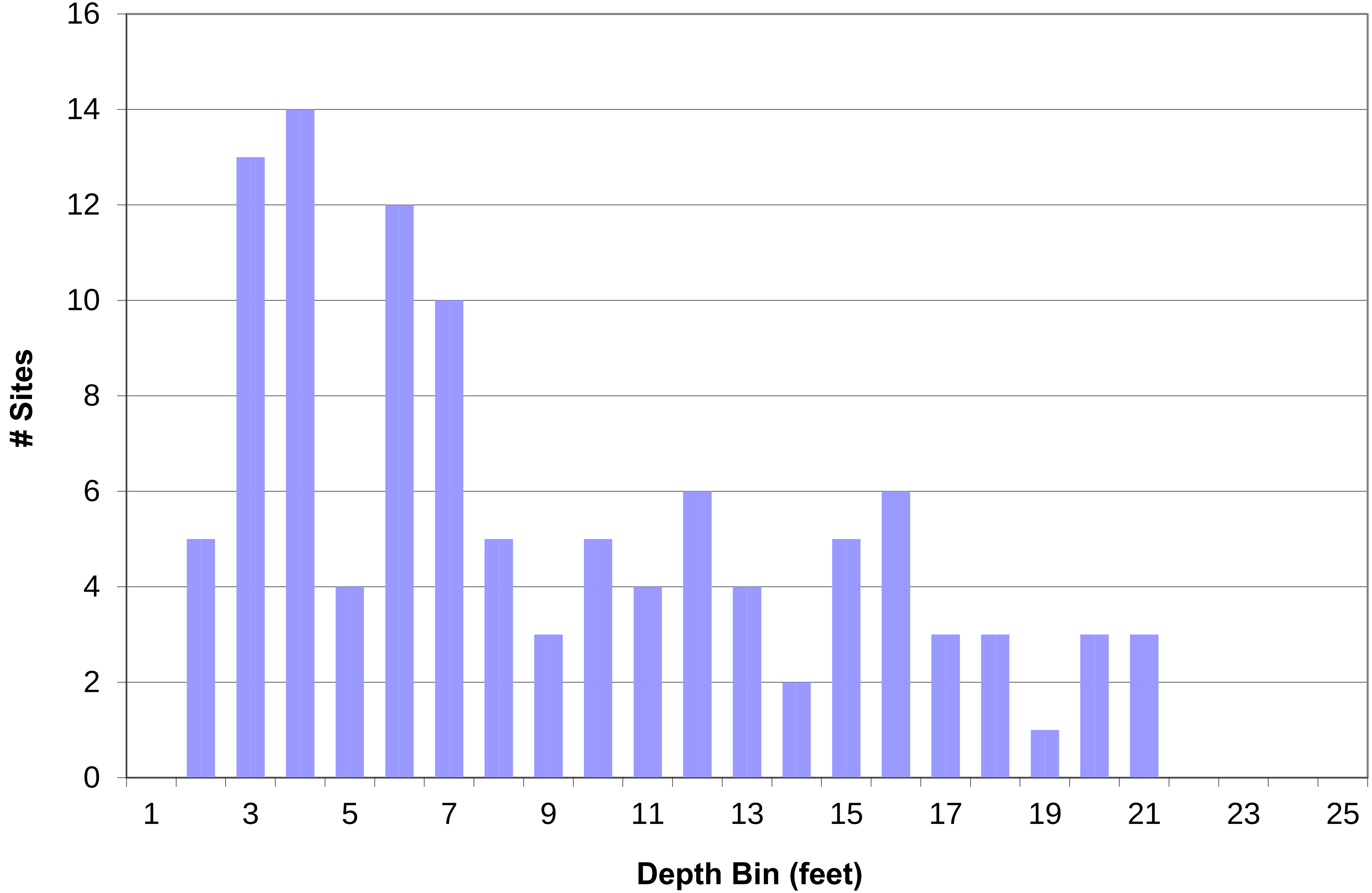

Figure 4. North Lake sampling sites less than or equal to maximum depth of rooted vegetation (2012).

Figure 5. North Lake substrate encountered at point-intercept plant sampling sites (2012).

Figure 6. North Lake aquatic plant occurrences for 2012 point-intercept survey data.

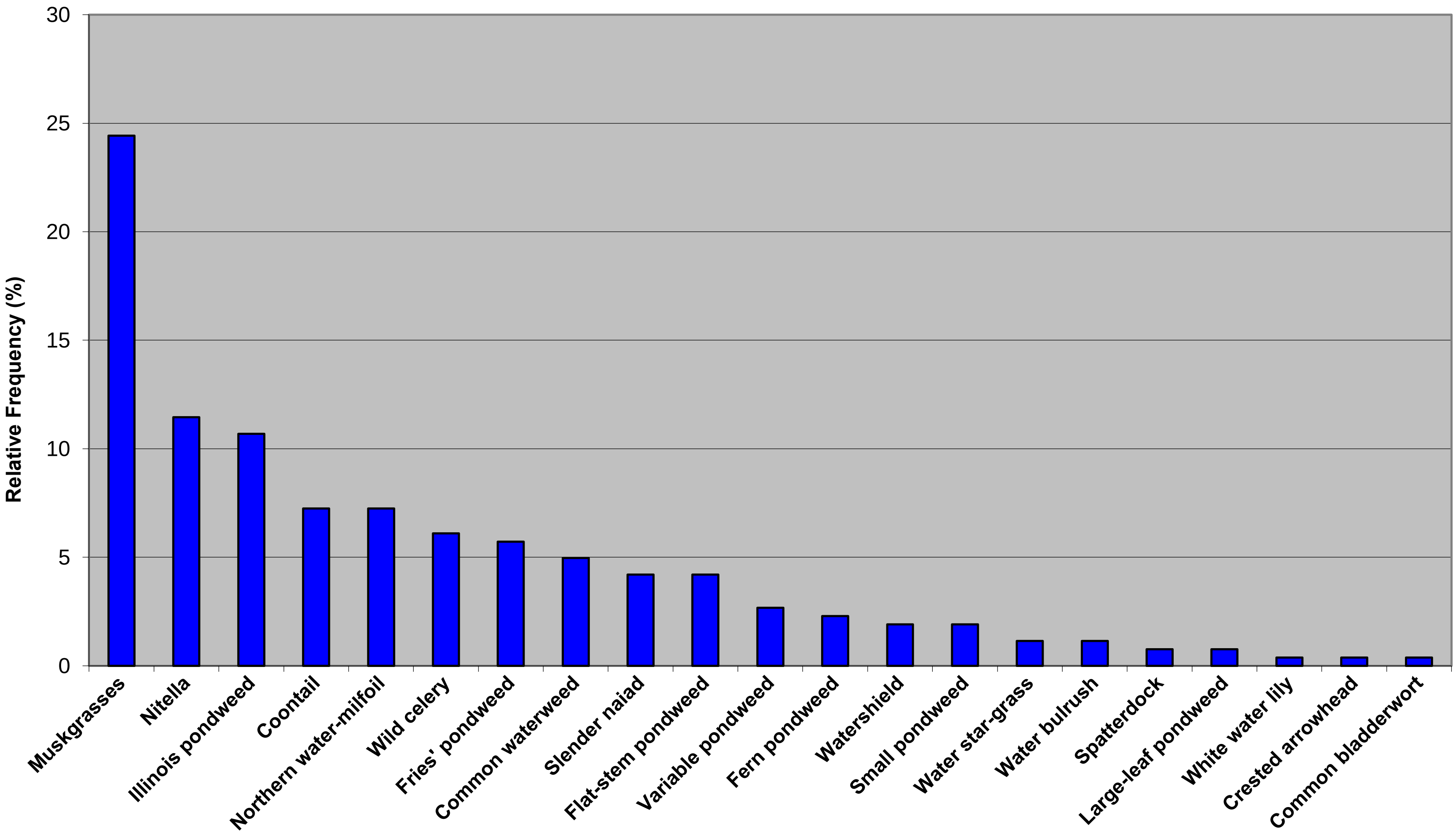

Figure 7. North Lake point-intercept plant sampling sites with emergent and floating aquatic plants (2012).

Figure 8. Distribution of plant species, North Lake (2012).

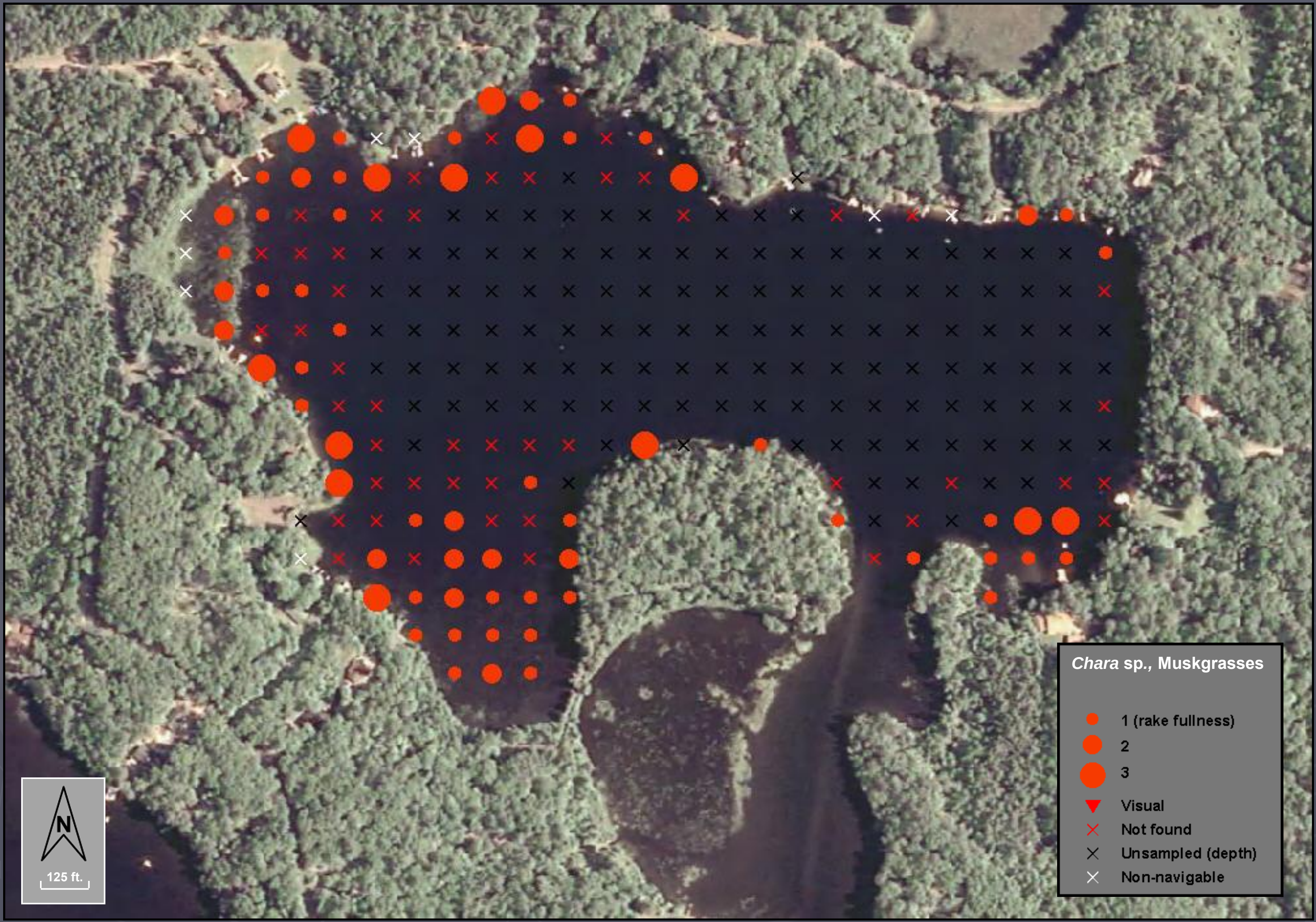

Figure 9. Distribution of plant species, North Lake (2012).

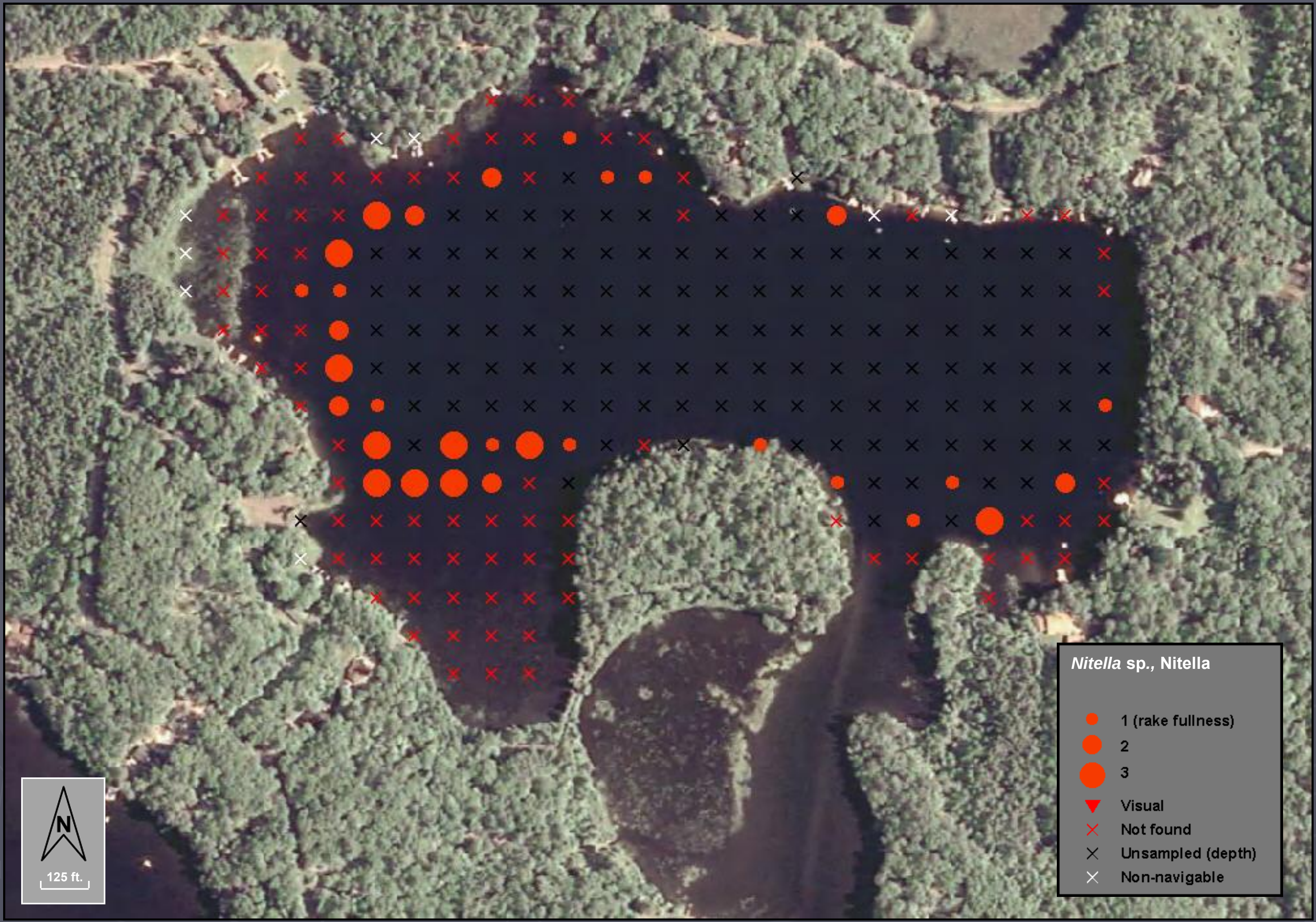

Figure 10. Distribution of plant species, North Lake (2012).

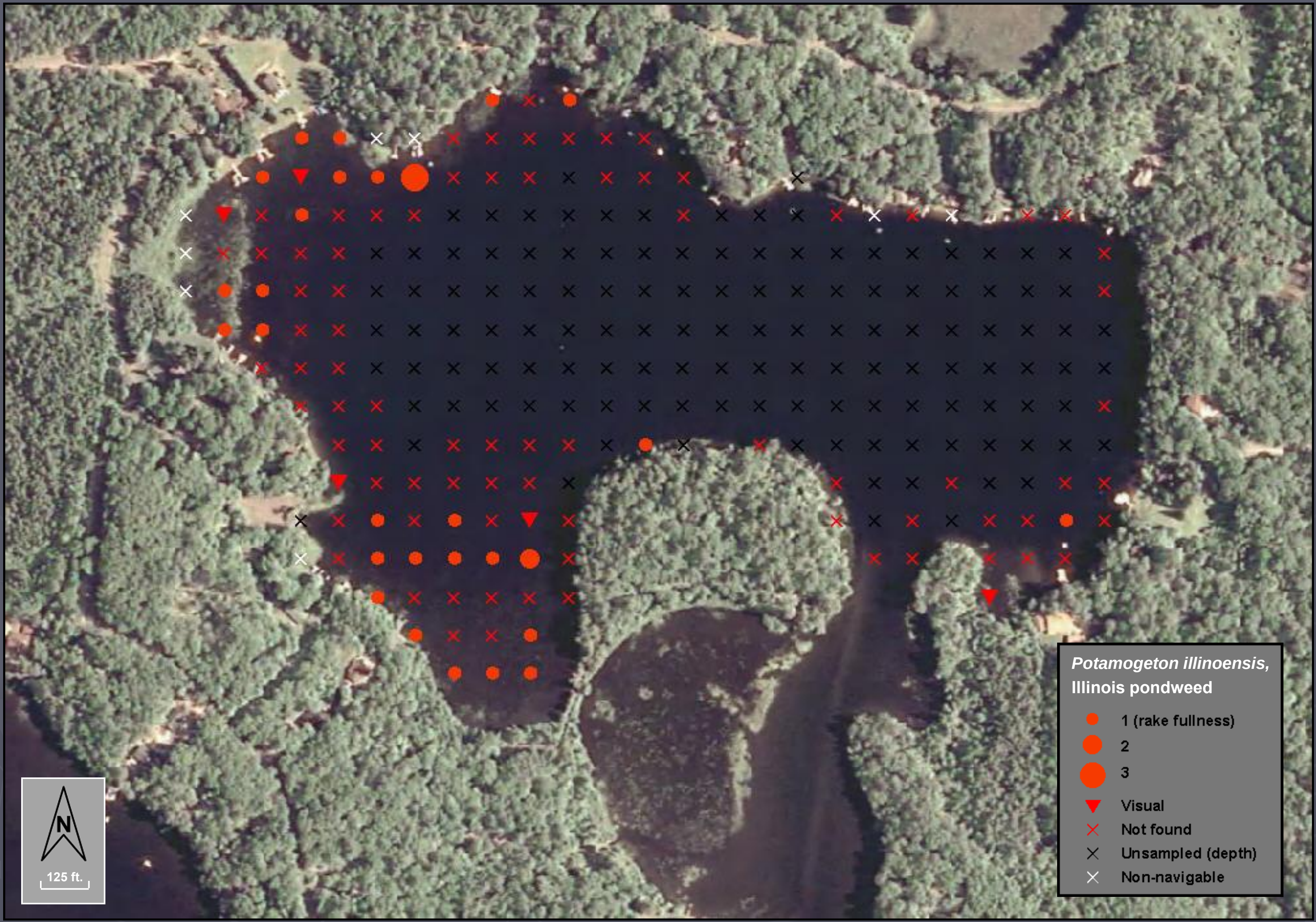

Figure 12. Distribution of plant species, North Lake (2012).

Figure 13. Distribution of plant species, North Lake (2012).

Figure 14. Distribution of plant species, North Lake (2012).

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Appendix 3

Review of North Lake Water Quality

Note: This document is available as Appendix C of the

North Lake Adaptive Management Plan

(starts on following page)

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Appendix C
North Lake Review of Water Quality

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Appendix C

Review of Lake Water Quality

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Review of North Lake Water Quality

Prepared by Angie Stine, B.S., and Caitlin Clarke, B.S., White Water Associates, Inc.

Introduction

North Lake is located in Florence County, Wisconsin. It is a 79 acre drainage lake with a maximum depth of 43 feet. The Waterbody Identification Code (WBIC) is 703000. The purpose of this study is to collect, organize, and interpret baseline data. In turn, this provides a baseline against which we can compare future North Lake water quality monitoring data. This will allow documentation of environmental changes in the lake (either natural or human-caused). Water quality data was retrieved from the WDNR SWIMS database in 1995, and from 1998 to present. White Water Associates collected water quality samples in 2012 and 2013. The majority of the water quality data on North Lake came from Citizen Lake Monitoring Network (CLMN) volunteers.

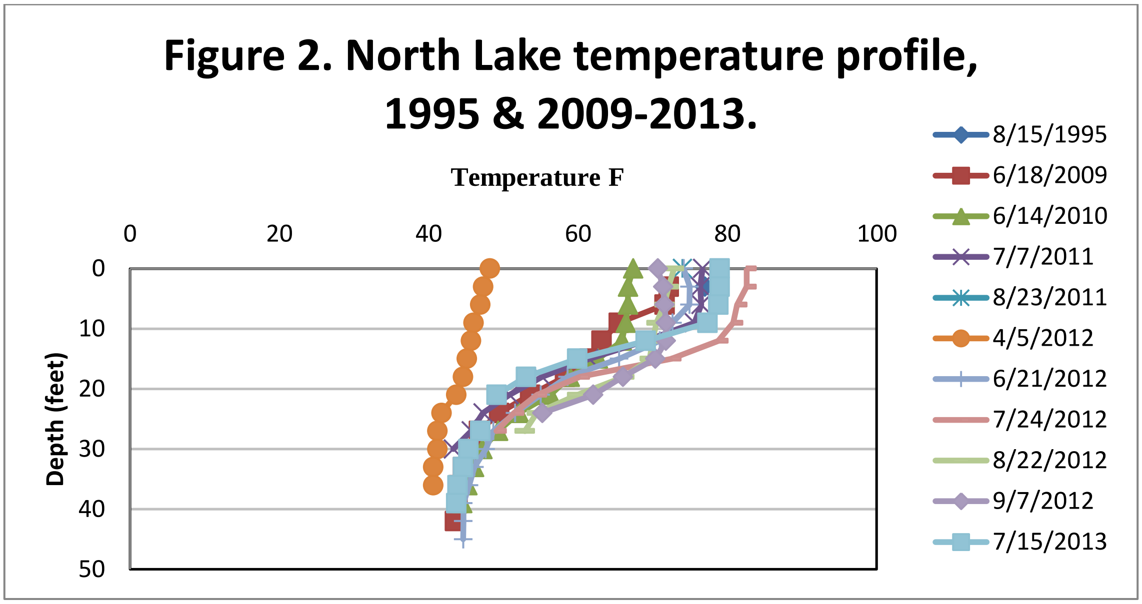
Comparison of North Lake with other datasets

Lillie and Mason's *Limnological Characteristics of Wisconsin Lakes* (1983) provides a good source to compare lakes within our region to a subset of lakes that have been sampled in Wisconsin. Wisconsin is divided into five regions for the purposes of comparing and interpreting water quality data for lakes. Florence County lakes are in the Northeast Region (Figure 1) and were among 243 lakes randomly selected and analyzed for water quality.

Figure 1. Wisconsin regions in terms of water quality.

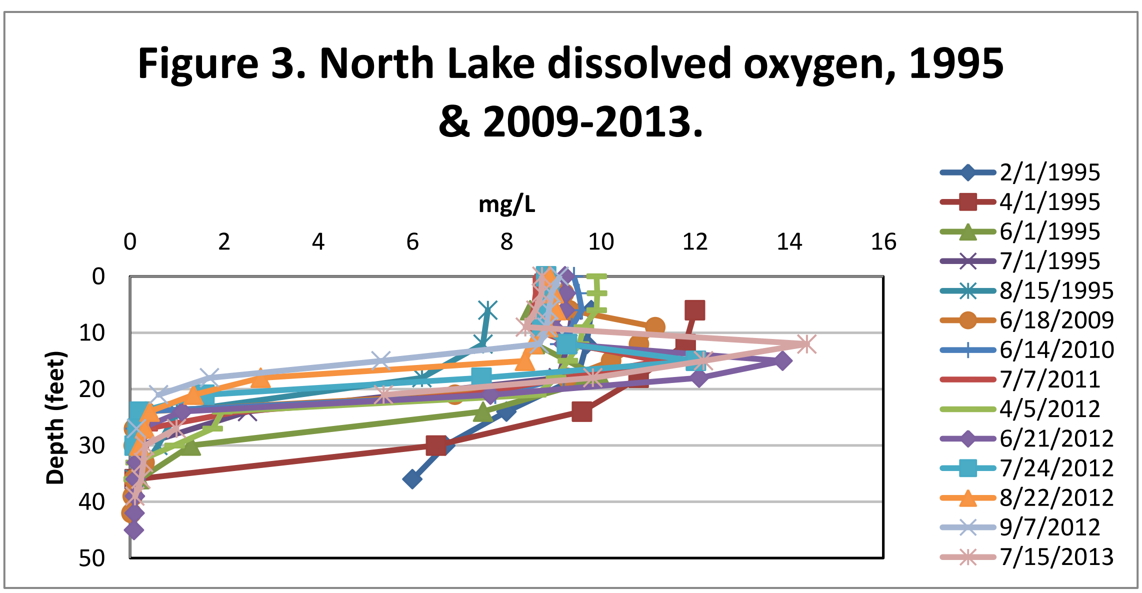
Temperature

Measuring water temperature at different depths in a lake will determine the influence it has on the physical, biological, and chemical aspects of the lake. Lake water temperature influences the rate of decomposition, nutrient recycling, lake stratification, and dissolved oxygen (D.O.) concentration. Temperature can also affect the distribution of fish species throughout a lake. Figure 2 documents temperature profiles for North Lake in 1995 and from 2009 to 2013. North Lake demonstrates stratification in the summer months. In other words, North Lake has different temperatures at different depths in the summer.



Dissolved Oxygen

The dissolved oxygen (D.O.) content of lake water is vital in determining presence and vitality of fish species and other aquatic organisms. Dissolved oxygen also has a strong influence on the chemical and physical conditions of a lake. The amount of dissolved oxygen is dependent on the water temperature, atmospheric pressure, and biological activity. Oxygen levels are increased by aquatic plant photosynthesis (at times of day and season when light is available), but reduced by respiration of plants, decomposer organisms, fish, and invertebrates. The amount of dissolved oxygen available in a lake, particularly in the deeper parts of a lake, is an important factor in describing lake health. Figure 3 provides North Lake dissolved oxygen profiles for 1995 and from 2009 to 2013. Since game fish typically avoid water with less than 5 mg/L D.O., they are most likely not present at depths greater than 18 feet in summer months. In February, 1995, D.O. levels were above 5 mg/L as deep as 35 feet.

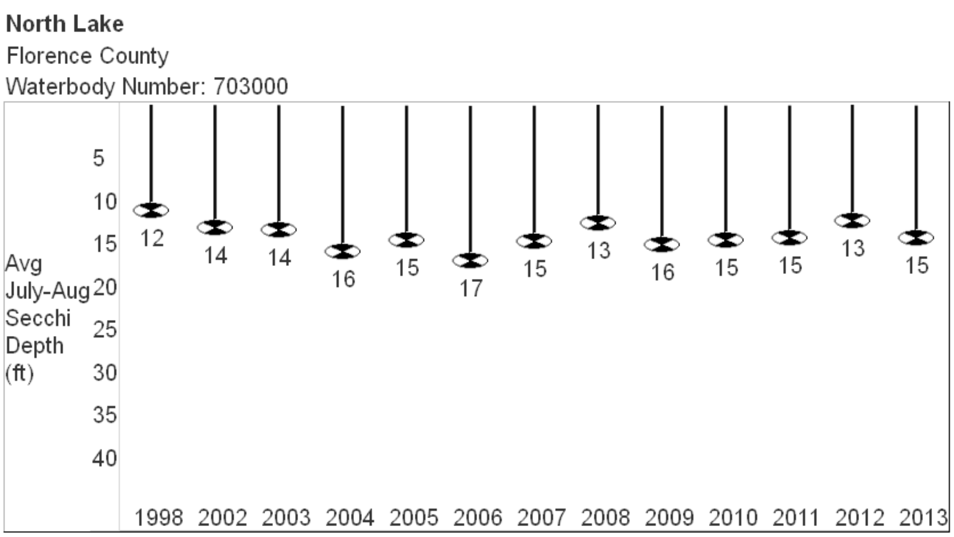


Water Clarity

Water clarity has two main components: turbidity (suspended materials such as algae and silt) and true color (materials dissolved in the water) (Shaw et al., 2004). Water clarity indicates the overall water quality in a lake. Water clarity is typically measured using a black and white Secchi disk lowered into the water column on a tether. The depth at which the pattern on the disk is no longer visible is taken as a measure of the transparency of the water (the Secchi depth).

Figure 4 shows the July and August mean Secchi depths for 1998 and from 2002 to 2013. In 2013, the mean Secchi depth classifies North Lake to have "good" to "very good" water clarity (Table 1). Figure 5 displays the mean, min, max and count of Secchi depths in North Lake in 1998 and from 2002 to 2013. The shallowest mean Secchi depth was 10 feet in 1998 and 2012, and the deepest reading was at 20 feet in 2006.

Figure 4. North Lake Secchi depth averages (July and August only).



Past secchi averages in feet (July and August only).

(WDNR, 2013)

Table 1. Water clarity index (Shaw et al., 2004).

Water clarity	Secchi depth (ft.)
Very poor	3
Poor	5
Fair	7
Good	10
Very good	20
Excellent	32

Figure 5. North Lake's July and August Secchi Data: Mean, Min, Max, and Secchi Count (1998, 2002-2013).

Year	Secchi Mean	Secchi Min	Secchi Max	Secchi Count
1998	11.5	10	13	2
2002	13.5	12	15	2
2003	13.7	13	14	3
2004	16.3	16	16.5	2
2005	15	12	18	2
2006	17.4	16	20	3
2007	15.2	13	16.5	3
2008	13	11	15	4
2009	15.5	14.5	16	3
2010	15	14.5	15.5	2
2011	14.8	14	16	4
2012	12.8	10	15	3
2013	14.8	14	16.5	5

Report Generated: 12/19/2013

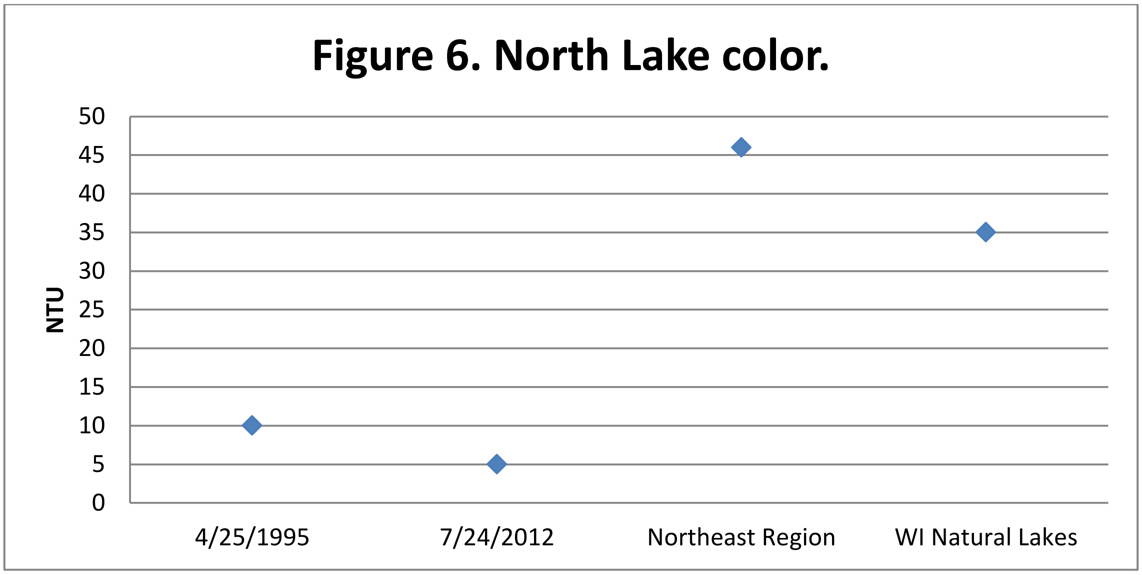
(WDNR, 2013)

Turbidity

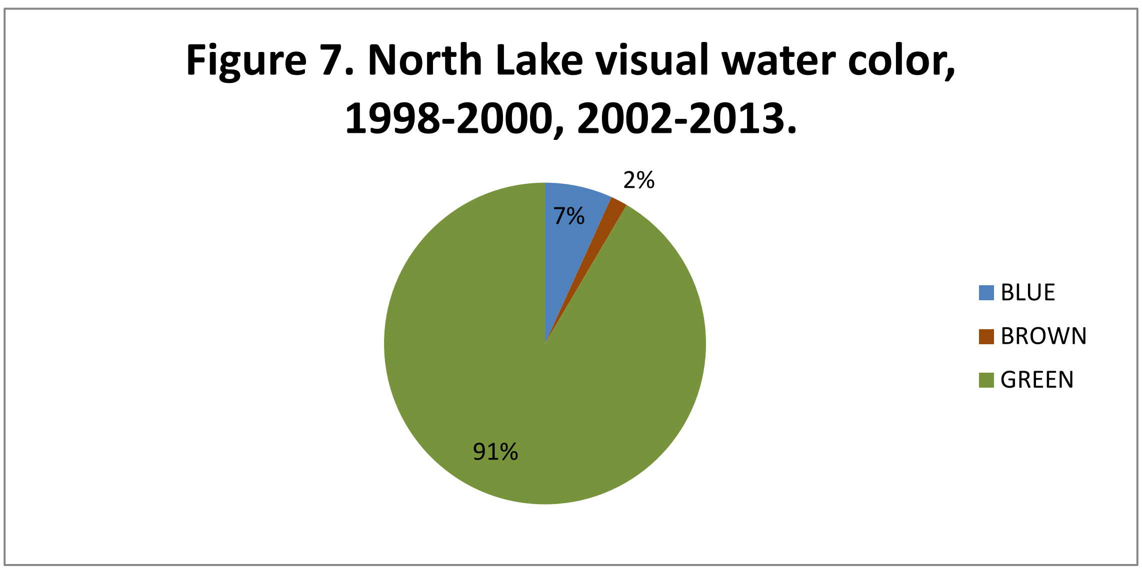
Turbidity is a measure of water clarity that measures the suspended particulate matter in the water (Shaw et al., 2004). Particles suspended in the water dissipate light and reduce the depth at which the light can penetrate. This affects the depth at which plants can grow. Turbidity also affects the aesthetic quality of water. Water that runs off the watershed into a lake can increase turbidity by introducing suspended soil and organic materials. Turbidity caused by algae is the most common reason for low Secchi readings (Shaw et al., 2004). In terms of biological health of a lake ecosystem, measurements less than 10 Nephelometric Turbidity Units (NTU) represent healthy conditions for fish and other organisms. North Lake's turbidity reading was 0.75 NTU in April, 1995 which is low compared to other Wisconsin natural lakes (average 2.9 NTU). While collecting samples, CLMN volunteers also rate the water clarity and describe the water as "clear" or "murky." From 1998 to 2000, and from 2002 to 2013, the water appeared "clear" except in one instance in July, 2011 when it was considered "murky."

Water Color

Color of lake water is related to the type and amount of dissolved organic chemicals in the water. Its main significance is aesthetics, although it may also influence light penetration and in turn affect aquatic plant and algal growth. Many lakes have naturally occurring color compounds from decomposition of plant material in the watershed (Shaw et al., 2004). Units of color are determined from the platinum-cobalt scale and are therefore recorded as Pt-Co units. Shaw states that a water color between 0 and 40 Pt-Co units is low. North Lake has had two color samples over the years. In April, 1995 a Pt-Co unit of 10 was recorded, and in July, 2012, color was 5 Pt-Co, which are low compared to the Northeast region and other Wisconsin natural lakes (Figure 6).



CLMN volunteers also recorded their impression as to what the water color looked like. The majority of volunteers (91%) said the water appeared green (Figure 7).

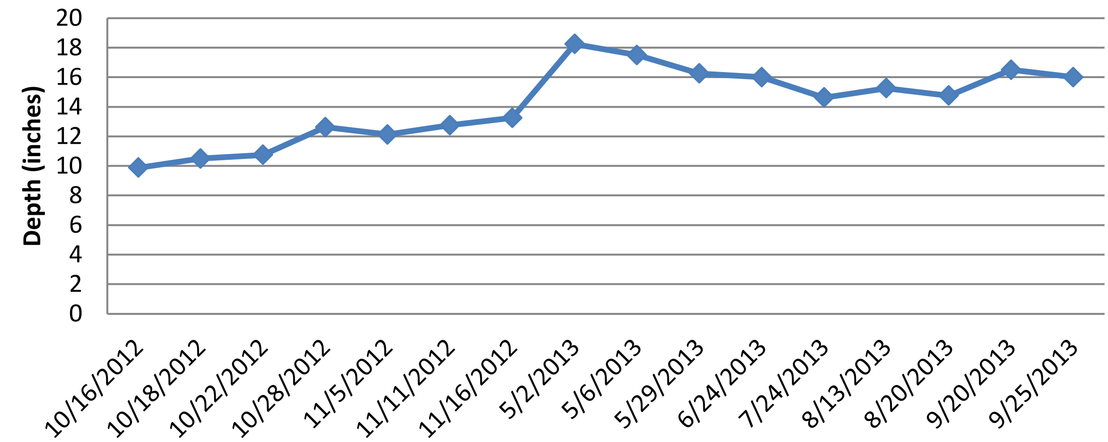


Water Level

When CLMN volunteers collect Secchi depth readings, they also record their perceptions of the lake level as "high," "normal," or "low." CLMN volunteers viewed North Lake as "normal" from 1998 to 2000, and from 2002 to 2013.

Figure 8 indicates that the water level of the Spread Eagle Chain, recorded by Glen Johnson (current President of the SECOLA). Water level was measured from his dock on East Lake from October, 2012 to September, 2013. He measured the water level by placing a yard stick on a wheel rim, which supports his pier (Johnson, 2013). As we can see, Spread Eagle Chain lake levels are highest in spring.

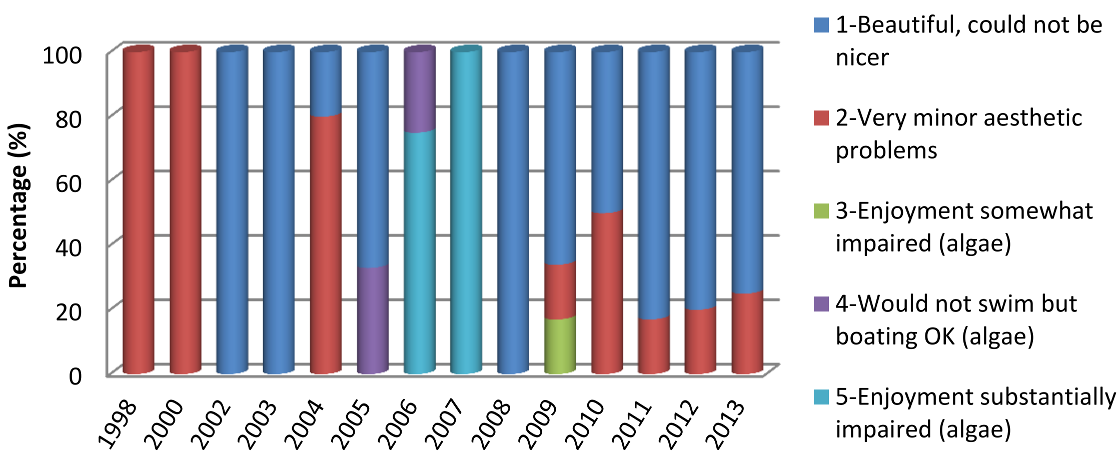
Figure 8. Spread Eagle Chain lake level, recorded from East Lake (Johnson, 2013).



User Perceptions

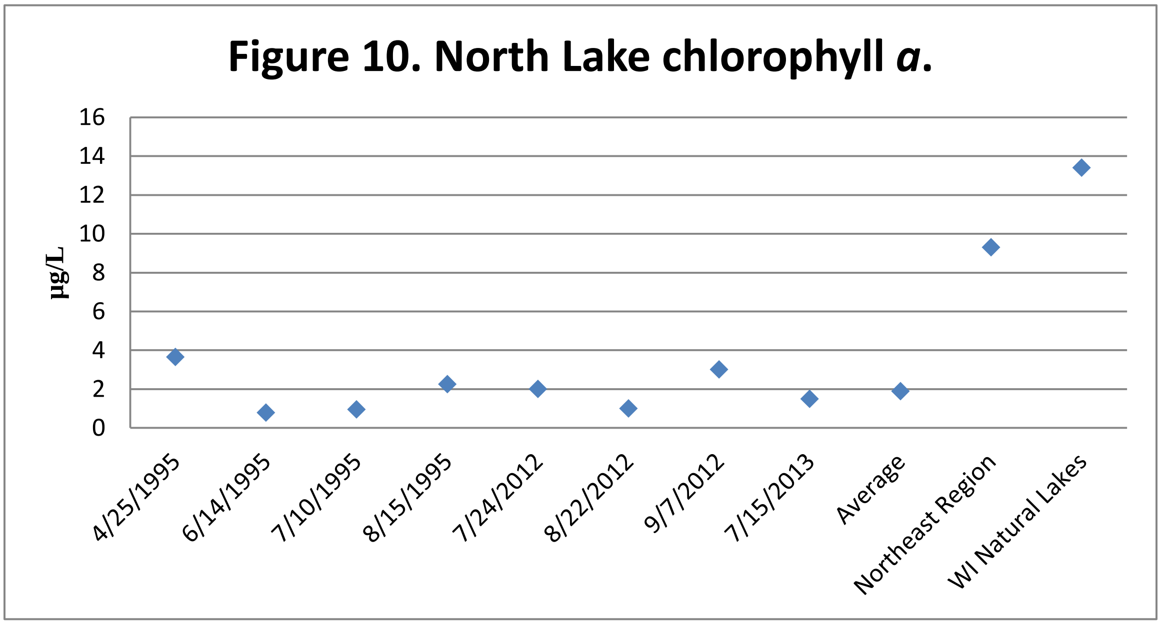
When Secchi depth readings are collected, the CLMN record their perceptions of the water, based on the physical appearance and the recreational suitability. These perceptions can be compared to water quality parameters to see how the lake user would experience the lake at that time. When interpreting the transparency data, we see that when the Secchi depth decreases, the rating of the lake's physical appearance also decreases. These perceptions of recreational suitability are displayed by year in Figure 9. In 2002, 2003 and 2008, 100% of CLMN volunteers said North Lake was "beautiful, could not be nicer." In 1998 and 2000, 100% of the CLMN said there were "very minor aesthetic problems." In 2007, 100% said their "enjoyment was substantially impaired (algae)."

Figure 9. North Lake aesthetic value, 1998-2013.



Chlorophyll *a*

Chlorophyll *a* is the photosynthetic pigment that makes plants and algae green. Chlorophyll *a* in lake water is therefore an indicator of the amount of algae. Chlorophyll *a* concentrations greater than 10 µg/L are perceived as a mild algae bloom, while concentrations greater than 20 µg/L are perceived as a nuisance algal bloom. Chlorophyll *a* has been monitored in North Lake for three years (Figure 10). The average chlorophyll *a* values indicate that North Lake is lower than the northeast region and other WI natural lakes.



Phosphorus

In more than 80% of Wisconsin's lakes, phosphorus is the key nutrient affecting the amount of algae and plant growth. If phosphorus levels are high, plant and algae grown is stimulated and excessive aquatic plant and/or algae growth can occur.

Phosphorus originates from a variety of sources, many of which are related to human activities. Major sources include human and animal wastes, soil erosion, detergents, septic systems and runoff from farmland or lawns (Shaw et al., 2004). Phosphorus provokes complex reactions in lakes. An analysis of phosphorus often includes both soluble reactive phosphorus and total phosphorus. Soluble reactive phosphorus dissolves in the water and directly influences plant growth (Shaw et al., 2004). Its concentration varies in most lakes over short periods of time as plants take it up and release it. Total phosphorus is considered a better indicator of a lake's nutrient status than soluble reactive phosphorus because its levels remain more stable (Shaw et al., 2004). Total phosphorus includes soluble phosphorus and the phosphorus in plant and animal fragments suspended in lake water. Ideally, soluble reactive phosphorus concentrations should be 10 µg/L or less at spring turnover to prevent summer algae blooms (Shaw et al., 2004). A concentration of total phosphorus below 20 µg/L for lakes should be maintained to prevent nuisance algal blooms (Shaw et al., 2004).

The average North Lake total phosphorus level for 1995, 2012 and 2013 is 9 µg/L (Figure 11). This average is considered "very good" (Figure 12).

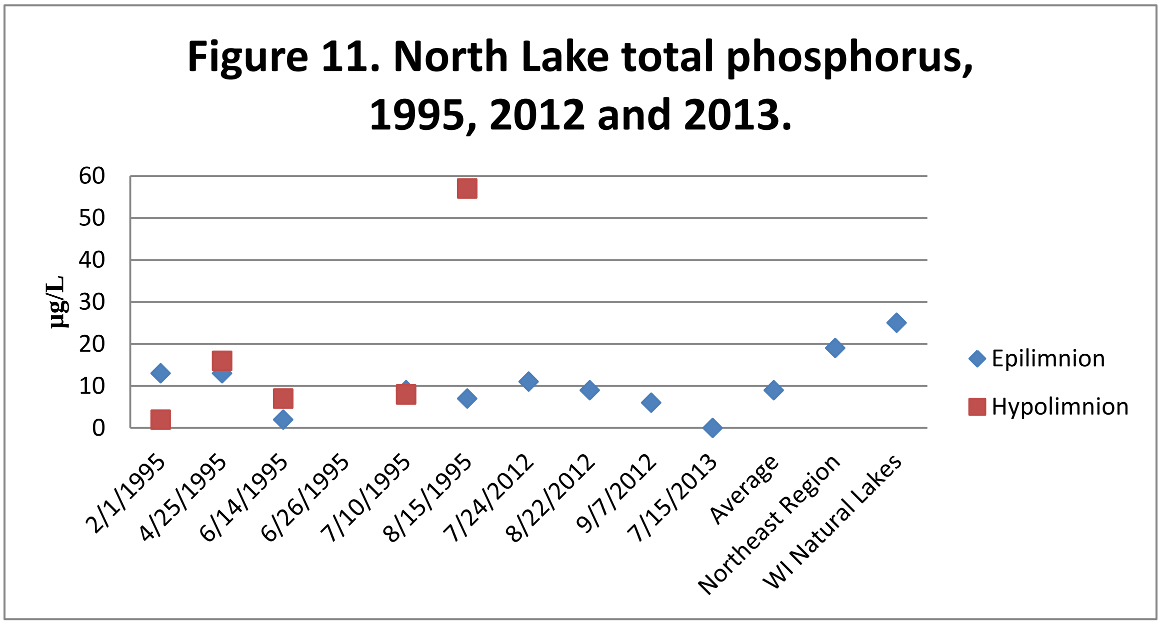
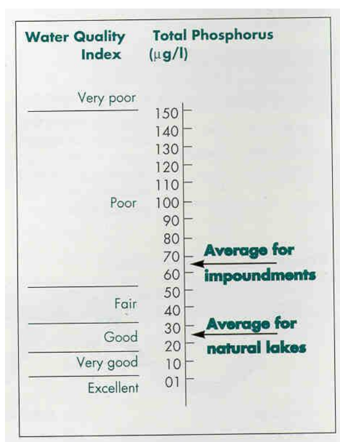


Figure 12. Total phosphorus concentrations for Wisconsin's natural lakes and impoundments (Shaw et al., 2004).



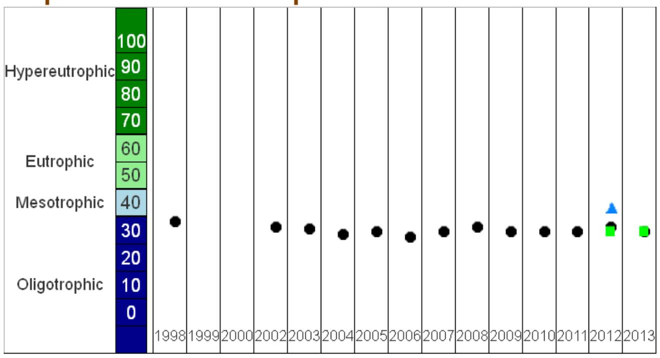
Trophic State

Trophic state is another indicator of water quality (Carlson, 1977). Lakes are often divided into three major categories based on trophic state – oligotrophic, mesotrophic, or eutrophic. These categories reflect a lake's nutrient and clarity levels (Shaw et al., 2004).

The Trophic State Index (TSI) for North Lake was calculated by the WDNR using Secchi measurements from the CLMN. North Lake is classified as "oligotrophic" (Figure 13 and Table 2).

Figure 13. North Lake, North Basin Trophic State Index (1998, 2002-2013).

Trophic State Index Graph



Monitoring Station: North Lake - Deep Hole, Florence County
Past Summer (July-August) Trophic State Index (TSI) averages.

● = Secchi ■ = Chlorophyll ▲ = Total Phosphorus

TSI(Chl) = TSI(TP) = TSI(Sec)	It is likely that algae dominate light attenuation.
TSI(Chl) > TSI(Sec)	Large particulates, such as Aphanizomenon flakes dominate
TSI(TP) = TSI(Sec) > TSI(Chl)	Non-algal particulate or color dominate light attenuation
TSI(Sec) = TSI(Chl) >= TSI(TP)	The algae biomass in your lake is limited by phosphorus
TSI(TP) > TSI(Chl) = TSI(Sec)	Zooplankton grazing, nitrogen, or some factor other than phosphorus is limiting algae biomass

(WDNR, 2013)

Table 2. Trophic State Index.

30-40	**Oligotrophic:** clear, deep water; possible oxygen depletion in lower depths; few aquatic plants or algal blooms; low in nutrients; large game fish usual fishery
40-50	**Mesotrophic:** moderately clear water; mixed fishery, esp. panfish; moderate aquatic plant growth and occasional algal blooms; may have low oxygen levels near bottom in summer
50-60	**Mildly Eutrophic:** decreased water clarity; anoxic near bottom; may have heavy algal bloom and plant growth; high in nutrients; shallow eutrophic lakes may have winterkill of fish; rough fish common
60-70	**Eutrophic:** dominated by blue-green algae; algae scums common; prolific aquatic plant growth; high nutrient levels; rough fish common; susceptible to oxygen depletion and winter fishkill
70-80	**Hypereutrophic:** heavy algal blooms through most of summer; dense aquatic plant growth; poor water clarity; high nutrient levels

(WDNR, 2013)

Researchers use various methods to calculate the trophic state of lakes. Common characteristics used to make the determination are: total phosphorus (important for algae growth), chlorophyll *a* concentration (a measure of the amount of algae present), and Secchi disk readings (an indicator of water clarity) (Shaw et al., 2004) (Table 3).

Table 3. Trophic classification of Wisconsin Lakes based on chlorophyll *a*, water clarity measurements, and total phosphorus values (Shaw et al., 2004).

Trophic class	Total phosphorus µg/L	Chlorophyll *a* µg/L	Secchi Disk (ft.)
Oligotrophic	3	2	12
	10	5	8
Mesotrophic	18	8	6
	27	10	6
Eutrophic	30	11	5
	50	15	4

Nitrogen

Nitrogen is second only to phosphorus as an important nutrient for aquatic plant and algae growth (Shaw et al., 2004). Human activities on the landscape greatly influence the amount of nitrogen in a lake. Nitrogen may come from lawn fertilizer, septic systems near the lake, or from agricultural activities in the watershed. Nitrogen may enter a lake from surface runoff or groundwater sources.

Nitrogen exists in lakes in several forms. North Lake was analyzed for total Kjeldahl nitrogen in April, 1995 (0.4 and 0.5 mg/L) and July, 2012 (0.66 mg/L); nitrate-nitrite in April, 1995 (0.013 and 0.056 mg/L) and July, 2012 (not-detected); and ammonium in April, 1995 (0.064 mg/L). Nitrogen is a major component of all organic matter. Decomposing organic matter releases ammonia, which is converted to nitrate if oxygen if present (Shaw et al., 2004). All inorganic forms of nitrogen can be used by aquatic plants and algae (Shaw et al., 2004). If these inorganic forms of nitrogen exceed 0.3 mg/L in spring, there is sufficient nitrogen to support summer algae blooms (Shaw et al., 2004). Elevated concentrations of ammonium, nitrate, and nitrite, derived from human activities, can enhance the development, maintenance and proliferation of primary producers such as phytoplankton, benthic algae, and marcrophytes. This contributes to the widespread phenomenon referred to as cultural eutrophication of aquatic ecosystems (Camargo et al., 2007). This kind of nutrient enrichment can cause important ecological effects on aquatic communities. For example, the overproduction of organic matter, and its subsequent decomposition, usually lead to low dissolved oxygen concentrations in bottom waters (Camargo et al., 2007). North Lake total nitrogen values are low or comparable to Wisconsin natural lakes (0.82 mg/L) and northeast Wisconsin lakes (0.66 mg/L).

Chloride

The presence of chloride (Cl^-) where it does not occur naturally indicates possible water pollution (Shaw et al., 2004). At the levels found in most Wisconsin lakes, chloride does not affect plant and algae growth and is not toxic to aquatic organisms Wisconsin (Shaw et al., 2004). Chloride for North Lake was 4.9 mg/L and 5.8 mg/L in April, 1995 which is slightly higher than the northeast Region (2 mg/L) and Wisconsin natural lakes (4 mg/L).

Sulfate

Sulfate in lake water is primarily related to the types of minerals found in the watershed, and to acid rain (Shaw et al., 2004). Sulfate concentrations are noted to be less than 10 mg/L in the Northeast region (Lillie and Mason, 1983). North Lake sulfate was measured April, 1995 (6 mg/L and 5 mg/L).

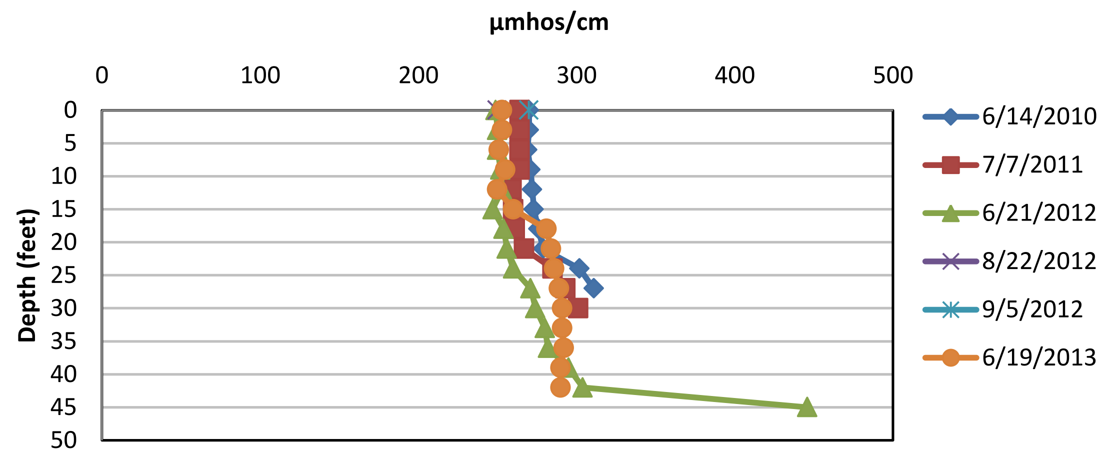
Conductivity

Conductivity is a measure of the ability of water to conduct an electric current. Conductivity is reported in micromhos per centimeter **(**µmhos/cm) and is directly related to the total dissolved inorganic chemicals in the water. Usually, values are approximately two times the water hardness, unless the water is receiving high concentrations of human-induced contaminants (Shaw et al., 2004). Conductivity depth profiles were measured from 2010 to 2013 (Figure 14).

Lake conductivity studies are conducted to determine if there are any faulty septic systems present which could be leaching excess nutrients into the lake. Low values of conductivity are characteristic of high-quality, oligotrophic (low nutrient) lake waters (GVSU, 2014). High values of conductivity are observed in eutrophic lakes where plant nutrients (fertilizer) are in great abundance (GVSU, 2014). Very high values are indicators of possible pollution sites (GVSU, 2014). A shoreline study compares conductivity levels found along the shoreline with those baseline levels found in the middle of the lake.

White Water biologist performed a shoreline conductivity study around the perimeter of North Lake (past Robbins Island) and also measured control points in the center of the lake. A comparison was made to the 1996 study conducted by MMA, Inc. A description and results of this study can be found in Appendix E.

Figure 14. North Lake conductivity, 2010-2013.



pH

The acidity level of a lake's water regulates the solubility of many minerals. A pH level of 7 is considered neutral. The pH level in Wisconsin lakes ranges from 4.5 in acid, bog lakes to 8.4 in hard water, marl lakes (Shaw et al., 2004). Natural rainfall in Wisconsin has an average pH of 5.6. Some minerals become more biologically available under low pH (especially aluminum, zinc, and mercury) and can inhibit fish reproduction and/or survival. Mercury and aluminum are not only toxic to many kinds of wildlife, but also to humans (especially those that eat mercury contaminated fish). The pH scale is logarithmic, so every 1.0 unit change in pH increases the acidity tenfold. Water with a pH of 6 is 10 times more acidic than water with pH of 7 and water with pH of 5 is 100 times more acidic than water with pH of 7. A lake's pH level is important for the release of potentially harmful substances and affects plant growth, fish reproduction and survival. A lake with neutral or slightly alkaline pH is a good lake for fish and plant vitality. North Lake is slightly alkaline with pH values above 7 in 1995, 2010, and 2012 (Figure 15). In June, 2013 the lake had a pH of 6.53, which is lower in comparison to the other years.

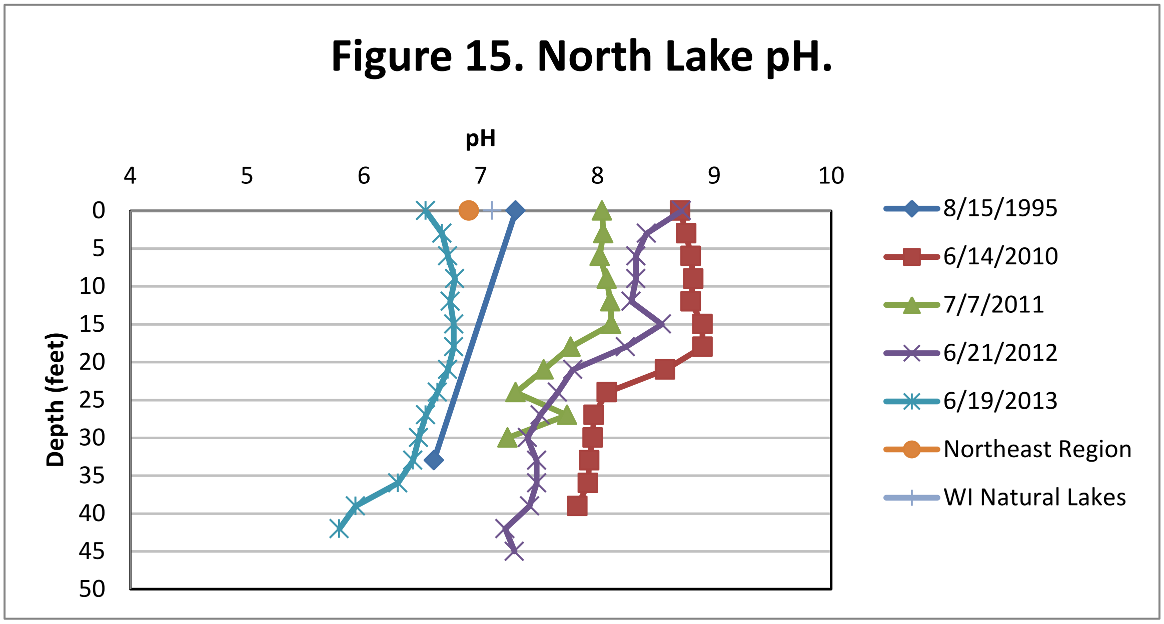


Table 4 indicates the effects pH levels less than 6.5 will have on fish. While moderately low pH does not usually harm fish, the metals that become soluble under low pH can be deleterious. In low pH waters, aluminum, zinc, and mercury concentrations increase if they are present in lake sediment or watershed solids (Shaw et al., 2004).

Table 4. Effects of acidity on fish species (Olszyk, 1980).

Water pH	*Effects*
6.5	Walleye spawning inhibited
5.8	Lake trout spawning inhibited
5.5	Smallmouth bass disappear
5.2	Walleye & lake trout disappear
5	Spawning inhibited in most fish
4.7	Northern pike, sucker, bullhead, pumpkinseed, sunfish & rock bass disappear
4.5	Perch spawning inhibited
3.5	Perch disappear
3	Toxic to all fish

Alkalinity

Alkalinity levels in a lake are affected by the soil minerals, bedrock type in the watershed, and frequency of contact between lake water and these materials (Shaw et al., 2004). Alkalinity is important in a lake to buffer the effects of acidification from the atmosphere. Acid precipitation has long been a problem with lakes that have low alkalinity levels. Alkalinity was sampled in North Lake in July, 2012 (115 mg/L). The mean for the Northeast Region is 37 mg/L. North Lake is not sensitive to acid rain based on its relatively high alkalinity level (Table 5).

Table 5. Sensitivity of Lakes to Acid Rain (Shaw et al., 2004)

Sensitivity to acid rain	*Alkalinity value (mg/L or ppm $CaCO_3$)*
High	0-2
Moderate	2-10
Low	10-25
Non-sensitive	>25

Hardness

Hardness levels in a lake are affected by the soil minerals, bedrock type in the watershed, and frequency of contact between lake water and these materials (Shaw et al., 2004). One method of evaluating hardness is to test for calcium carbonate ($CaCO_3$). With a hardness value of 120 mg/L in April, 1995, North Lake can be categorized has having “moderately hard water” bordering on “hard water” (Table 6).

Table 6. Categorization of hardness (mg/L of calcium carbonate ($CaCO_3$)) (Shaw et al., 2004).

Soft water	0-60
Moderately hard water	61-120
Hard water	121-180
Very hard water	>180

Calcium and Magnesium Hardness

The carbonate system provides acid buffering through two alkaline compounds: bicarbonate and carbonate. These compounds are usually found with two hardness ions: calcium and magnesium (Shaw et al., 2004). Calcium is the most abundant cation found in Wisconsin lakes. Its abundance is related to the presence of calcium-bearing minerals in the lake watershed (Shaw et al., 2004). Aquatic organisms such as native mussels use calcium in their shells. The aquatic invasive zebra mussel tends to need calcium levels greater than 20 mg/L to maintain shell growth. North Lake has calcium levels at 28 mg/L in April, 1995 and 25 mg/L in July, 2013. These are suitable for zebra mussels to thrive. Magnesium levels were 12 mg/L (1995) and 14.6 mg/L (2012). Average magnesium levels for the Northeast Region is 5 mg/L and for Wisconsin natural lakes is 7 mg/L.

Sodium and Potassium

Sodium and potassium are possible indicators of human pollution in a lake, since naturally occurring levels of these ions in soils and water are very low. Sodium is often associated with chloride and gets into lakes from road salting, fertilizers, and human and animal waste (Shaw et al., 2004). Potassium is the key component of commonly-used potash fertilizer, and is abundant in animal waste. Both sodium and potassium are held by soils to a greater extent than is chloride or nitrate; therefore, they are not as useful as indicators of pollution impacts (Shaw et al., 2004). Although not normally toxic themselves, they provide a strong indication of possible contamination by more damaging compounds (Shaw et al., 2004). Sodium was 2.6 mg/L in April, 1995. Potassium was also sampled in 1995, at 1.1 mg/L. Sodium and potassium values in 1995 are considered low.

Dissolved Organic Carbon

Dissolved Organic Carbon (DOC) is comprised of dissolved organic materials that nourish and support the growth of microorganisms. DOC plays an important role in global carbon cycle through the microbial loop (Kirchman et al., 1991). In general, organic carbon compounds are a result of decomposition processes of dead organic matter. When water contacts highly organic soils, these components can drain into rivers and lakes as DOC. DOC is also extremely important in the transport of metals in aquatic systems. Metals form extremely strong complexes with DOC, enhancing metal solubility while also reducing metal bioavailability. Base flow concentrations of DOC in undisturbed watersheds generally range from 1 to 20 mg/L carbon. North Lake DOC has not been tested, and could be included in future water quality sampling.

Silica

The earth's crust is abundant with silicates or other compounds of silicon. The water in lakes dissolves the silica and pH can be a key factor in regulating the amount of silica that is dissolved. Silica concentrations are usually within the range of 5 to 25 mg/L. Generally lakes that are fed by groundwater have higher levels of silica. Because silica data is unknown for North Lake, future water quality sampling could include measurement of this parameter.

Aluminum

Aluminum occurs naturally in soils and sediments. In low pH (acidic) environments aluminum solubility increases greatly. With a low pH and increased aluminum values, fish health can become impaired. This can have impacts on the entire food web. Aluminum also plays an important role in phosphorus cycling in lakes. When aluminum precipitates with phosphorus in lake sediments, the phosphorus will not dissolve back into the water column as readily. Because aluminum levels are unknown in North Lake, future water quality sampling could include measurement of this parameter.

Iron

In the presence of dissolved oxygen, iron forms sediment particles that bind with and store phosphorus. When oxygen concentration gets low (for example, in winter or in the deep water near sediments) the iron and phosphorus dissolve in water. This phosphorus is available for algal blooms. North Lake iron levels were 0.03 mg/L and 0.07 mg/L in April, 1995. These are considered low levels.

Manganese

Manganese is a mineral that occurs naturally in rocks and soil. In lakes, manganese is usually in particulate form. When the dissolved oxygen levels decrease, manganese can convert from an insoluble form to soluble ions. A manganese concentration of 0.05 mg/L can cause color and staining problems. Manganese was 0.037 mg/L in April, 1995.

Sediment

Lake bottom sediments are sometimes analyzed for chemical constituents that they contain. This is especially true for potentially toxic metals such as mercury, chromium, selenium, and others. Lake sediments also tend to record past events as particulates settle down and become part of sediment strata. Biological clues for the historic conditions in the lake can be gleaned from sediment samples. Examples include analysis of pollen or diatoms that might help understand past climate or trophic states in the lake. Sediment data has not been collected for North Lake, and future sampling could include this parameter.

Total Suspended Solids

Total suspended solids are all particles suspended in lake water. Silt, plankton, and wastes are examples of these solids and can come from runoff of agricultural land, erosion, and can be produced by the rooting of bottom-feeding fish such as carp. As the suspended solid levels increase, they absorb heat from sunlight which can increase the water temperature. They can also block the sunlight that plants need for photosynthesis. These events can affect the amount of dissolved oxygen in the lake. Lakes with total suspended solids levels less than 20 mg/L are considered “clear,” while levels between 40 and 80 mg/L are “cloudy.” No record of total suspended solids data in North Lake exists and future water quality sampling could include measurement of this parameter.

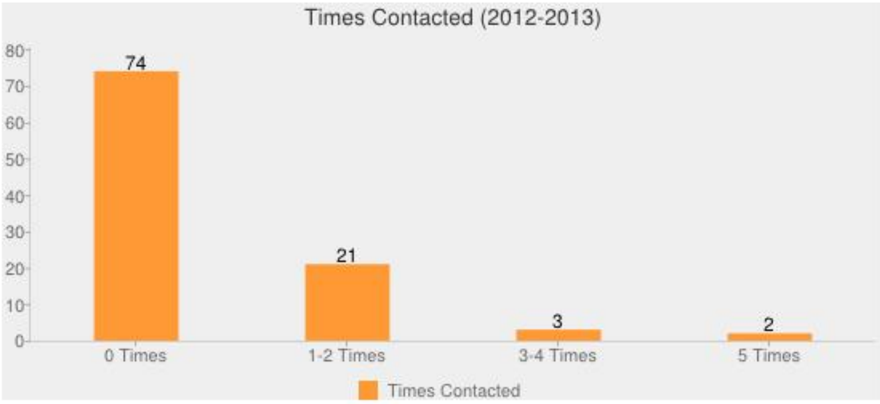
Aquatic Invasive Species

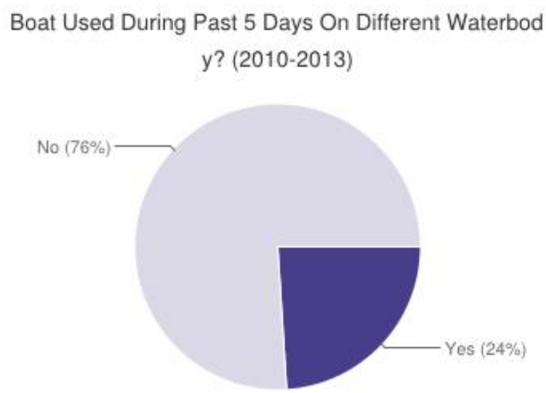
In the past five years, five aquatic invasive species (AIS) with significant populations have been recorded in North Lake: (1) rusty crayfish (*Orconectes rusticus*) discovered in 2008, (2) banded mystery snail (*Viviparus georgianus*) discovered in 2009, (3) freshwater jellyfish (*Craspedacusta sowerbii)* discovered in 2009, (4) zebra mussels (*Dreissena polymorpha*) discovered in 2010, (5) and Eurasian water-milfoil (*Myriophyllum spicatum)* discovered in 2012. It was also noted in the 2012 point-intercept study that pink water lily (*Nymphaea odorata*) was observed. This is one of many cultivated color-variations of the native white water lily. Although it is not technically an invasive species, it is not native to northern Wisconsin lakes and was likely planted by someone into the lake. Also observed in the 2012 point-intercept study was European marsh thistle (*Cirsium palustre*). This thistle is considered a *Restricted* wetland/terrestrial species in Wisconsin. For more information about the invasive species present in North Lake, see Appendix K, *North Lake Invasive Species,* of the North Lake Adaptive Management Plan.

Clean Boats Clean Waters (CBCW) is a program that inspects boats for aquatic invasive species and in the process educates the public on how to help stop the spread of these species. At the North Lake public access site, 397 boats were inspected in 2012 and 459 boats were inspected in 2013 (Figure 16-18). Since 2005, 4,876 people have been contacted by a CBCW attendant at North Lake. Continuation of the CBCW program on North Lake is very important because of the invasive species present. This serves a dual purpose: (1) to protect North Lake against introduction of new AIS, and (2) to protect other regional lakes from AIS that are carried on boats and equipment from North Lake. Because the only access to the Spread Eagle Chain of Lakes is through North Lake, having a CBCW representative at the access is essential to the future health of the entire Spread Eagle Chain of Lakes.

Figure 16. Clean Boats Clean Waters North Lake (WDNR, 2014).

Figure 17. Clean Boats Clean Waters North Lake (WDNR, 2014).





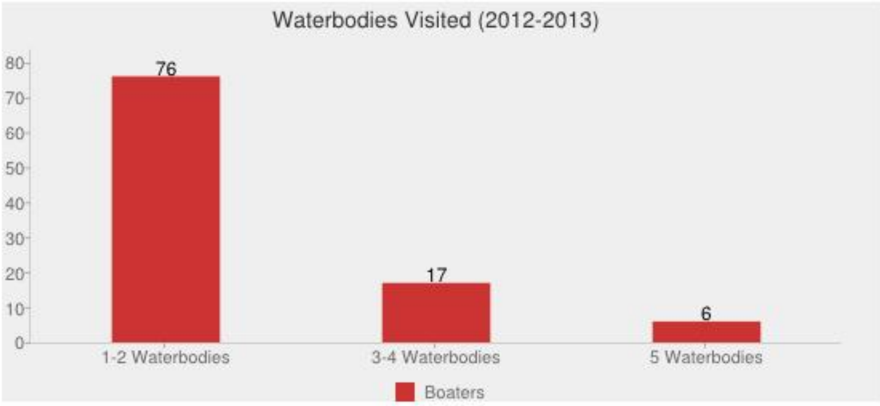
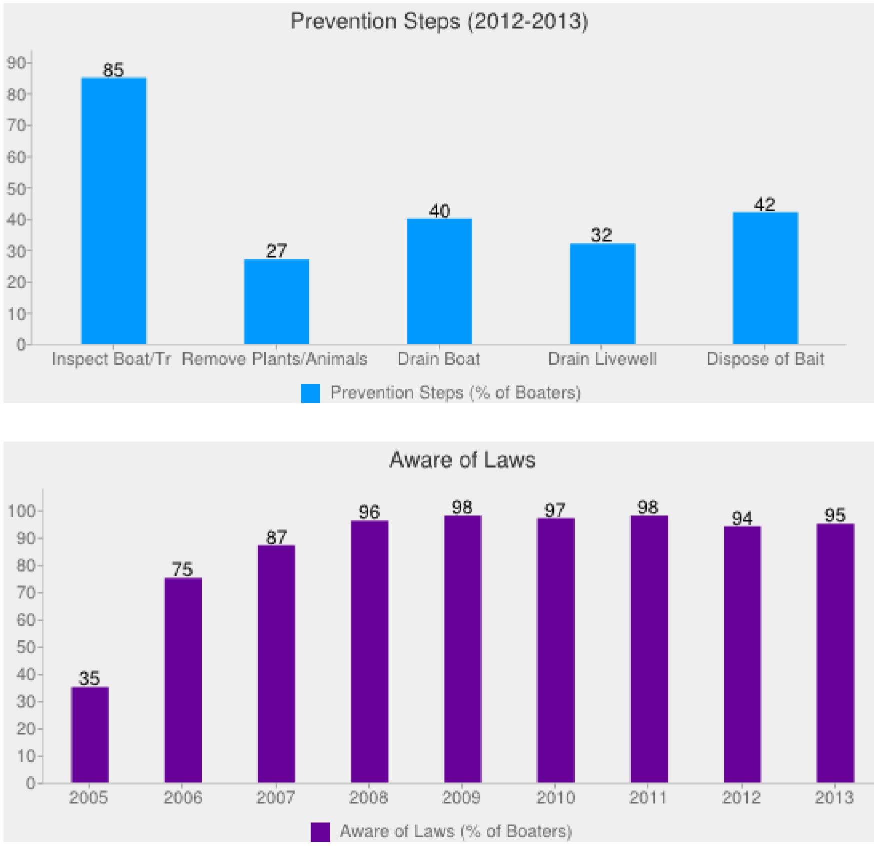


Figure 18. Clean Boats Clean Waters North Lake (WDNR, 2014).



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WHITE WATER ASSOCIATES, INC.

Appendix D
North Lake Watershed, Water Quality, and WiLMS Modeling

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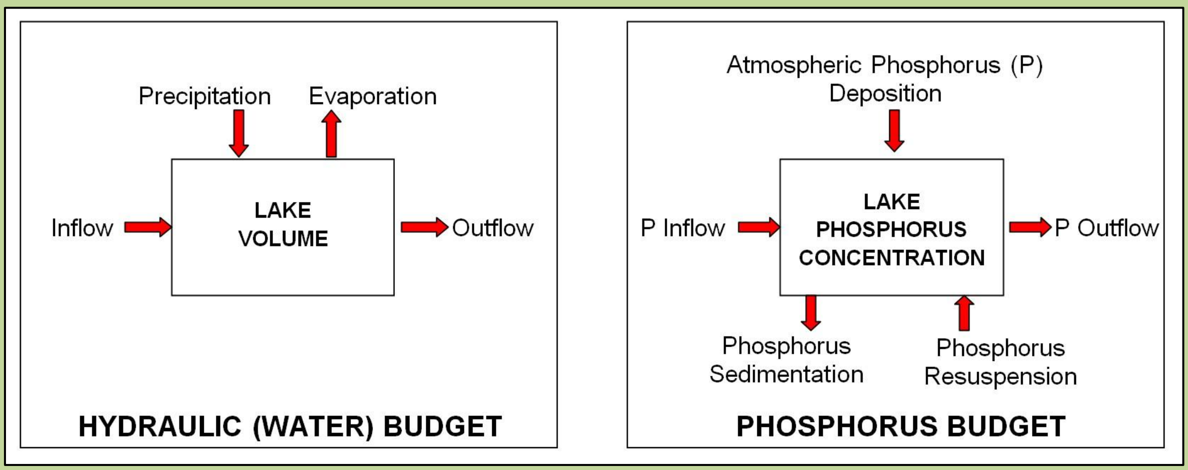
White Water Associates, Inc.

Watershed, Water Quality, and WiLMS Modeling

Freshwater algae and rooted aquatic plants (macrophytes) require a number of nutrients in order to grow. Two of these nutrients, phosphorus and nitrogen, are often present in small amounts and limit algae and macrophyte growth. In fact, phosphorus is the nutrient that most often limits the growth of aquatic plants in freshwater systems and, when present in high concentrations, is most often responsible for algal blooms, rampant growth of rooted plants, and lake eutrophication. This is the reason that phosphorus is a large focus when it comes to concerns of lake water quality.

The water (hydraulic) budget of a lake is closely associated with the phosphorus budget (both illustrated in Figure 1). The graphics show in general terms the overall movement of water and phosphorus into and out of a lake ecosystem.

Figure 1. Hydraulic (water) and phosphorus budgets in lakes.



Modified from Brylinsky (2004)

Several interrelated factors are at play when it comes to the water quality of a lake. These include water source, watershed size, retention time, watershed cover types, and internal loading. Because each lake and its watershed have unique characteristics and interactions, no two lakes behave in exactly the same way. Nevertheless, being familiar with these factors and how they interrelate is helpful for lake planning and stewardship.

The sources of water for a lake strongly influence the lake's water quality because the water carries with it nutrients such as phosphorus. The four water sources include precipitation, runoff from the surrounding land, upwelling groundwater, and inflow from a stream. The relative importance of each of these sources depends on several things. For example some lakes have no incoming stream, so these lakes depend on precipitation, runoff, and groundwater. A lake with a small drainage basin (watershed) receives relatively less water as runoff. Water can leave a lake through an outflow, evaporation, and groundwater seeping back into the aquifer (water table).

Water source is the factor that lake scientists use to classify lakes into four categories (Shaw et al., 2004). A “seepage lake” is fed by precipitation, limited runoff, and groundwater and has no inlet or outlet. A “groundwater drainage lake” is fed by groundwater, precipitation, and limited runoff and has a stream outlet. A “drainage lake” is fed by one or more streams, groundwater, precipitation, and runoff and has a stream outlet. Finally, an “impoundment” is a manmade lake formed by damming a stream and is also drained by a stream. When water comes into a lake from its various sources, it also carries other materials to the lake. Some of these are dissolved in the water (like phosphorus, nitrogen, and calcium). Some of the materials are suspended in the water (like silt and small bits of detritus). Precipitation (rain and snow) also carries with it dissolved and suspended materials to the lake (acid precipitation and dust are examples).

The size of a lake’s watershed (drainage basin) relative to the lake’s surface area is important in determining the amount of nutrients and other materials that come into the lake (Shaw et al., 2004). This ratio of drainage basin area to lake area is a measure of how important the watershed is as the lake’s source of water, nutrients (like phosphorus), and other materials. A higher DB/LA ratio means the watershed is relatively more important and runoff contributes more water and nutrients to the lake. With their small watersheds, seepage lakes receive fewer nutrients from runoff than drainage lakes and tend to be higher in water quality.

Another important concept in a lake’s water and nutrient “budget” (that is, inputs and outputs) is “retention time” (also called “water residence time”), the average length of time that water stays in the lake. This is determined by a lake’s size (volume), water sources, and watershed size. For some lakes and impoundments, retention time can be quite short (days or weeks). In other lakes, retention time can be as long as decades or centuries. Retention time also indicates how long nutrients stay in the lake. In short retention time lakes, nutrients are flushed through the system rather quickly. In long retention time lakes, nutrients stay around a longer time and can move into the sediments where they become a long-term part of the lake’s chemistry.

The type of land cover (for example, forest, grassland, row crops, or human development) is also an important variable in determining amounts and kinds of materials (like nutrients and sediment) that are carried off the land and into the water. This is especially important close to the lake (the riparian area), but the entire watershed is a contributor and we often map the cover types and measure their acreages to give us some idea of how at risk the lake might be to receiving unwanted materials. Certain kinds of agriculture (tilled row crops) and urban areas (with their impervious surfaces) have a tendency to give up sediments and nutrients to runoff. In contrast, native vegetation (forests, wetlands, and grasslands), tend to slow runoff of water and nutrients, allowing the soil to absorb them. When excessive nutrients and sediment reach a lake they can cause increased growth of aquatic plants, algal blooms, and reduced water clarity.

The DB/LA (drainage basin/lake area) ratio interacts in an interesting way with drainage basin cover type when it comes to nutrient runoff to a lake. For lakes where the ratio is relatively high (greater than 15:1), the role of drainage basin size in delivering water and nutrients to the lake tends to dominate the role of cover type. In small ratio lakes, the kind of cover type on the watershed has the greater influence than the absolute size of the watershed. For these small DB/LA ratio lakes maintaining or restoring good quality native cover type in the watershed will likely have a positive and observable influence on the lake.

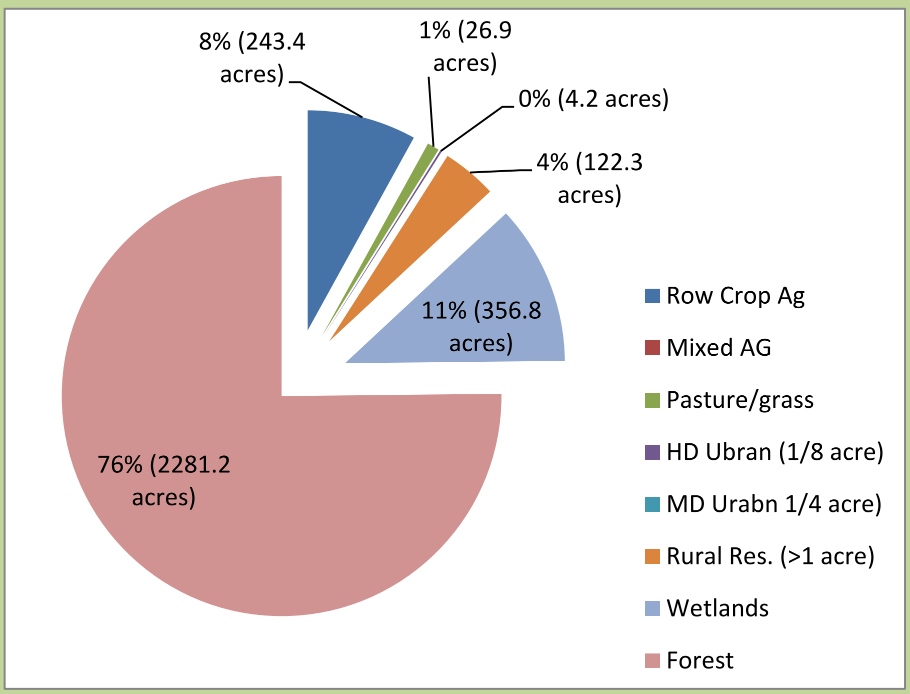
Internal loading refers to phosphorus (and other nutrients) that are present in the lake bottom sediment. Some of the phosphorus in a lake ecosystem continually falls to the bottom and becomes part of the sediment layer and is generally unavailable for plants. Under conditions of low dissolved oxygen, however, this phosphorus can go back into the water column and be taken up by algae and macrophytes. The amount of phosphorus contained in the sediment can be quite high, resulting from centuries of deposition. The phenomenon of internal loading can therefore make available a large amount of phosphorus to the algae and plants of the lake and typically happens at spring and fall overturn periods. Even if sources of phosphorus outside of the lake are reduced, the internal loading can still enrich the lake and cause eutrophic conditions.

Because it is often challenging to work out how these several factors interact to influence the water quality of a specific lake, the Wisconsin Department of Natural Resources developed the "Wisconsin Lake Modeling Suite" (WiLMS) as a lake water quality planning tool (WDNR, 2003). WiLMS is a computer program into which the user enters information about the lake (e.g., surface area, depth, and nutrient measures) and the watershed (e.g., acreage and cover type). The model also has information about average rainfall, aerial deposition of materials, and cover type characteristics that it uses to help predict nutrient (phosphorus) loading scenarios to the lake.

In this project, we applied the WiLMS models to North Lake. The 79.2 acre lake has a watershed of 3,034.90 acres and a drainage basin/lake area ratio of about 38 to 1. This is a relatively high ratio. Lakes with this size ratio usually have significant surface water inflow and inputs of more nutrients and sediments to lakes. Water quality problems can result. Perhaps because of the preponderance of forest and wetland cover types in its watershed (see below); North Lake does not seemed to be influenced by excessive nutrients. It is classified as oligotrophic, although it borders on mesotrophic. North Lake volume is 1,309.7 acre-feet and the mean lake depth is 16.54 feet. The WiLMS model calculates the annual runoff volume as 3,464.8 acre-feet and the annual difference between precipitation and evaporation (precipitation minus evaporation) as 5.6 inches. The hydraulic loading for North Lake is 3,501.8 acre-feet per year and the areal water load is 44.2 feet per year. The WiLMS model calculates the annual lake flushing rate as 2.67 times per year and the water residence time (retention time) as 0.37 year.

The cover types in the North Lake watershed are shown in Figure 2 with their respective acreages. Forest cover type is the predominant land cover at 76%. Wetland cover is also important, comprising about 12% of the watershed.

Figure 2. North Lake watershed land cover types.



Note: the “wetlands” category also includes the surface area of the lake.

Table 1 presents output from the WiLMS model for non-point source phosphorus input to North Lake. No point-source data is available for North Lake. The WiLMS model indicated that 216.4 kg (477.1 pounds) of phosphorus are most likely delivered to the lake each year from watershed runoff and from direct deposition onto the lake surface (via precipitation and airborne particles). The WiLMS model predicts that most of the phosphorus delivered to North Lake comes from row crop agriculture, even though this cover type is not the dominant cover type in the watershed.

Table 1. WiLMS estimated non-point source phosphorus loading based on watershed land use type and acres.

Land Use	Land Use Acres	Loading (kg/ha-year)				Loading kg/year		
		Low	Most Likely	High	Loading %	Low	Most Likely	High
Row Crop Ag.	243.4	0.5	1	3	45.5	49	98	295
Mixed Agricultural	0	0.3	0.8	1.4	0	0	0	0
Pasture/Grass	26.9	0.1	0.3	0.5	1.5	1	3	5
High Density Urban (1/8 acre)	4.2	1.0	1.5	2	1.2	2	3	3
Mid Density Urban (1/4 acre)	0	0.3	0.5	0.8	0	0	0	0
Rural Residential (>1 acre)	122.3	0.05	0.1	0.25	2.3	2	5	12
Wetlands	356.8	0.1	0.1	0.1	6.7	14	14	14
Forest	2281.2	0.05	0.09	0.18	38.4	46	83	166
Lake Surface	79.2	0.1	0.3	1	4.4	3	10	32
				Totals	100.0	117	216	527

The WiLMS generated an estimate of internal loading of phosphorus. These data are presented in Table 2. The model predicts that about -93 pounds (-42 kg) of phosphorus are released each year from North Lake sediments. This negative number reveals that this amount of phosphorus is actually being stored in the sediment and not available for aquatic plant and algae growth. The model calculates a predicted phosphorus retention coefficient as 0.48 (this represents the fraction of phosphorus entering the lake that is lost by settling to the sediment). The observed phosphorus retention coefficient is 0.67 indicating that the availability of phosphorus is less than the predicted value. These data are consistent with other measures and observations that indicate that North Lake is oligotrophic/border mesotrophic.

Table 2. WiLMS Method 1 – Complete Phosphorus Mass Budget.	
Parameter	**Value**
Phosphorus Concentration of Lake (input into model)	16.44 mg/m^3
Phosphorus Inflow Concentration	50.1 mg/m^3
Areal External Loading	675.2 mg/m^2-year
Predicted Phosphorus Retention Coefficient *(the predicted fraction of phosphorus entering the lake that is lost by settling to the sediment)*	0.48
Observed Phosphorus Retention Coefficient	0.67
Internal Load (amount released annually from the sediment)	-93 pounds (-42kg) *

**Note, this negative number indicates that phosphorus is being retained in the sediment*

The WiLMS also allow us to manipulate the cover type acreages as an illustration of how watershed cover can influence the delivery of phosphorus to a lake. As an example, we re-ran the non-point source data model, but altered landscape composition to simulate the effect of converting 200 acres of the forest cover type to row crop agriculture. The results are dramatic as the most likely total kilograms of phosphorus delivered to the lake from non-point source was calculated at 293 kg (compare to the 216 kg under the actual conditions in the watershed).

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Appendix E
North Lake Conductivity and Sediment Studies, 1996 and 2012

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WHITE WATER ASSOCIATES, INC.

North Lake Conductivity and Sediment Studies, 1996 and 2012

In this appendix, we provide results and comparisons of the 1996 and 2012 North Lake conductivity and sediment studies. In February, 1996, consultants MMA, Inc. performed conductivity and sediment studies around the shoreline of North Lake (including the area south of Robbins Island). White Water Associates, Inc. performed the 2012 conductivity and sediment studies around the same perimeter of North Lake. Results and comparisons of the conductivity and sediment studies are provided in this appendix.

North Lake Conductivity Study

Introduction

Conductivity is the measure of the water's ability to conduct an electric current (Shaw et al., 2004). It depends on ions (such as chloride, calcium, potassium or iron) in the water. The more ions present, the higher the conductivity. A lake's natural conductivity is influenced by the geology and soils the watershed. Minerals that leach from the bedrock and soils enter the lake through runoff and contribute to conductivity. Human activities also affect lake water conductivity. When elevated or increasing conductivity is observed in a lake, it can be due to human activity such as road salting, faulty septic systems, urban runoff, or agricultural runoff. New construction that alters runoff patterns and exposes new soil and bedrock areas can also contribute to elevated conductivity. Conductivity is also influenced by temperature. As water temperature increases, conductivity increases (EPA, 2012).

Lake conductivity studies are sometimes conducted to determine if there are any faulty septic systems or other pollution sources present that could be delivering excess nutrients into the lake. Low values of conductivity are characteristic of high-quality, oligotrophic (low nutrient) lake waters (GVSU, 2014). High values of conductivity are observed in eutrophic lakes where plant nutrients (fertilizers) are in great abundance (GVSU, 2014). Very high values are indicators of possible pollution sites (GVSU, 2014). A shoreline study compares conductivity levels found along the shoreline with those baseline levels found in the middle of the lake.

Procedure

White Water biologists conducted the study via boat on August 22, 2012. They began at the boat landing and collected water samples for conductivity reading approximately every 100 feet around the shoreline. The objective was to collect a set of data in a similar manner to that collected in the 1996 survey so the two data sets could be compared. In 2012, there were 78 points around the shoreline. Eight points were positioned in the middle of the lake to establish a mid-lake control value for conductivity in North Lake. The perimeter points would later be evaluated against the control data. Water samples were analyzed using a Myron Ultrameter II 6P conductivity meter. At each sample site, conductivity level and global positioning system (GPS) coordinates (latitude/longitude) were recorded. In addition to the conductivity data collected at each point, sediment depth data was collected. Results of the sediment study are at the end of this appendix.

Results

The seventy-eight 2012 sampling points and eight control sites are displayed in Figure 1. Conductivity values for the North Lake shoreline points ranged from 244.7 µmhos/cm to 256.7 µmhos/cm (a range of 12 µmhos/cm). The eight control points had a mean conductivity of 249.8 µmhos/cm. The standard deviation of these points was 0.9. The confidence interval (at 95%) was ±0.615. Any shoreline measured value that was within the range of the confidence interval (249.8±0.615 or 249.1 to 250.4) was not statistically different than the control value mean. In 2012, there were 44 sites that fell below the 95% confidence interval and 15 that were above it. Of these high conductivity shoreline sample sites, five (sites 27-31) exceeded the control mean value by 6.0 µmhos/cm. Two sites (sites 1 and 2) exceeded the control value by 4-5+ µmhos/cm. These sites can be seen in Figure 1.

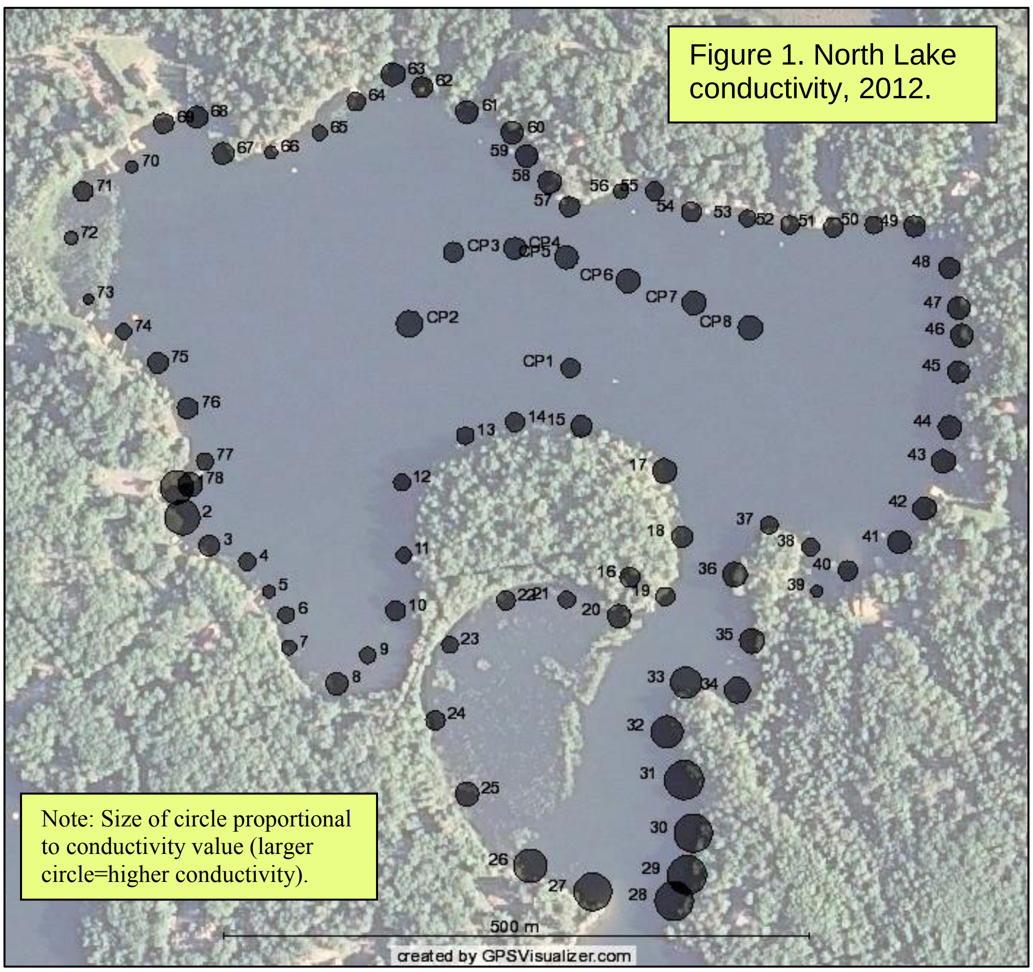

Figure 1. North Lake conductivity, 2012.

In February, 1996 a conductivity study was completed by MMA, Inc. consultants. In this study, there were 101 points sampled around the perimeter of the lake and four control points in lake's center (Figure 2). Although 1996 and 2012 studies differed in the number of points, some comparisons are possible.

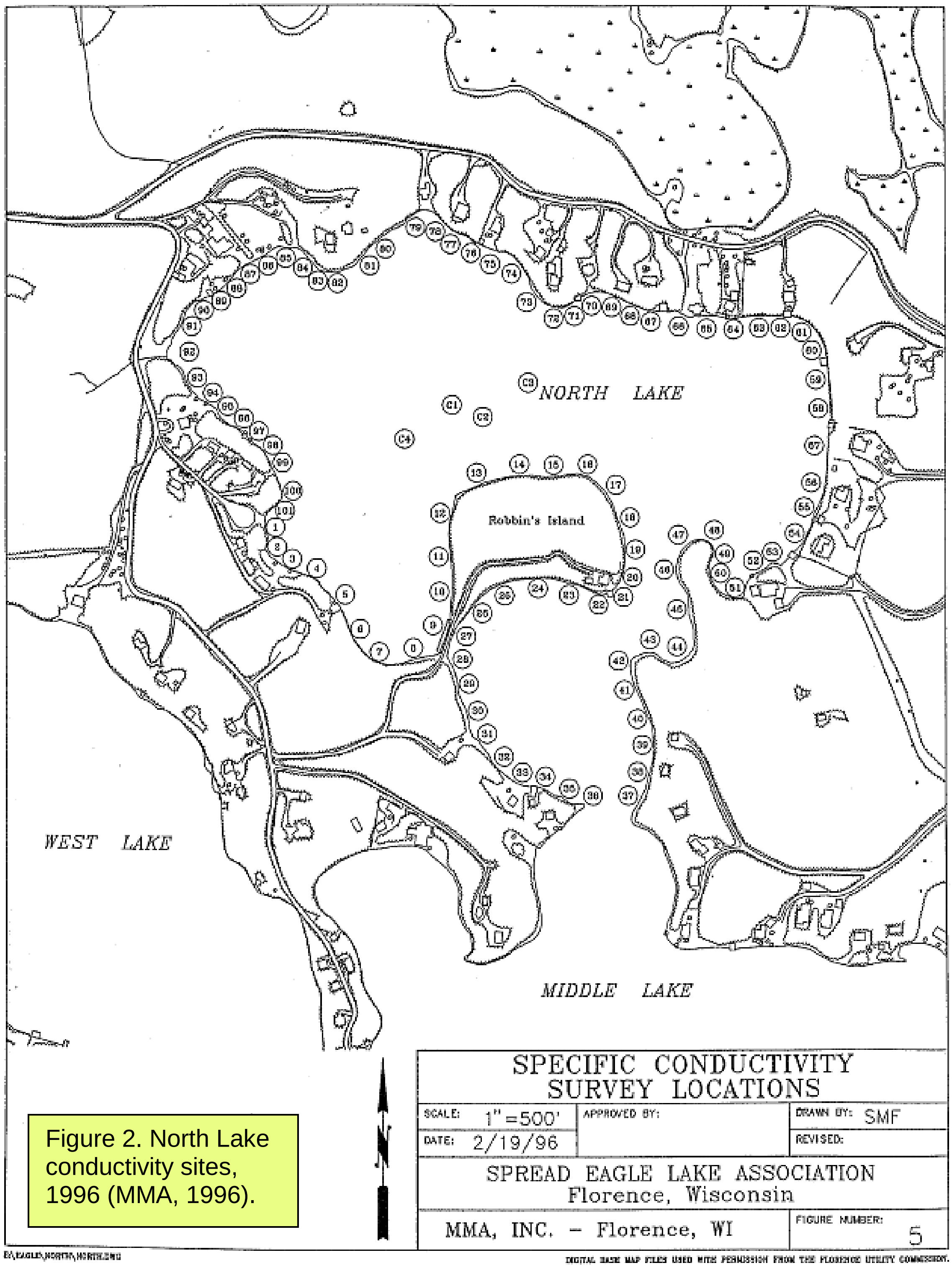

Figure 2. North Lake conductivity sites, 1996 (MMA, 1996).

In 1996, conductivity readings ranged from 213.0 µmhos/cm to 235.0 µmhos/cm (MMA, 1996). This was range of values was considerably greater than the 2012 range and this variability is documented by a greater standard deviation of the mean values (STD for 2012=2.68; STD for 1996=5.35). The 2012 and 1996 data sets were statistically different (0.05 level of significance) with the mean conductivity value in 1996 (227.3 µmhos/cm) 22 units lower than the mean value for 2012 (249.3 µmhos/cm). This difference could reflect a real environmental difference or a difference in the conductivity meters used.[1] In 1996, the mean control site value (four sites) was 226 µmhos/cm (MMA, 1996). This value was also much lower than the mean control site value in 2012 (249.8 µmhos/cm). The standard deviation of the control points was 4.8 (MMA, 1996).

The 95% confidence interval for the mean control value in 1996 was 221.6 µmhos/cm to 230.9 µmhos/cm. In 1996, there were 19 sites with conductivity values less than the confidence interval range and 40 that had higher values. Similar to 2012, some 1996 sample sites had conductivity values that exceeded the mean control site value by as much as 6.0µmhos/cm. These sites were located at the south end of the lake (site 37), along the east shoreline of the lake (49, 54-57), in the northeast corner of the lake (63), along the northwest edge of the lake (78, 80, 83, 85), and slightly north of the boat access (98, 100). These locations can be seen in Figure 2.

The data indicate an increase in overall conductivity values has occurred between 1996 and 2012 (Figure 3), but we cannot confidently conclude this without knowledge of the type and accuracy of the conductivity meter used in 1996. It is interesting to note that, like the 2012 study, the 1996 study revealed sites with higher-than-average conductivity levels. Even though different conductivity meters may have been used, these differences are real (since the within-year readings were done by the same meter and relative differences are accurate). It's possible these areas with increased conductivity levels are caused by runoff of materials (for example, lawn fertilizers or road salts) into the lake. A hopeful observation is that fewer of these high conductivity sites existed in the 2012 study than in the 1996 study. This might reflect some improvement with regard to shoreline buffer areas, but would need to be field checked. The relatively higher values found in 2012 at sites 1 and 2 (in front of the boat landing) may indicate some runoff from the boat landing into North Lake.

[1] *The 1996 study did not report the type of conductivity meter used. Conductivity is influenced by water temperature. The meter used in the 2012 study was a temperature-compensated unit, but it is unknown whether the 1996 meter took temperature into consideration with its readings.*

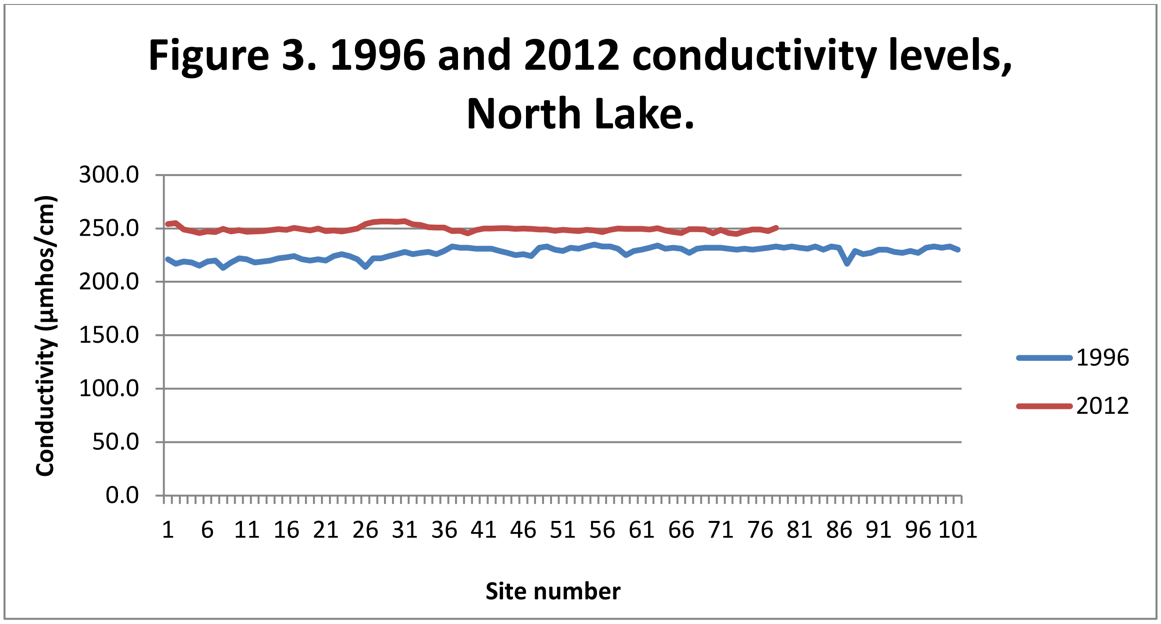

Figure 3. 1996 and 2012 conductivity levels, North Lake.

Discussion

Elevated conductivity readings are typically due to human activity such as road salting, faulty septic systems, and agricultural runoff. The following are things riparian landowners can do to minimize the potential for increasing conductivity:

1. Limit soil disturbance and bedrock exposure on your property
2. Create vegetative buffers to filter and reduce the amount of storm water runoff from your property
3. Replace a conventional beach to a natural beach
4. Pump your septic system tank once every one to three years
5. Replace or upgrade a failing leach field immediately
6. Discuss alternatives to road salt use near the lake and its tributaries

A future conductivity study conducted with an accurate, temperature-compensated meter would provide insight as to whether conductivity values in North Lake are changing over time.

Literature Cited

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North Lake Sediment Study

Introduction

A sediment study was conducted in conjunction with the North Lake conductivity study. Determining lake sediments allows scientists to study past climate and environmental changes, understand the impact of benthic habitat on lake fisheries and other biological communities, and provide insight about trends in sedimentation (NOAA, 2014).

Procedure

Since the conductivity and sediment studies were conducted simultaneously, the same 78 sample sites were used in both studies. White Water biologists stopped approximately every 100 feet to collect a sediment reading. A fiberglass sounding pole was gently lowered to the top of the sediment surface and this was recorded as the "depth to sediment surface." Then, the pole pushed further into the sediment until firm substrate was encountered (great resistance to pushing the rod any deeper). This depth was recorded as "depth to firm substrate." If the rod went past 12 feet, it was noted as "12+." White Water biologists also characterized the general substrate type ("m-muck," "s-sand," "g-gravel" or "c-cobble"). Muck is defined as well decomposed accumulated organic sediment, with a low content of plant fiber relative to bulk density.

Results

Sediment depths (differences of depth to firm substrate and depth to sediment surface) were categorized as: 0-5.99 inches, 6-11.99 inches, 12-23.99 inches, 24-36 inches, and 36.1+ inches. Table 1 provides the 2012 sediment data. Figure 1 shows the variation in sediment depths in North Lake. The majority of sediment found in North Lake was 0-5.99 inches deep, followed by 36.1+ inches deep.

Table 1. Sediment Depth and Type for the 2012 Study on North Lake.

Site Number	Sediment Depth (ft)	Substrate Type		Site Number	Sediment Depth (ft)	Substrate Type
1	8.8	m		40	0	c
2	3	m		41	0.1	s
3	0.1	m		42	0.1	s
4	4.5	m		43	0.4	s-g
5	5.3	m		44	0.1	s-c
6	4	m		45	0	s-c
7	5.5	m		46	0.1	s-g
8	3.5	m		47	0	s-g
9	5	m		48	0	s-c
10	2.5	m		49	0	s
11	3	m		50	0	s
12	4	m		51	0	s
13	1.5	m		52	0.5	s
14	1	s		53	2.5	m
15	0.4	s-g		54	0.3	s
16	0.5	s-g		55	0.9	s-m
17	0.5	s-g		56	0.3	s-g
18	0.5	s-c		57	0.2	s-c
19	3	s-m		58	0.1	s
20	2.5	m		59	0.3	s
21	6	m		60	0.6	s-m
22	11	m		61	1.1	s-m
23	9.2	m		62	1	m
24	8	m		63	6.2	m
25	12	m		64	3.7	m
26	0	s		65	0.1	s
27	0.1	s		66	0	s
28	1	s-m		67	1.3	m
29	3.5	s-m		68	7.6	m
30	1.8	s-m		69	1.8	m
31	1.5	s-m		70	2.9	m
32	0.2	s		71	10.8	m
33	1	s-m		72	9.5	m
34	6	m		73	8.5	m
35	0	s-g		74	0.3	s-m
36	0	c		75	0.5	s
37	0	c		76	0.2	s
38	1	s		77	0.5	s
39	7.5	m		78	7.4	m

Substrate Types: "m=muck," "s=sand," "g=gravel" or "c=cobble"

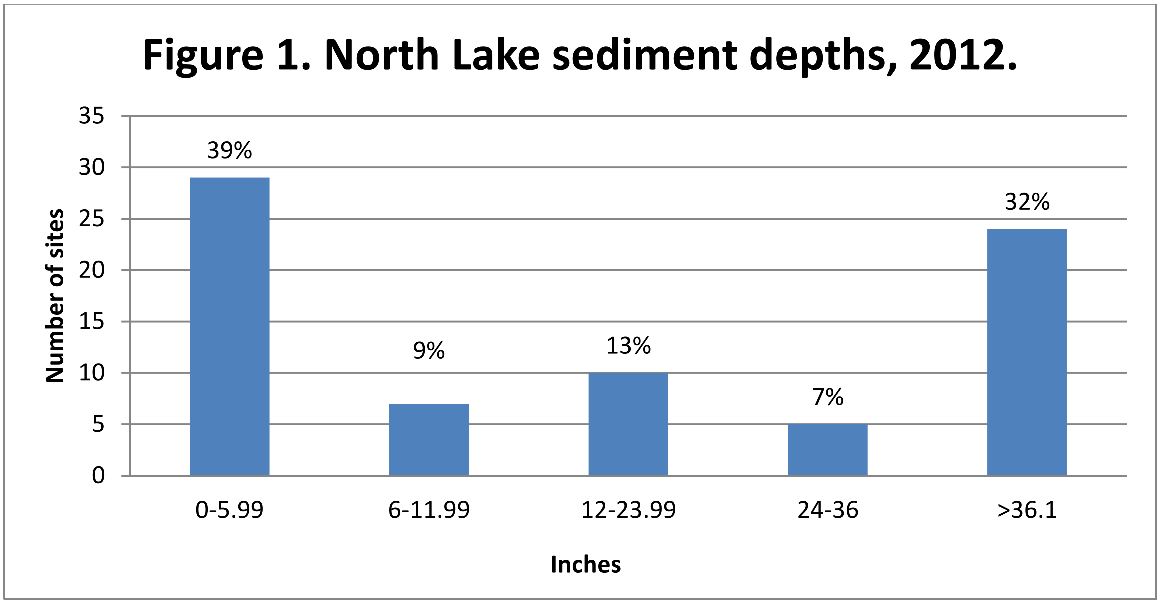


Figure 2 displays the types of sediments observed in North Lake. If a site was recorded as "sand/gravel," both sand and gravel were counted as a sediment type. Sand and muck were the two most dominant sediments found in North Lake.

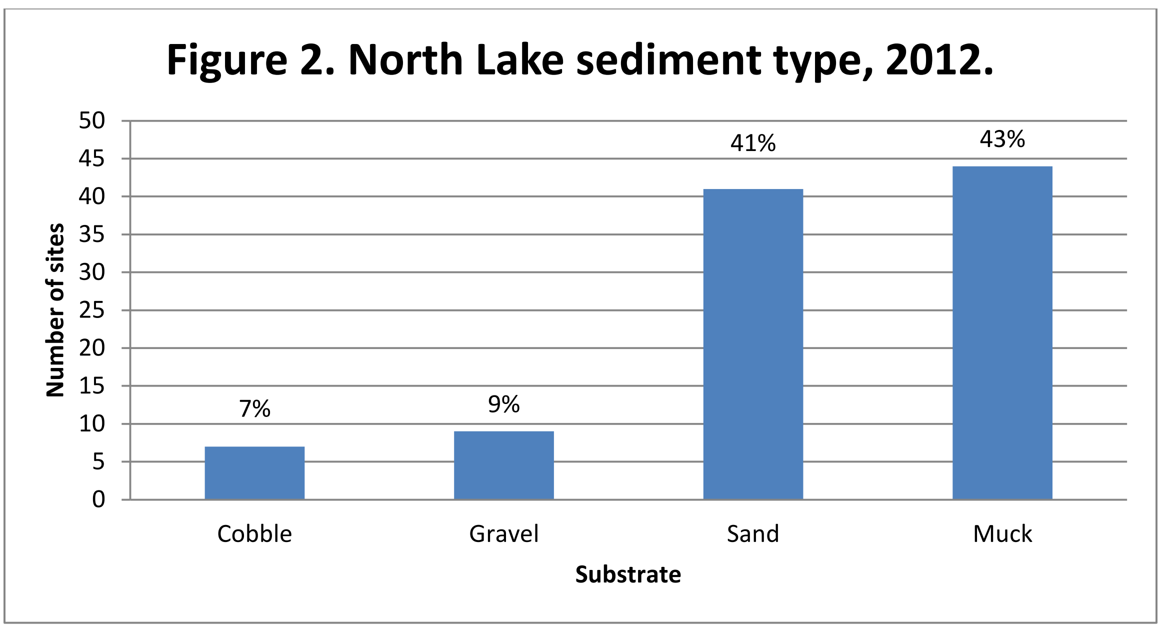


Figure 3 displays the sediment depths observed in North Lake in 2012. Locations where sediment was deepest (>3 feet) include: the boat landing, on the south side of Robbins Island, and in the northwest bay of the lake, and other small bays around the lake. These areas are generally protected from wind and boating traffic and support dense vegetation.

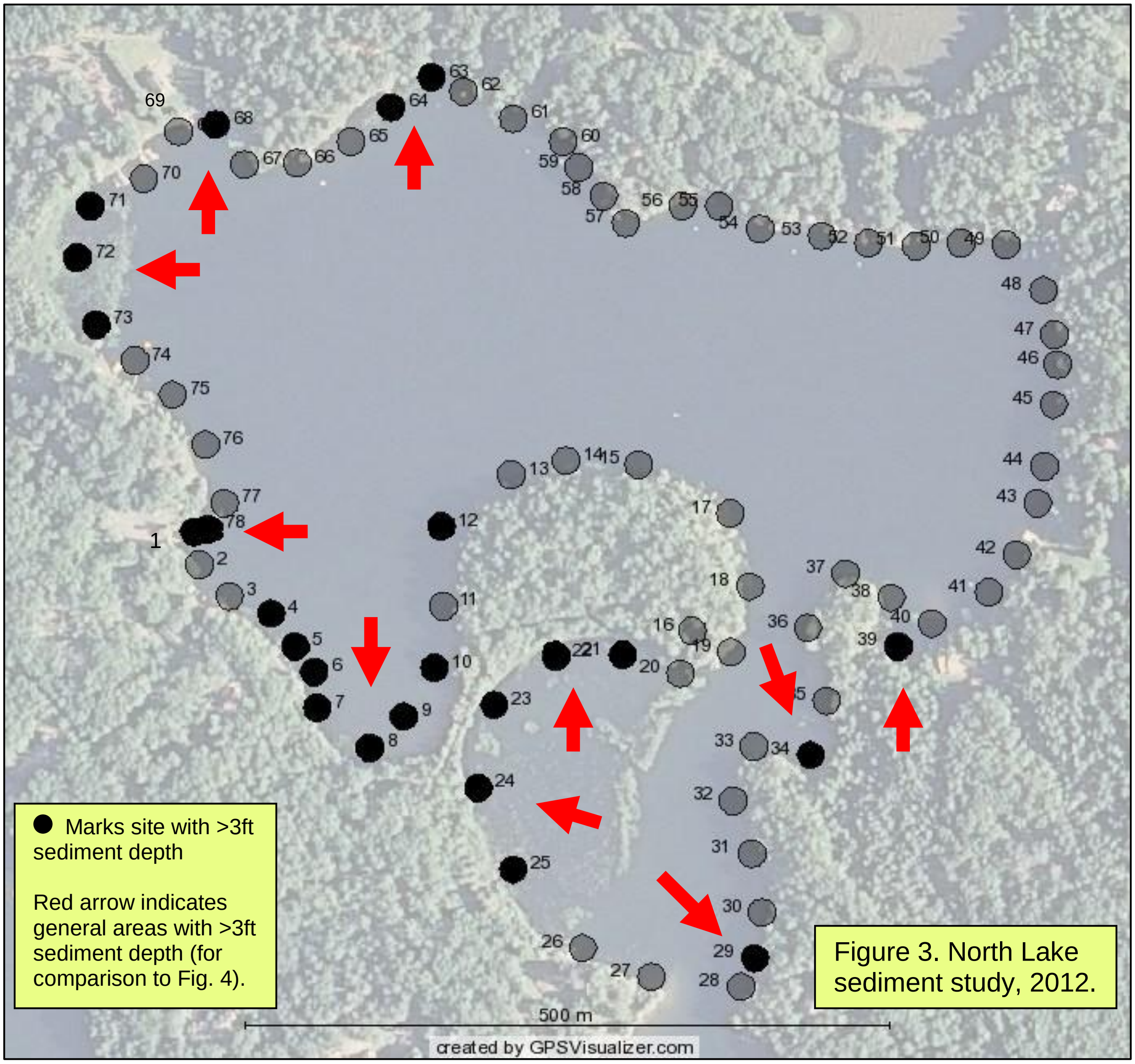
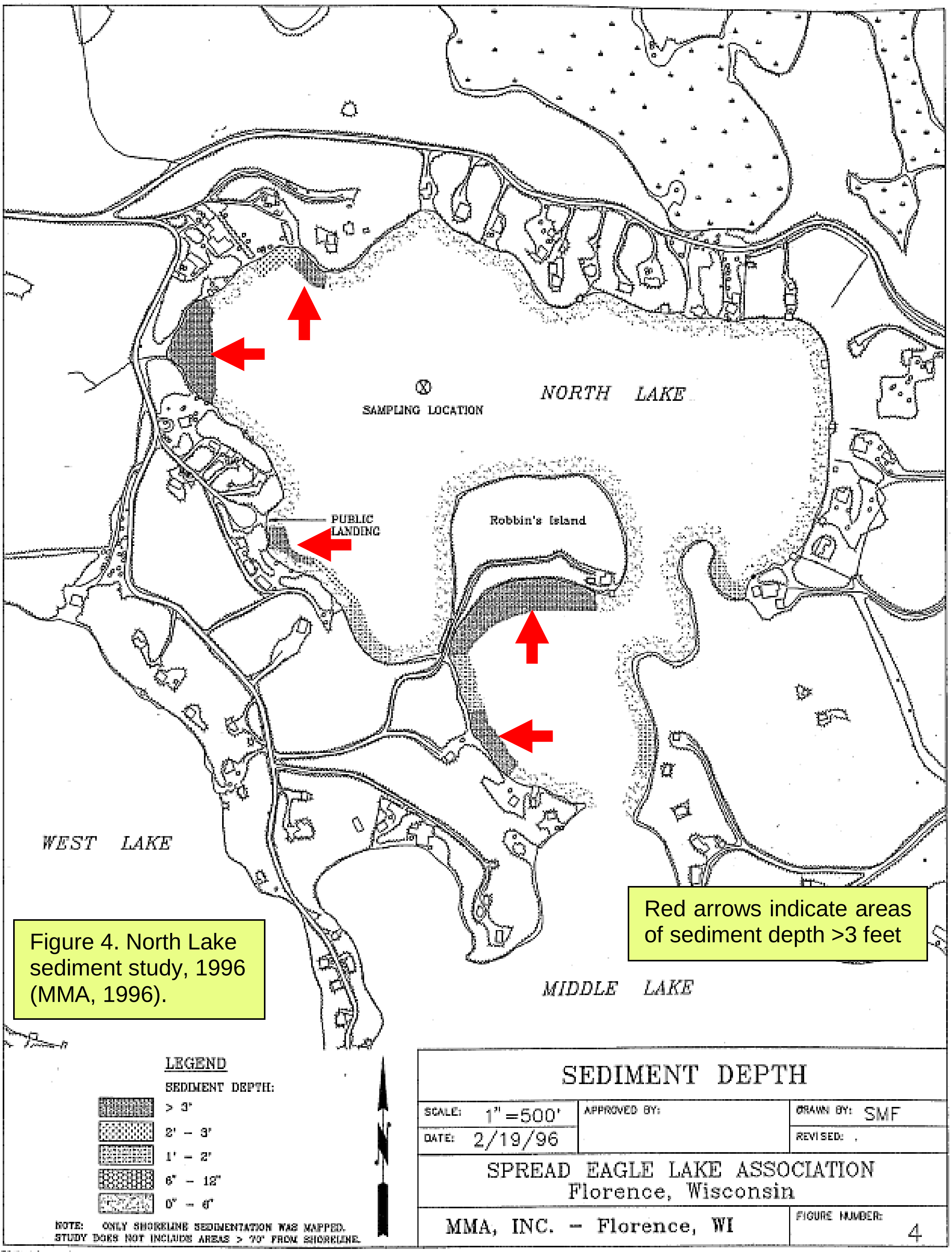


Figure 3. North Lake sediment study, 2012.

In February, 1996 a sediment study was completed by MMA, Inc consultants (in conjunction with a conductivity study). MMA sampled 101 points in 1996. Although the numbers of points from the 1996 study are slightly different than the 2012 study, some comparisons can be drawn.

As seen in Figure 4, the location of sediments greater than 3 feet (36.1 inches) deep are at the boat landing, on the south side of Robbins Island, and in the northwest bay of the lake (MMA, 1996). When we compare this with the 2012 data, we see that the areas with the deepest sediment have not drastically changed, but there are a few additional areas in 2012 where sediment depth was measured as greater than 3 feet.


NORTH LAKE
SAMPLING LOCATION
PUBLIC LANDING
Robbin's Island
WEST LAKE
MIDDLE LAKE
Red arrows indicate areas of sediment depth >3 feet
Figure 4. North Lake sediment study, 1996 (MMA, 1996).
LEGEND
SEDIMENT DEPTH:
> 3'
2' – 3'
1' – 2'
6" – 12"
0" – 6"
NOTE: ONLY SHORELINE SEDIMENTATION WAS MAPPED. STUDY DOES NOT INCLUDE AREAS > 70' FROM SHORELINE.
SEDIMENT DEPTH
SCALE: 1" =500'
DATE: 2/19/96
APPROVED BY:
DRAWN BY: SMF
REVISED:
SPREAD EAGLE LAKE ASSOCIATION
Florence, Wisconsin
MMA, INC. – Florence, WI
FIGURE NUMBER: 4
DIGITAL BASE MAP FILES USED WITH PERMISSION FROM THE FLORENCE UTILITY COMMISSION.

Discussion

Lake sediments are comprised mainly of clay, silt, sand sizes, organic debris, chemical precipitates, or combinations of these. The amount of each depends upon the composition of the local drainage basin, hydrology, lake area, lake depth, climate, and the age of a lake. Decaying plants and animals in a lake and leaves that fall into the lake from the riparian area contribute to this sediment. Although a natural process, human activities (especially alterations of the landscape) can contribute to increased sedimentation. Wind, waves, and water currents can influence where in a lake the sediment accumulates. Movement of the water by boats can influence where sediment accumulates in a lake.

Literature Cited

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National Oceanic and Atmospheric Administration (NOAA). 2014. *Why Study Seafloor Composition?* Retrieved 2014. <http://www.ngdc.noaa.gov/mgg/geology/why.html>

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WHITE WATER ASSOCIATES, INC.

Appendix F
North Lake EPA Littoral and Shoreline Survey

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North Lake EPA Littoral and Shoreline Survey

Introduction

North Lake's littoral and shoreline zones were assessed in 2013 by White Water field staff using the US Environmental Protection Agency's (EPA) National Lakes Assessment (NLA) protocol and the Wisconsin Department of Natural Resources (WDNR) Supplemental Lakeshore Assessment protocol. The intention of the National Lakes Assessment (NLA) project was to provide a comprehensive State of the Lakes assessment for lakes, ponds, and reservoirs across the United States (USEPA, 2009). This assessment at North Lake will stand as a baseline against which future changes can be measured and can be used to compare North Lake with other lakes measured using the same protocols.

Methods

Ten physical habitat (P-Hab) stations were spaced equidistantly around the lake (Figure 1 and 2). For the purposes of this assessment, the area south of Robbin's Island was not included among the sites. At each site, White Water biologists recorded information about the littoral zone bottom substrate, littoral zone aquatic macrophytes (plants), littoral zone fish cover, riparian zone canopy, understory and ground cover, shoreline substrates, human influences, classification of fish habitat, bank features, any invasive species observed (terrestrial or aquatic), land cover, human development and the number of piers between sites.

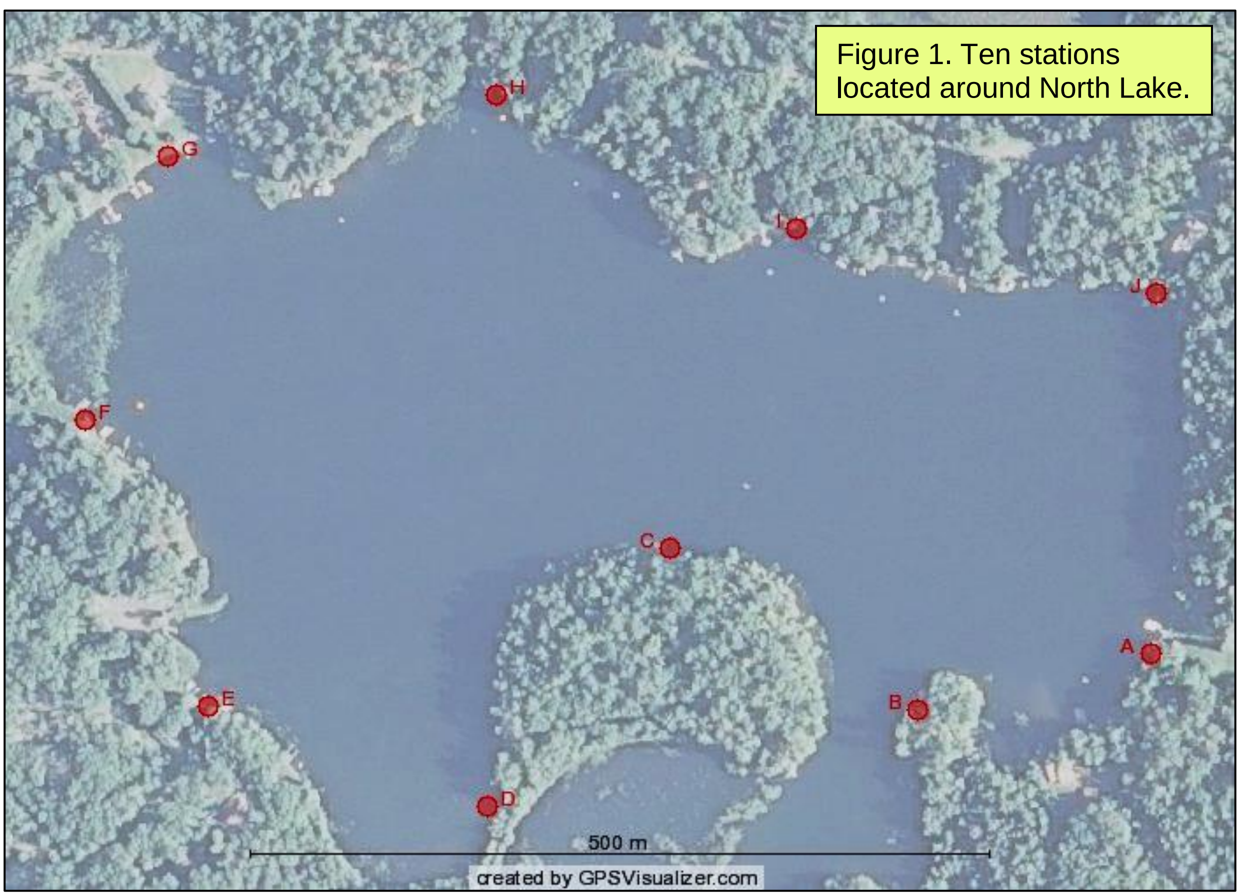

Figure 1. Ten stations located around North Lake.

At each P-Hab site, biologists collected macroinvertebrates for later identification. A fecal indicator sample was collected at one site to be analyzed for levels of *E. coli*.

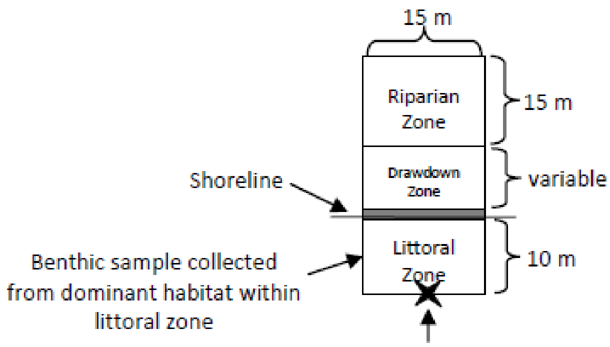

Figure 2. Dimensions and layout of a P-Hab station.

Results

The average depth of the ten stations was 2.37 feet (the range was from 1.5 to 3.5 feet). No surface film was observed at any of the ten stations.

Table 1 contains the littoral zone bottom substrate data collected from the ten North Lake sampling stations. Bedrock was not observed as a bottom substrate at any station. Boulders were sparse at one station. Gravel was present at seven stations. Sand was present at nine of the ten stations. Cobble, silt, clay and muck were encountered at five stations each. Woody debris was present at six stations. Brown colored sediment occurred at one station, while gray sediment was observed at the remaining nine stations. No odor was associated with the bottom substrate at any station.

Table 1. USEPA Habitat Characterization – Littoral Zone Bottom Substrate.

Station	A	B	C	D	E	F	G	H	I	J
Bedrock	0	0	0	0	0	0	0	0	0	0
Boulders	0	1	0	0	0	0	0	0	0	0
Cobble	0	1	1	2	0	0	1	0	1	0
Gravel	0	2	2	2	0	0	1	2	2	2
Sand	4	4	4	3	1	1	0	4	4	4
Silt, Clay, Muck	0	0	1	2	4	3	4	0	0	0
Woody Debris	1	1	1	2	0	0	0	3	0	2
Color	Gray	Gray	Gray	Gray	Gray	Gray	Brown	Gray	Gray	Gray
Odor	None	None	None	None	None	None	None	None	None	None

Bedrock (>4000mm); Boulders (250-4000mm); Cobble (64-250mm); Gravel (2-64mm); Sand (0.02-2mm); Silt, Clay, or Muck (<0.06mm, not gritty). 0=Absent (0%); 1=Sparse (<10%); 2=Moderate (10-40%); 3=Heavy (40-75%); 4=Very Heavy (>75%)

Table 2 presents the observations made on aquatic macrophytes in the littoral zone. Submergent aquatic plants were observed at nine of the ten stations. Emergent macrophytes were observed at three stations as both sparse (two stations) and moderate (one station) coverage. Three of the ten stations had floating macrophytes present with sparse coverage. Total macrophyte cover was sparse at three stations, moderate at four stations, heavy at one station, and very heavy at one station. Macrophytes extended lakeward from the plot at nine stations.

Table 2. USEPA Habitat Characterization – Littoral Zone Aquatic Macrophytes.

Station	A	B	C	D	E	F	G	H	I	J
Submergent	1	0	1	2	3	2	4	2	2	1
Emergent	0	0	0	2	0	0	0	0	1	1
Floating	0	0	0	0	1	1	0	1	0	0
Total Aquatic Macrophyte Cover	1	0	1	2	3	2	4	2	2	1
Do macrophytes extend lakeward from plot?	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

0=Absent (0%); 1=Sparse (<10%); 2=Moderate (10-40%); 3=Heavy (40-75%); 4=Very Heavy (>75%)

Littoral zone fish cover observations are presented in Table 3. Aquatic and/or inundated herbaceous vegetation was observed at four stations, having coverages of sparse (two stations) and moderate (two stations). Woody debris and snags greater than 0.3 meters in diameter were observed at three stations and had sparse coverage. Woody brush/woody debris less than 0.3 meters in diameter was found at four stations. Inundated live trees (greater than 0.3 meters in diameter) were observed at one station. Overhanging vegetation within one meter of the surface was observed at nine stations, six as sparse, two as heavy and one as moderate coverage. Ledges or sharp drop-offs were not observed. Boulders were observed at one station. Finally, human structures (such as docks, landings, etc.) were observed as fish cover at three of the stations.

Table 3. USEPA Habitat Characterization – Littoral Zone Fish Cover.										
Station	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Aquatic & Inundated Herbaceous Cover	0	0	0	2	1	0	0	2	0	1
Woody Debris/Snags >0.3 m dia.	0	1	1	0	0	0	0	0	0	1
Woody Brush/ Woody Debris <0.3 m dia.	0	0	1	2	0	0	0	2	0	1
Inundated Live Trees >0.3 m dia.	0	0	0	0	0	0	0	0	0	1
Overhanging veg. w/in 1 m of surface	1	1	1	3	0	2	1	1	1	3
Ledges or Sharp Drop-offs	0	0	0	0	0	0	0	0	0	0
Boulders	0	0	0	0	0	0	0	0	1	0
Human Structures (docks, landings, etc.)	1	0	0	0	1	2	0	0	0	0
0=Absent (0%); 1=Sparse (<10%); 2=Moderate (10-40%); 3=Heavy (40-75%); 4=Very Heavy (>75%)										

Table 4 shows observations made at the riparian zone canopy (>5 meters high), understory (0.5 to 5 meters), and ground cover (<0.5 meters). Mixed (conifer and deciduous) canopy type was observed in eight of the ten stations, deciduous canopy type was observed at one station and coniferous canopy type was observed at one station. The coverage of big trees (>0.3 meters diameter) was sparse to very heavy, and coverage of small trees (<0.3 meters diameter) was sparse to moderate. Mixed understory type was observed at three stations, deciduous canopy type at five stations, and coniferous and no understory were each observed at one station. Coverage of understory woody shrubs and saplings was sparse (seven stations) and moderate (one station). Understory tall herbs, grasses, and forbs were present at three stations with sparse coverage. Ground cover of woody shrubs and saplings were observed at nine stations with coverages of sparse (eight stations) and moderate (one station). Groundcover herbs, grasses, and forbs were observed at all ten stations with sparse (four station), moderate (three stations), heavy (two stations), and very heavy (one station) coverage. Standing water or inundated vegetation was not observed. Barren, bare dirt or buildings were observed at two stations having moderate coverage.

Table 4. USEPA Habitat Characterization – Riparian Zone.										
Station	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
CANOPY (>5 m high)										
Type	Mix	Mix	Mix	Con	Dec	Mix	Mix	Mix	Mix	Mix
Big Trees (Trunk >0.3 m dia.	2	4	4	4	2	3	1	2	3	3
Small Trees (Trunk <0.3 m dia.	0	1	1	2	0	1	1	0	0	1
UNDERSTORY (0.5 to 5 m high)										
Type	Dec	Dec	Mix	Con	Mix	Mix	None	Dec	Dec	Dec
Woody Shrubs and Saplings	1	1	0	1	1	1	0	1	1	2
Tall Herbs, Grasses, Forbes	0	0	0	1	0	1	0	0	0	1
GROUND COVER (<0.5 m high)										
Woody Shrubs and Saplings	1	1	1	1	1	1	0	1	1	2
Herbs, Grasses and Forbes	1	2	1	4	1	2	1	3	3	2
Standing Water/ Inundated Veg.	0	0	0	0	0	0	0	0	0	0
Barren, Bare Dirt, or Buildings	2	0	0	0	2	0	0	0	0	0
0=Absent (0%); 1=Sparse (<10%); 2=Moderate (10-40%); 3=Heavy (40-75%); 4=Very Heavy (>75%); Mix = Mixed conifer and deciduous; Dec = Deciduous										

Table 5 presents observations recorded on the riparian shoreline substrate zone. Bedrock was not observed at any of the ten stations. Boulders were observed at two of the ten stations with sparse coverage. Cobble substrate was observed at five stations with coverages of sparse (two stations), moderate (one station), heavy (one station) and very heavy (one station). Gravel substrate was observed at two of ten stations. Sand substrate was observed at one station. Silt, clay, or muck substrate was observed at one station and had heavy coverage. Woody debris was observed at seven of ten stations with sparse, moderate and heavy coverage. Vegetation or other was observed at all stations with coverages of moderate (three stations), heavy (four stations), and very heavy (three stations).

Table 5. USEPA Habitat Characterization – Riparian Zone – Shoreline Substrate Zone.										
Station	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Bedrock	0	0	0	0	0	0	0	0	0	0
Boulders	1	1	0	0	0	0	0	0	0	0
Cobble	0	3	0	1	0	0	2	1	4	0
Gravel	0	0	0	0	0	0	1	2	0	0
Sand	0	0	0	0	0	1	0	0	0	0
Silt, Clay, Muck	0	0	0	0	3	0	0	0	0	0
Woody Debris	1	1	2	1	0	1	0	3	0	1
Vegetation or other	3	3	4	4	2	3	3	2	2	4
0=Absent (0%); 1=Sparse (<10%); 2=Moderate (10-40%); 3=Heavy (40-75%); 4=Very Heavy (>75%)										

Observations of human influence in the riparian zone are shown in Table 6. Human influence was moderately low. Buildings were observed outside the plot at seven stations. Docks or boats were observed inside the plot at three stations and outside the plot at seven stations. Walls, dykes, revetments were located within the plot at four of the stations and outside the plot at one station. Landfill/trash was present outside the plot at one station. Lawn was observed inside and outside the plot at five stations. All other human influences (commercial development, park facilities/manmade beach, roads/railroads, powerlines, row crops, pasture/range/hayfield, and orchards) were not observed at any of the ten stations.

Table 6. USEPA Habitat Characterization – Riparian Zone – Human Influence Zone.										
Station	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Buildings	P	0	0	0	P	P	P	P	P	P
Commercial	0	0	0	0	0	0	0	0	0	0
Park Facilities/ manmade beach	0	0	0	0	0	0	0	0	0	0
Docks/Boats	PC	0	0	0	PC	PC	P	P	P	P
Walls, dykes, revetments	C	0	0	0	C	0	P	PC	C	0
Landfill/Trash	0	0	0	0	0	0	0	0	0	P
Roads or Railroad	0	0	0	0	0	P	0	0	0	0
Powerline	0	0	0	0	0	0	0	0	0	0
Rowcrops	0	0	0	0	0	0	0	0	0	0
Pasture/Range/Hayfield	0	0	0	0	0	0	0	0	0	0
Orchard	0	0	0	0	0	0	0	0	0	0
Lawn	PC	0	0	0	PC	PC	PC	0	PC	0
0 = Not Present; P = Present outside plot; C = Present within plot										

Table 7 reports the observations made on littoral fish macrohabitat classification. Human disturbance was observed at seven stations. Cover class was recorded as patchy (six stations), continuous (two stations), no/little (one station), and boulder and vegetation (one station). Cover type was recorded as woody at seven stations, as vegetation at eight stations, and artificial at three stations. Dominant substrate was sand/gravel at six stations, mud/muck at three stations, and cobble/boulder at one station.

Table 7. USEPA Habitat Characterization – Littoral Zone Macrohabitat Classification.

Station	A	B	C	D	E	F	G	H	I	J
Human Disturbance	Low	None	None	None	Mod	Mod	Low	Low	Low	Low
Cover Class	Patchy	Patchy	Patchy	Cont	Patchy	Patchy	No/Lit	Patchy	Bould Veg	Cont
Cover Type	Art	Woody Veg	Woody Veg	Woody Veg	Art Veg	Art Woody	Woody Veg	Woody Veg	Veg	Woody Veg
Dominant Substrate	S/G	C/B	S/G	S/G	M/M	M/M	M/M	S/G	S/G	S/G

Mod = Moderate; Cont = Continuous Cover; Art = Artificial; No/Lit = No or Little Cover; Bould = Boulder; Veg = Vegetation; M/M = Mud/Muck; C/B = Cobble/Boulder; S/G = Sand/Gravel

Plot bank features are presented in Table 8. Bank angle was considered gradual at four stations, steep at one station and near vertical at four stations. The vertical height from waterline to the high water mark varied at all stations. The horizontal distance from waterline to the high water mark averaged 0.17 meters (range was 0.02 to 0.91 meters).

Table 8. USEPA Habitat Characterization – Within Plot Bank Features.

Station	A	B	C	D	E	F	G	H	I	J
Angle	Grad	Steep	NV	Steep	Grad	Grad	NV	Grad	NV	NV
Vertical Height (m) to HWM	0.05	0.00	0.05	0.05	0.03	0.05	0.05	0.3	0.06	0.05
Horizontal Distance (m) to HWM	0.02	0.00	0.02	0.00	0.05	0.02	0.00	0.91	0.02	0.00

HWM = High Water Mark; Flat = <5 degrees; Grad = Gradual (5-30 degrees); Steep (30-75 degrees)

Table 9 displays the invasive plant and invertebrate species found in North Lake. Zebra mussels were present at four of the ten stations. Banded mystery snails were present at eight stations. No invasive species were observed in the shoreline/riparian plot.

Table 9. USEPA Habitat Characterization – Invasive Plant and Invertebrate Species.										
Station	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Target Invasive Species in Littoral Plot	ZM, BMS	None	None	BMS	BMS	ZM, BMS	BMS	ZM, BMS	ZM, BMS	BMS
Target Invasive Species in Shore-line/Riparian Plot	None	None	None	None	None	None	None	None	None	None
Target Invasive Species include: Zebra or Quagga Mussel, Eurasian Water-milfoil, Hydrilla, Curly Pondweed, African Waterweed, Brazilian Waterweed, European Water Chestnut, Water Hyacinth, Parrot Feather, Yellow Floating Heart, Giant Salvinia, Purple Loosestrife, Knotweed (Giant or Japanese), Hairy Willow Herb, Flowering Rush										

The WDNR Supplemental Methodology data are presented in Tables 10 and 11. Table 10 shows 25 pieces of small woody material (>5cm diameter) counted at five littoral zone transects. Fifteen pieces of large woody material were found at four stations. None of the five target invasive species (Japanese stiltgrass, reed canary grass, Phragmites, cattails, or yellow iris) were observed. An *Iris* sp. was observed although suitable plant structures for a positive identification were not present.

Table 10. WDNR Supplemental Methodology– Wood and Invasive Plant Species.										
Station	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Wood: >5cm diameter	0	0	7	3	0	1	0	8	0	6
Wood: >10cm diameter	0	1	6	6	0	0	0	0	0	2
Invasive: Japanese stiltgrass	No	No	No	No	No	No	No	No	No	No
Invasive: Reed canary grass	No	No	No	No	No	No	No	No	No	No
Invasive: Phragmites	No	No	No	No	No	No	No	No	No	No
Invasive: Cattails	No	No	No	No	No	No	No	No	No	No
Invasive: Yellow Iris	No	No	No	No	No*	No	No	No	No	No
*Iris species observed, but no flowers present for positive identification.										

Table 11 tabulates that riprap (four stations), lawn (five stations), and pavement (one station) were found in North Lake. Seawalls and artificial beaches were not present on the study plots. Residences were observed in the riparian plot of one station and were observed in the upland plot of seven stations. Commercial buildings were not observed. Structures were observed in the riparian plot of one station and in the upland plot of five stations. A boat lift and a swim raft were observed at one station each. Docks were observed at two stations. The WDNR protocol called for counting piers between each of the ten stations. Forty-five piers were counted between stations on the perimeter of North Lake.

Table 11. WDNR Supplemental Methodology– Land cover, Human Development, and Piers. (1 number given for riparian plot; if 2 numbers, 1st for riparian plot & 2nd for upland plot)										
Station	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
LANDCOVER Key: 0 (0-1%), 1 (>1-10%), 2 (>10-40%), 3 (>40-75%), 4 (>75%)										
Seawall	0	0	0	0	0	0	0	0	0	0
Rip Rap	0	0	0	0	4	0	3	3	3	0
Artificial beach	0	0	0	0	0	0	0	0	0	0
Lawn	4/4	0	0	0	4	3/4	4	0	2/3	0
Pavement	0/1	0	0	0	0	0	0	0	0	0
HUMAN DEVELOPMENT										
Residences	1/2	0	0	0	0/1	0/2	0/2	0/1	0/2	0/1
Commercial buildings	0	0	0	0	0	0	0	0	0	0
Structures (sheds/boat houses)	0/1	0	0	0	0/1	1/1	0	0	0/2	0/1
Boat lifts	0	0	0	0	1	0	0	0	0	0
Swim rafts	1	0	0	0	0	0	0	0	0	0
Docks	0	0	0	0	0	0	0	0	1	1
NUMBER OF PIERS BETWEEN STATIONS										
From:	A-B	B-C	C-D	D-E	E-F	F-G	G-H	H-I	I-J	J-A
Count	2	4	0	2	3	3	10	6	11	4

The USEPA protocol called for a composite sample of aquatic benthic macroinvertebrates, combining net sweeps from each station into one sample. Table 12 provides the identified invertebrate taxa and counts of individuals by taxa for the composite sample. A total of twenty-five taxa and 584 individual organisms were identified.

Table 12. Composite Benthic Macroinvertebrate Sample from North Lake.				
Taxon	**Count**		**Taxon**	**Count**
Annelida: Oligochaeta	2		Coleoptera (aquatic beetles): Elmidae (6), Haliplidae (2), Psephenidae (3)	11
Crustacea: Amphipoda (33), Isopoda (4)	37		Diptera (true flies): Ceratopogonidae (2), Chaoboridae (2), Chironomidae (196), Culicidae (1)	201
Ephemeroptera (mayflies): Baetidae (1), Caenidae (116), and Ephemerellidae (9)	126		Mollusca: Gastropoda: Hydrobiidae (94), Planorbidae (39), Viviparidae-banded mystery snail (33)	166
Anisoptera (dragonflies): Gomphidae (1), Libellulidae (3)	4		Mollusca: Pelecypoda: Dreissenidae-zebra mussel (3), Sphaeriidae (19)	22
Zygoptera (damselflies): Coenagrionidae (11), Lestidae (1)	12			
Trichoptera (caddisflies): Hydroptilidae (2), Polycentropodidae (1)	3		**Total Taxa**	**25**

Finally, the USEPA protocol called for a fecal indicator sample at the final sampling station (Station J). In the case of North Lake, we analyzed the sample collected for *Escherichia coli* (*E. coli*). The *E. coli* analysis resulted in values of 88 CFU (Colony Forming Units) per 100 milliliters of sample. To place this value in context, the USEPA recommends a water quality advisory (for swimming) when a level of the indicator bacterium *E. coli* exceeds a limit is 235 CFU per 100 milliliters of water.

Table 13 indicates the latitude and longitude of Stations A-J. A photo was taken at each of the ten stations. The station photos are displayed below.

Table 13. North Lake USEPA & WDNR Physical Habitat Locations.		
Station	*Latitude*	*Longitude*
A	45.902742	-88.133492
B	45.902401	-88.135532
C	45.90339	-88.137702
D	45.901818	-88.139304
E	45.902428	-88.141749
F	45.90417	-88.142832
G	45.905777	-88.142097
H	45.906146	-88.139223
I	45.905332	-88.136589
J	45.904944	-88.133452

Station A – North Lake

(USEPA & WDNR Physical Habitat Assessment) Photograph taken 6/7/2013, White Water Associates, Inc.

Station B – North Lake

(USEPA & WDNR Physical Habitat Assessment) Photograph taken 6/7/2013, White Water Associates, Inc.

Station C – North Lake

(USEPA & WDNR Physical Habitat Assessment) Photograph taken 6/7/2013, White Water Associates, Inc.

Station D – North Lake

(USEPA & WDNR Physical Habitat Assessment) Photograph taken 6/7/2013, White Water Associates, Inc.

Station E – North Lake

(USEPA & WDNR Physical Habitat Assessment) Photograph taken 6/7/2013, White Water Associates, Inc.

Station F – North Lake

(USEPA & WDNR Physical Habitat Assessment) Photograph taken 6/7/2013, White Water Associates, Inc.

Station G – North Lake

(USEPA & WDNR Physical Habitat Assessment) Photograph taken 6/7/2013, White Water Associates, Inc.

Station H – North Lake

(USEPA & WDNR Physical Habitat Assessment) Photograph taken 6/7/2013, White Water Associates, Inc.

Station I – North Lake

(USEPA & WDNR Physical Habitat Assessment) Photograph taken 6/7/2013, White Water Associates, Inc.

Station J – North Lake

(USEPA & WDNR Physical Habitat Assessment) Photograph taken 6/7/2013, White Water Associates, Inc.

Literature Cited

United States Environmental Protection Agency (USEPA). 2009. *National Lakes Assessment: A Collaborative Survey of the Nation's lakes. EPA 841-R-09-001.* U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, D.C. Retrieved 2014. <water.epa.gov/type/lakes/upload/nla_newlowres_fullrpt.pdf>

Appendix G
Summary of the North Lake Shoreline Photo Survey

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WHITE WATER ASSOCIATES, INC.

Summary of the North Lake Shoreline Photo Survey

A photo survey was conducted on North Lake In August, 2013. This survey was done to systematically document the littoral zone and riparian area condition of the lake. Documenting the shoreline condition of the lake helps to determine the extent of future distresses and asses the efficacy of regulatory programs intended to protect the riparian area and lake. Fifty (50) shoreline segments (approximately 150 feet long) were assessed for a variety of shoreline parameters. Members of SECOLA helped conduct the survey. The data and photographs of each segment are provided in CD-ROM format. This data will be a useful tool in identifying and planning restoration projects in the North Lake riparian area and for monitoring long-term change. The following is a summary of the data collected. Some segments had more than one type recorded.

North Lake Shoreline – Development		
Type	Number of records	% records
house	28	56%
shed	7	14%
garage	3	6%
gravel drive	0	0%
paved drive	1	2%
lawn	21	42%
other	2	4%

In 18 segments, no development was noted (36% of the segments).

North Lake Shoreline – Structures		
Type	Number of records	% records
dock	27	54%
breakwater	0	0%
stormwall	7	14%
boathouse	10	20%
rip-rap	9	18%
other	0	0%

In 17 segments, no structure was noted (34% of the segments).

North Lake Shoreline – Access		
Type	Number of records	% records
none	22	44%
unimproved path	11	22%
gravel path	0	0%
chip path	0	0%
paved path	2	4%
boardwalk	2	4%
stairs	15	30%
other	0	0%

In 22 segments, no access was noted (44% of the segments).

North Lake Shoreline – Beach		
Type	Number of records	% records
none	47	94%
natural	3	6%
artificial	0	0%
stable	1	2%
eroding	0	0%
other	0	0%

In 47 segments (94%), there was no beach observed.

North Lake Shoreline – Vegetation		
Type	Number of records	% records
upland	43	86%
wetland	14	28%
forested	32	64%
shrub	15	30%
natural openings	9	18%
stream	0	0%
other	3	6%

Upland vegetation was the most common type of vegetation observed (86%).

North Lake Shoreline – Buffer		
Type	Number of records	% records
none	20	40%
1-3 ft	3	6%
4-10 ft	5	10%
above 10 ft	22	44%
type: herbaceous	23	46%
type: shrubs	22	44%
type: trees	22	44%
type: other	1	2%

There were 22 segments (44%) where shoreline buffer was above 10 ft.

North Lake Shoreline – Erosion		
Type	Number of records	% records
none	43	86%
undercut banks/slumping	6	12%
furrows/gullies	1	2%
bare earth	0	0%
other	0	0%

Erosion was not observed along the North Lake shoreline at 43 segments (86%). In 7 segments, there was some form of erosion.

North Lake Shoreline – Bank Height		
Type	Number of records	% records
none	4	8%
slight (< 2 ft)	19	38%
abrupt (2 ft or greater)	27	54%

Abrupt banks made up over half of the shorelines, while no bank was observed at only 4 segments.

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Appendix H

North Lake Fisheries Summary

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WHITE WATER ASSOCIATES, INC.

North Lake (Spread Eagle Chain of Lakes) Fisheries Summary

Table of Contents

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Introduction

Various fish surveys have been conducted on North Lake by Wisconsin Department of Natural Resources (WDNR) biologists. Because North Lake is a part of the Spread Eagle Chain of Lakes, fisheries reports include information for all lakes in the chain. In 2011, comprehensive fish evaluations of the Spread Eagle Chain lakes were completed by Greg Matzke (2012). Four types of sampling occurred in 2011: early spring fyke netting, early spring electrofishing, late spring fyke netting, and fall electrofishing (Matzke, 2012). This appendix summarizes the research conducted on the Spread Eagle Chain in 2011.

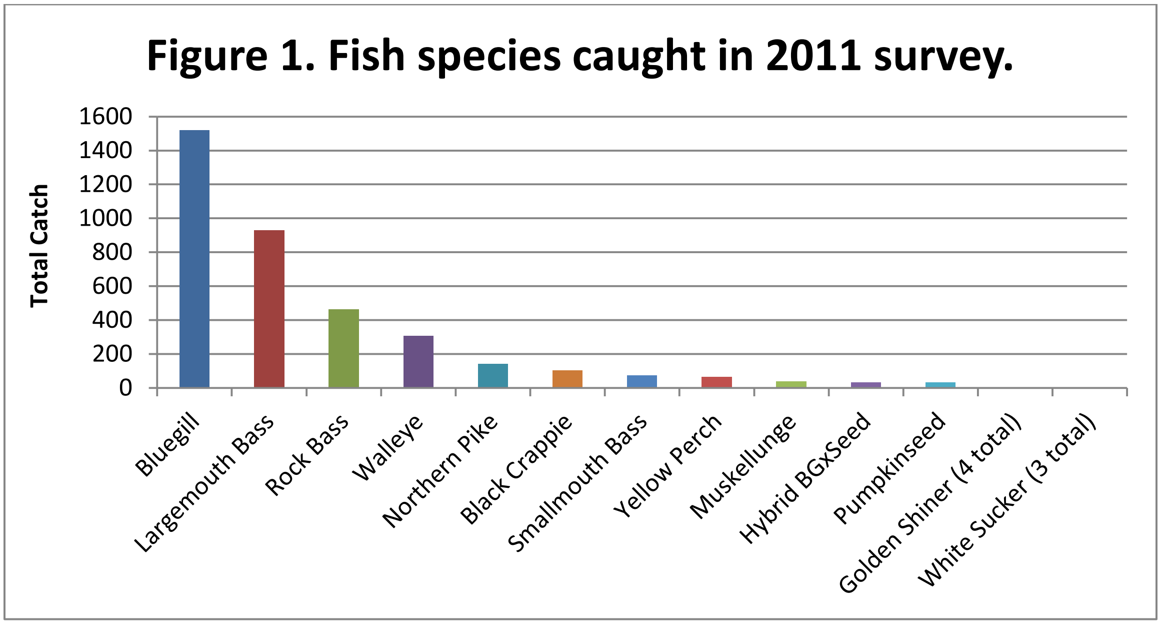
Fish stocking has taken place in the Chain for decades. Species stocked include: bluegill, largemouth bass, muskellunge, smallmouth bass, walleye and yellow perch (Table 1).

Table 1. Known Stocking History for Spread Eagle Chain (Matzke, 2012).

Species	*Age Class*	*Year(s)*
Bluegill	Adults	1939
Largemouth Bass	Fingerlings	1942
Muskellunge	Large Fingerlings	2002-2008 Even Years (Private), 2012
Muskellunge	Yearlings	2004 (Private)
Smallmouth Bass	Fingerlings	1941 and 1943
Walleye	Fry	1937, 1938 and 1940-1944
Walleye	Fingerlings	23 of 67 years between 1945 and 2011
Walleye	Large Fingerlings	2011 (Private)
Yellow Perch	Adults/fingerlings	1939

In the 2011 survey of the Spread Eagle Chain, five gamefish species, six panfish species and two non-game species were captured. These species include: black crappie, bluegill, golden shiner, bluegill x pumpkinseed hybrid, largemouth bass, muskellunge, northern pike, pumpkinseed, rock bass, smallmouth bass, walleye, white sucker and yellow perch. Figure 1 displays the total catch of each species in 2011.

The remainder of this fisheries summary provides information about these fish species found in the Spread Eagle Chain.



Fish Species

For each fish species discussed, several statistics have been recorded. Total count has been recorded for all species. Measurements of fish were collected to create a representation of species size structure. Species growth rate has also been estimated. This value is derived by calculating the average length by its age. The growth rate values are compared to those of the Northern Region of Wisconsin (NOR). For gamefish species (largemouth bass, walleye, northern pike, smallmouth bass, and muskellunge), analysis of the species' recruitment is also provided.

Bluegill

In 2011, bluegills were the most abundant species with a total catch of 1,520 fish. In the survey, 257 bluegills were captured for measurements, and lengths ranged from 4.0 to 7.9 inches with a modal length of 6 inches (Figure 2). Matzke (2012) indicates that the general trend of bluegill size structure is decreasing over time, which is likely related to higher fishing pressure, improved electronics, and increased harvest. Matzke states that more restrictive regulation on all panfish (including bluegills) would improve the quality of the panfish populations (2012).

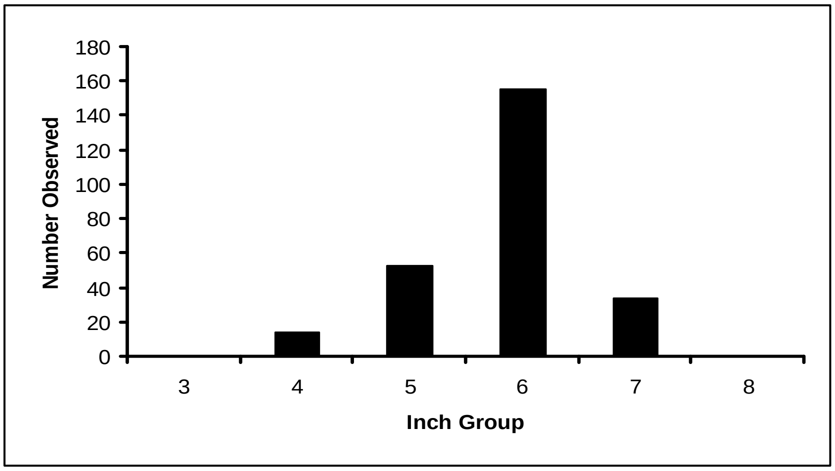


Figure 2. Length frequency of bluegill in summer, 2011 (Matzke, 2012).

Bluegill growth in the Chain was very similar to the NOR bluegill growth rate. On average, it takes 6 years for a bluegill to reach 7 inches; however no bluegills captured in 2011 were over 7 inches (2012).

Largemouth bass

Largemouth bass were the most abundant gamefish caught (928) in 2011 (Matzke, 2012). 793 largemouth bass were measured and the majority of bass sampled were between 10 and 14.9 inches (Matzke, 2012). The longest largemouth bass was 21.4 inches and the average was 12.4 inches (Figure 3).

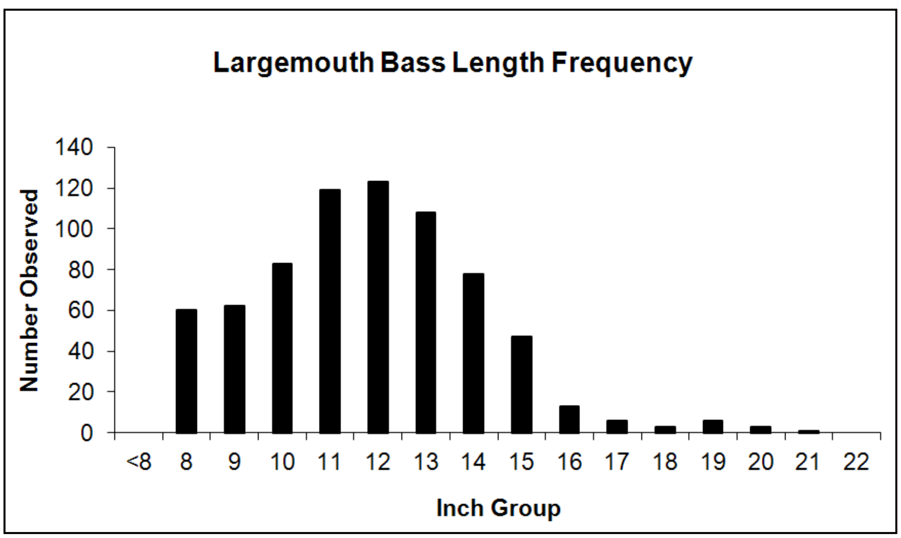


Figure 3. Length frequency of largemouth bass in spring 2011 (Matzke, 2012).

Spread Eagle Chain largemouth bass were slightly below the NOR average growth rate until age 7 (Matzke, 2012). Beyond age 8, Spread Eagle Chain largemouth bass were above the NOR average growth rate. On average, it takes a Spread Eagle Chain largemouth bass six years to reach 14 inches (Matzke, 2012).

Due to the presence of all year class ages (1-10) in the 2011 survey, the largemouth bass population is likely capable of sustaining itself at or near the current level (Matzke, 2012).

Rock Bass

Rock bass was the second most abundant panfish caught with a total or 464. Of 44 rock bass sampled, the size ranged from 3.9 to 9.4 inches, with a modal length of 5 inches (Figure 4) (Matzke, 2012). According to Matzke (2012), the size structure of rock bass has stayed fairly stable since 1949.

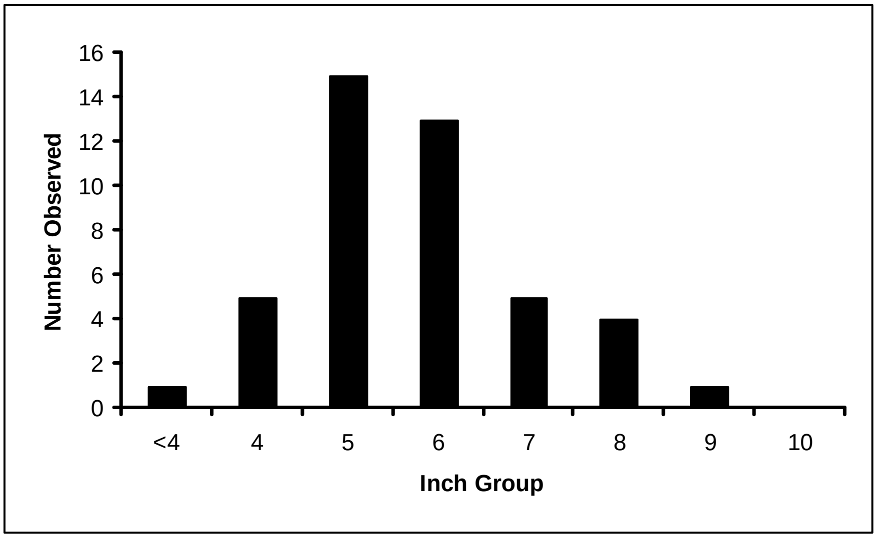


Figure 4. Length frequency of rock bass in summer, 2011 (Matzke, 2012).

Growth rates of rock bass in the Spread Eagle Chain are just below the state average (Matzke, 2012). On average, it takes a Spread Eagle Chain rock bass five years to reach 7 inches, and seven years to reach 8 inches (Matzke, 2012).

Walleye

Walleye was the most common gamefish capture in 2011 with 307 fish. Of this total, 167 walleye were sampled for measurements. Walleye lengths ranged from 14.1 to 26.4 inches, with a mean length of 19.5 inches (Matzke, 2012). The modal size was 19.5 inches (Figure 5). We can see from Figure 5 that the average length of walleye has increased since 1998.

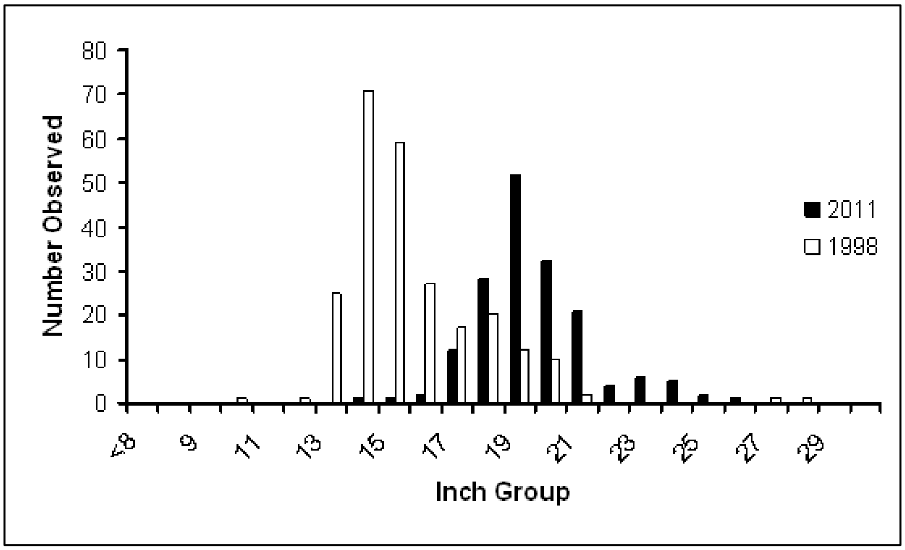


Figure 5. Length frequency of walleye in spring, 2011 compared to 1998 (Matzke, 2012).

In Matzke's study, he noticed that female walleye grew at a faster rate than males. Growth rate of female walleyes was above the NOR average, while male walleyes showed below average growth rates (Matzke, 2012).

Walleye appear to have some limited natural reproduction although they are not capable of maintaining their populations naturally (Matzke, 2012). The 2011 survey, along with four other surveys conducted from 1979 to 1998, confirms that natural reproduction of walleyes in the Spread Eagle Chain is minimal and not high enough to maintain a population without stocking (Matzke, 2012). Carl Sundberg, a member of the Spread Eagle Chain of Lakes Association (SECOLA), noted in the SECOLA 2011/2012 newsletter that the association will be reinstating a fish fund on the membership form. He hopes to have a fall stocking of larger walleye fingerlings so that they might have a higher chance of survival (Sundberg, 2012).

In fall, 2011 only two young-of-the-year (YOY) walleye were captured, and upon further analysis, it was decided they were from the 2011 walleye stocking (Matzke, 2012). Matzke (2012) indicates that natural reproduction of walleyes is minimal and not high enough to maintain a population without stocking. He also states that while no naturally reproduced walleye were captured in the fall survey, four age-1 walleye were captured indicating that while natural reproduction of walleyes is minimal, it is occurring (Matzke, 2012).

Northern Pike

The second most abundant game fish species captured in the 2011 survey was the Northern Pike, with a total of 141. Matzke (2012) describes this population as low. After drawing comparisons from the 1979 and 1988 data, it is suggested that the northern pike population is approximately half the size as from those years (Matzke, 2012). Northern pike size ranged from 11.7 to 33.9 inches, with the average pike measuring 19.2 inches and the modal length being 16 inches (Figure 6).

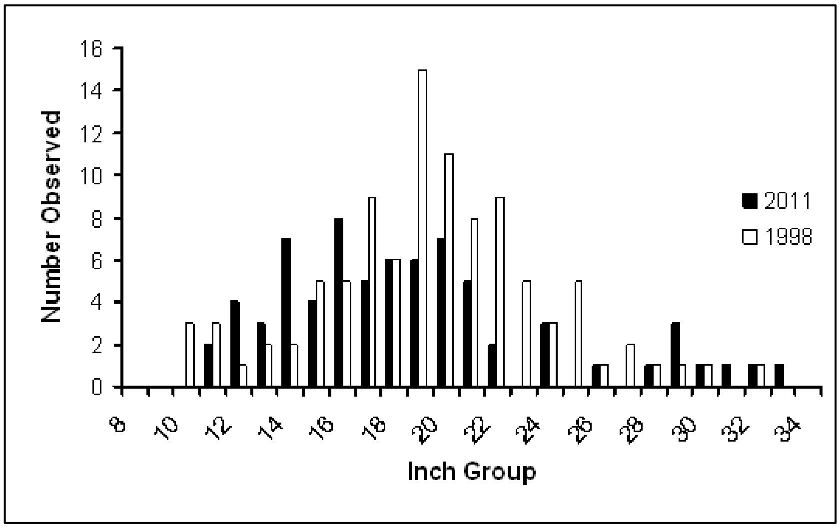


Figure 6. Length frequency of northern pike in spring, 2011 compared to 1998 (Matzke, 2012).

Similar to walleye, the Spread Eagle Chain northern pike growth rates varied among females and males. The growth rate of female northern pike was well above average for the NOR growth rate (Matzke, 2012). On the other hand, Spread Eagle Chain male northern pike's growth rate is similar to the NOR rate until age 4 and then the growth rate decreases to below the NOR average (Matzke, 2012).

In the 2011 fall electrofishing survey, no YOY northern pike were observed, however, eight age-1 pike were captured (Matzke, 2012). These young fish, suggest that northern pike natural reproduction is capable of maintain a fairly low population (Matzke, 2012).

Black Crappie

In 2011, 103 crappies were captured. Of these fish, 40 were randomly selected for measurements, and lengths ranged from 4.5 to 11.8 inches (Matzke, 2012). The majority of crappies caught measured 9 and 10 inches (Figure 7). Matzke (2012) states that the size structure observed in 2011 was better than in the last three surveys conducted.

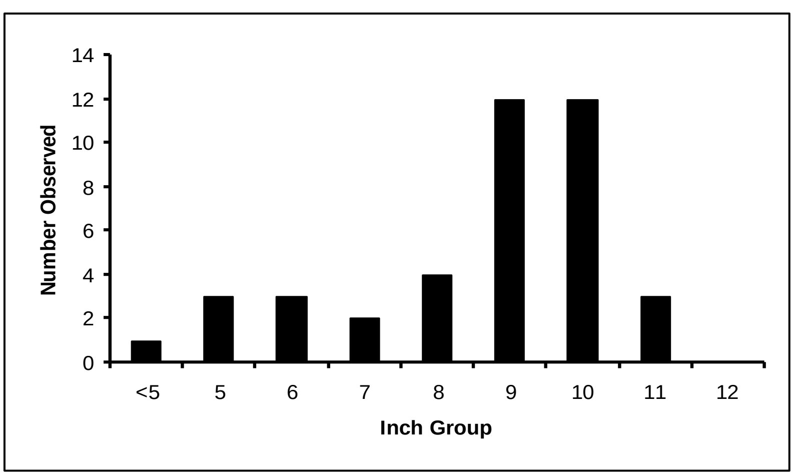


Figure 7. Length frequency of black crappie in spring, 2011 (Matzke, 2012).

Black crappie growth in the Chain was very similar to the NOR black crappie growth rate. On average, it takes about four years for a black crappie in the Chain to reach 8 inches, and seven years to reach 10 inches (Matzke, 2012).

Smallmouth Bass

Smallmouth bass were the least abundant gamefish captured with a total of 73. Smallmouth bass measured up to 18.1 inches and the average length was 12.5 inches (Figure 8) (Matzke, 2012). Most smallmouth bass capture measured 10 inches.

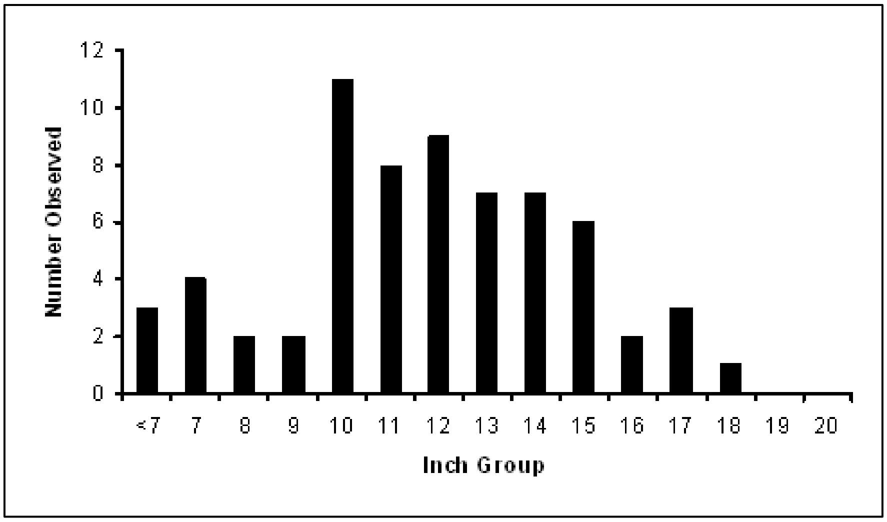


Figure 8. Length frequency of smallmouth bass in spring, 2011 (Matzke, 2012).

The Spread Eagle Chain smallmouth bass growth rate was above the NOR average until after age 4 when it declined (Matzke, 2012). On average, a Spread Eagle Chain smallmouth bass reaches 10 inches after age 4.

No YOY and only one age-1 smallmouth bass were captured in the fall, 2011 survey. This indicates that the natural reproduction of smallmouth bass is low; however, presence of year classes 1-8 suggests that there is some natural reproduction to support a small population (Matzke, 2012).

Yellow Perch

There were 66 yellow perch captured in 2011. These fish ranged from 5.6 to 10.2 inches, with a modal length of 6 inches (Figure 9).

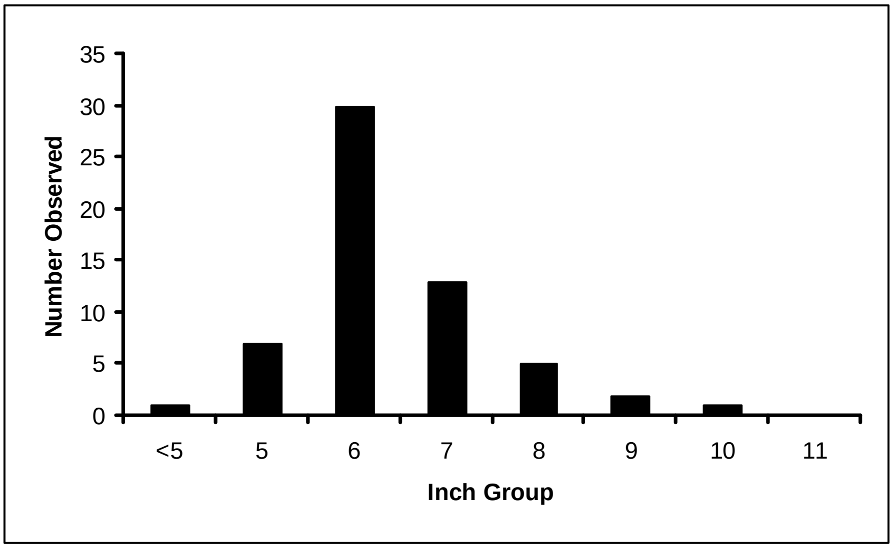


Figure 9. Length frequency of yellow perch in 2011 (Matzke, 2012).

Yellow perch growth rate is above the NOR average (Matzke, 2012). On average it takes a Spread Eagle Chain yellow perch six years to reach 9 inches.

Muskellunge

There was a low number (38) of muskellunge captured in 2011 (Matzke, 2012). In a 2012 muskellunge recapture survey, 30 were captured—14 of which were captured in 2011. Matzke (2012) estimates there are only 12 juvenile fish (20-29.9 inches) in the system currently. Muskellunge size in 2011 ranged from 20.2 to 43.8 inches with an average of 35.4 inches (Matzke, 2012). The average length was 35.4 inches (Figure 10). In the 2012 muskellunge recapture survey, lengths ranged from 28.5 to 44.5 inches with an average length of 36.2 inches (Figure 10).

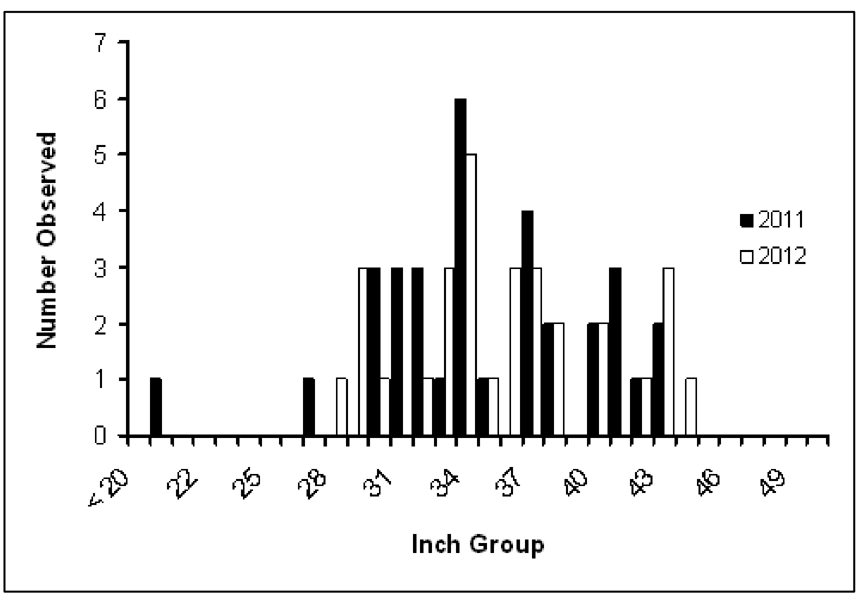


Figure 10. Length frequency of muskellunge in 2011 and 2012 (Matzke, 2012).

Similar to walleye and northern pike, female muskellunge grew at a faster rate than males, especially beyond age 4 (2012). Both genders of muskellunge are well above the NOR average growth rate. By age 6, the average muskellunge reaches 35.1 inches and by age 10 the average muskellunge reaches 42 inches.

No YOY or age-1 muskellunges were observed in the fall, 2011 survey. There was however an age-2 muskellunge that was not from a stocking event, meaning it was naturally reproduced (Matzke, 2012). If only a few adult muskellunge were able to successfully reproduce, the fishery could become self-sustaining (Matzke, 2012).

Pumpkinseed

There were thirteen pumpkinseeds captured in 2011. Pumpkinseed length ranged from 4.4 to 7.0 inches (Matzke, 2012). The majority of pumpkinseeds were 5 inches in length (Figure 11).

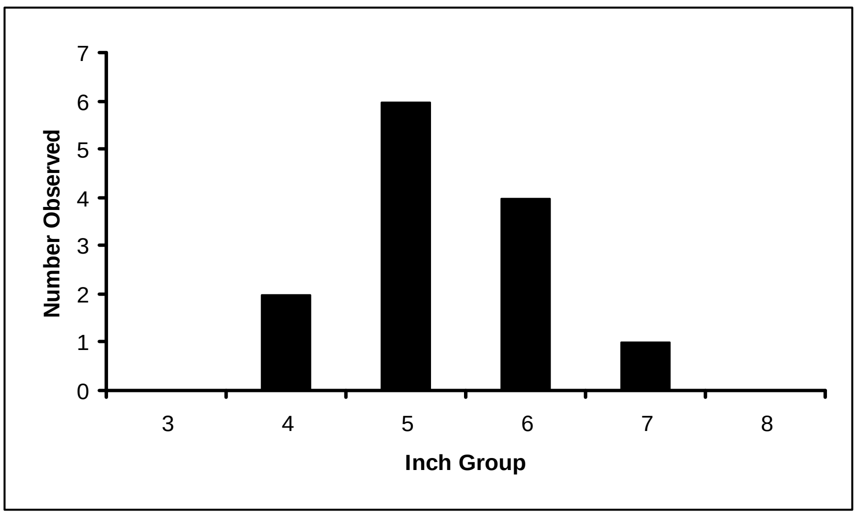


Figure 11. Length frequency of pumpkinseed in summer, 2011 (Matzke, 2012).

Pumpkinseed growth rate was slightly higher than the state average, up to 5 years age (Matzke, 2012). No pumpkinseeds were captured older than 6 years.

Golden Shiner, White Sucker, Hybrid BGxSeed

Golden shiner and white sucker had very low numbers. In 2011, four golden shiners and three white suckers were caught. No information was available regarding the bluegill X pumpkinseed hybrid.

Literature Cited

Matzke, Gregory. 2012. *Comprehensive Fisheries Evaluation of the Spread Eagle Chain of Lakes, Florence County, Wisconsin 2011.* Wisconsin Department of Natural Resources. Retrieved 2014. <http://dnr.wi.gov/topic/fishing/documents/north/2011SpreadEagleFlorenceComp.pdf>

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WHITE WATER ASSOCIATES, INC.

Appendix I
North Lake Stewardship Program
Volunteer Anglers' Journal Report

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WHITE WATER ASSOCIATES, INC.

Spread Eagle Chain of Lakes Association (SECOLA): North Lake Stewardship Program Volunteer Anglers' Journal Report

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WHITE WATER ASSOCIATES, INC.

Introduction

One component of the North Lake Stewardship Program was to establish a means by which anglers could collect meaningful fisheries data. Members of the Spread Eagle Chain of Lakes Association (SECOLA) and their consultant (White Water Associates) worked with the Wisconsin Department of Natural Resources (WDNR) to develop the Volunteer Anglers' Journal. The goal of the journals (and the resulting data) was to augment the periodic WDNR fish surveys (including Fyke nets, electroshocking, and creel surveys) with continuously collected and annually reported fishing data from systematically recorded angler journals. This report documents the methods and findings for 2012 and 2013 volunteer fish monitoring in North Lake.

Methods

This volunteer angler journal program was designed so that volunteer anglers can systematically record their fishing experiences. The program was conceived and designed by White Water Associates although components of the program (and field form) were drawn from literature sources (similar programs have been established in other states). Review by WDNR fisheries staff (Dennis Scholl and David Seibel) and WDNR Water Resources Management Specialist (Kevin Gauthier) resulted in several meaningful modifications.

We hope that participating anglers will be engaged in the journaling process on an ongoing basis, however, the system can also accommodate anglers who participate for one fishing trip only. This activity will engage anglers in collecting fish data and contribute to the understanding of fish population dynamics. The objectives for the angler journal program include providing information on:

- Species of fish caught while angling on North Lake;
- Size distribution of fishes caught on North Lake;
- Fishing emphases of North Lake anglers (time spent on panfish, walleyes, bass, etc.);
- Fishing techniques used on North Lake (trolling, bait fishing, spin fishing, etc.);
- Relative amount of catch and release fishing; and
- Catch-per-effort for various North Lake fish species

Volunteer anglers participating in the journal program were provided with field data forms and specific instructions on how to fill out the forms (Figure 1).

Figure 1. Volunteer Anglers' Journal field data form.

VOLUNTEER ANGLERS JOURNAL FIELD DATA FORM

Important Instructions (*see Angler Journal Description for details*)
Fill sheet out only for yourself (a partner fills out a separate sheet). Use new sheet for each fishing trip. Record unsuccessful trips too. Measure and record all gamefish caught and indicate if kept/released. For panfish, measure the length of the first ten of each species and indicate if kept or released. For additional panfish, count number kept and number released and record. Complete a journal form every time you fish.

Angler and Fishing Trip Data

Angler Name:	Phone:	Date:
Time start (actual fishing time):	Time end (actual fishing time):	Total time fishing (excluding lunch break, etc.):

List fish species sought and % time spent for each. If you are seeking all species listed during your entire outing, list "100%" by each.

Watercraft (circle one): Ice Pontoon Fishing boat Canoe Kayak Other (specify):

Fishing Style (circle 1 or more): Tip-up Jigging Trolling Casting Bait Fly Other (specify):

Weather Conditions:				
	Sunny _____	Air temp (°F) _____	Calm winds _____	Wind Direction _____
	Partly Cloudy _____	Water temp (°F) _____	Moderate winds _____	Other weather notes:
	Overcast _____	Rainy _____	Strong winds _____	

Level of satisfaction (circle one): Low Medium High Explain:

Record Fish Caught on Trip

Catch #	Fish Species Common Name	Length (nearest ¼ inch)	Check one: Kept	Released	Catch #	Fish Species Common Name	Length (nearest ¼ inch)	Check one: Kept	Released	Counts of unmeasured panfish
1					11					Bluegill
2					12					
3					13					Pumpkinseed
4					14					
5					15					Crappie
6					16					
7					17					Yellow Perch
8					18					
9					19					Other (specify)
10					20					

Data continued on second page? (circle one): YES NO Note: If you need more space, indicate by circling "YES" and then record data on back of this sheet or on a 2nd data form.

Important instructions to the volunteers were summarized on the data form and emphasized on a separate handout. These instructions included the following:

- Fill out the data form only for yourself (if they wish, a fishing partner should fill out his/her own);
- Use a new sheet for each fishing outing;
- Record all trips including unsuccessful trips (even if you have caught no or few fish);
- Record actual time spent fishing (boating to and from your fishing areas and time spent doing reconnaissance with sonar are considered fishing activities and you should include the time spent on these activities even though you may not have a line in the water). Don't include non-fishing activity such as a lunch break or time spent swimming);

- Measure all fish caught (even tiny ones) in inches from tip of the snout to tip of the tail. Measure to the nearest one-quarter (1/4) inch. We want to understand the population size structure;
- Indicate if the fish was kept or released;
- Be consistent; fill out a journal field data sheet every time you fish;
- List the fish species you are seeking during a fishing trip and estimate a percentage of time devoted to each. If you are seeking all species listed during your entire outing, record “100%” by each species;
- Measure and record all game fish species caught. For panfish species, measure the length of the first ten of each species and indicate if kept or released. For additional panfish (beyond 10), simply count (don’t measure) the number kept and number released. Record these numbers;
- If you need additional space for recording fish, indicated “continued on another page” and then record on back of the Field Data Form or on a second Field Data Form.

As with any biological sampling (whether done by professionals or volunteers), appropriate scientific and resource management use of data must recognize possible limitations of the data. In the case of the North Lake Volunteer Anglers’ Journal, data will be most valid and useful if volunteers: (1) carefully follow directions regarding data recording, (2) accurately identify fish and measure fish length, (3) honestly record all data (big fish, little fish, many fish, and few fish), (4) consistently use the journal on all fishing outings, and (5) participate for multiple years.

Results

General Statistics

North Lake is a 79 acre lake with a maximum depth of 43 feet. It is located in Florence County and is an oligotrophic drainage lake. The volunteer anglers’ journal endeavor began with a small number of participants, but we anticipate that this number will grow. The scientific value of the information collected will increase with a greater number of participants and participation of several years. There were a total of 63 angler journals in 2012 and 22 people participated. There were 98 angler journals in 2013 and 30 people participated. The completed journal entries represent fishing trips (outings). The journal periods referred to in this report were from January 11, 2012 to August 31, 2012 and January 10, 2013 to October 16, 2013.

Table 1. Sport fishing effort summary, North Lake, 2012-13 season.				
Month	*Total Angler Hrs. (Angler Journal)*		*Total Angler Hrs./Acre (Angler Journal)*	
	2012	*2013*	*2012*	*2013*
January	9.50	71.5	0.16	1.21
February		2.00		0.03
May	24.25	9.00	0.41	0.15
June	42.00	26.5	0.71	0.45
July	41.00	58.75	0.69	1.00
August	29.75	65.25	0.50	1.11
September		22.25		0.38
October		10.50		0.18
Total	**146.50**	**265.75**	**2.47**	**4.51**

Table 1 displays the fishing effort of anglers on North Lake in 2012 and 2013. Total angler hours are the estimated number of hours that anglers spent fishing on North Lake during each month. Total angler hours/acre is the total angler hours divided by the area of the lake in acres.

Figure 2 illustrates the fishing effort reported on North Lake by month. June, 2012 and January, 2013 had the most fishing effort hours with 42 hours and 71.5 hours respectively.

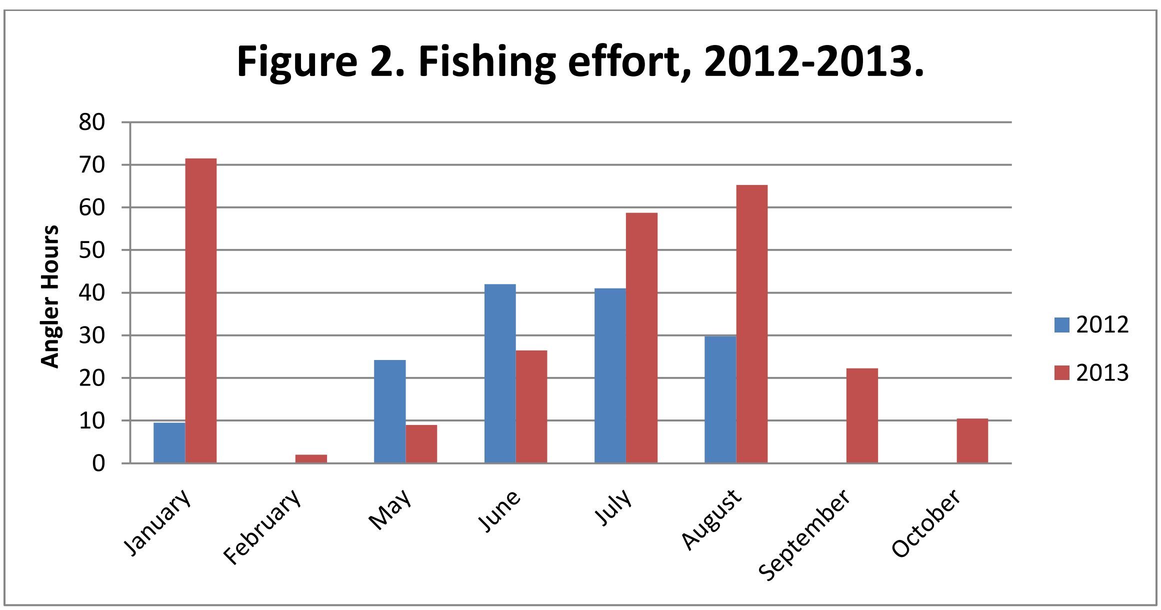
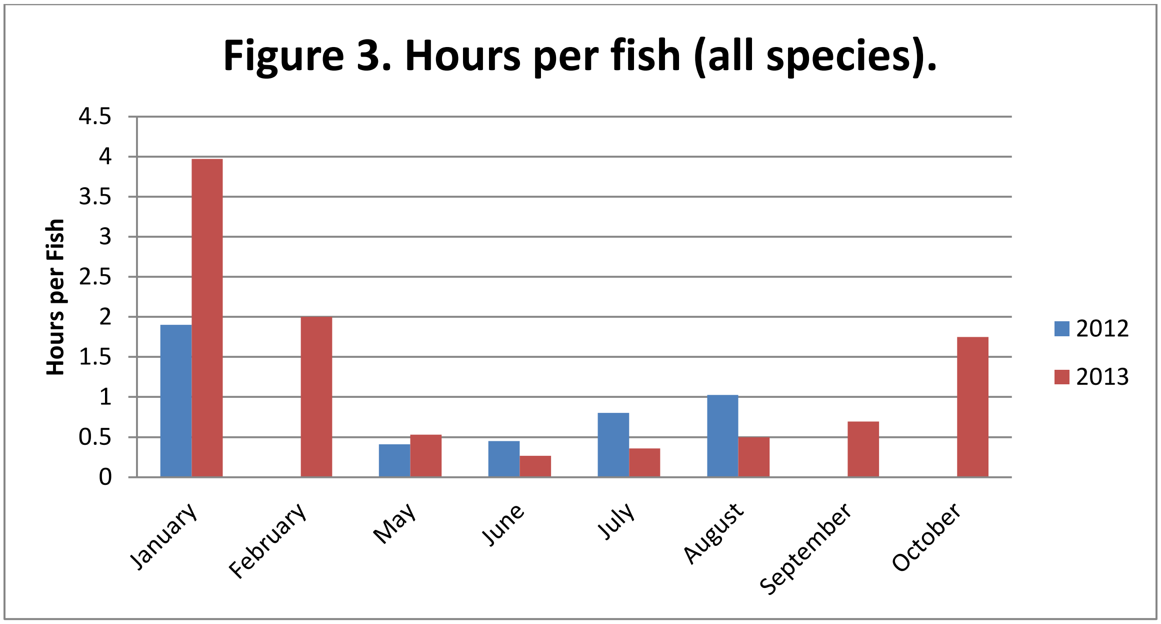
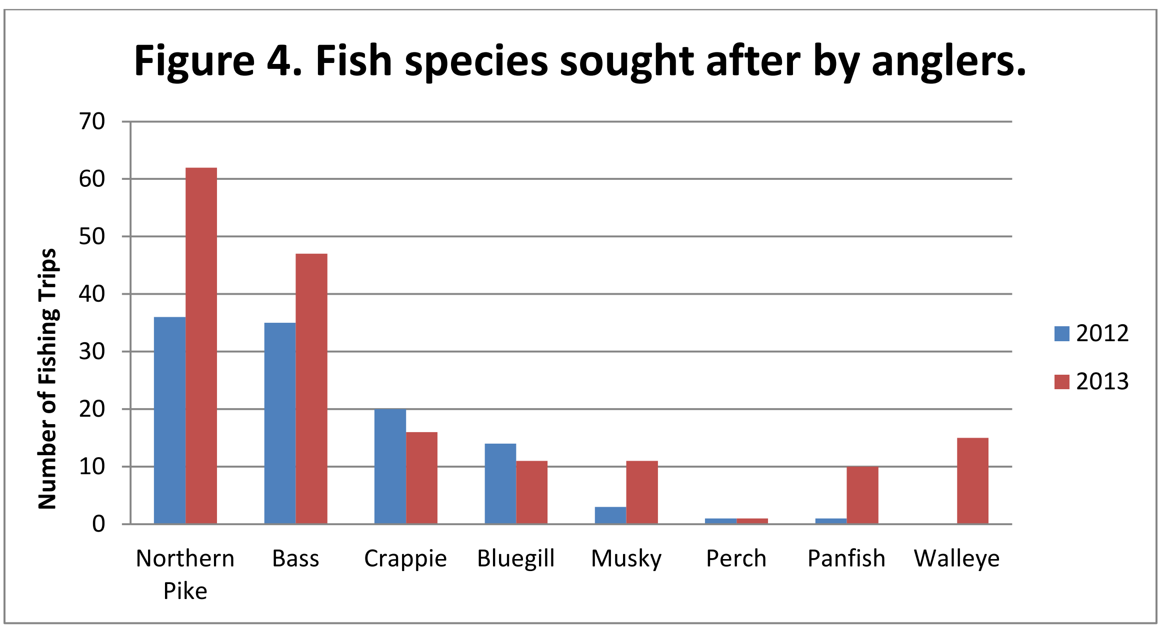


Figure 3 indicates the hours spent per fish in 2012 and 2013. January had the highest effort per fish rate in both years.



Anglers indicated (with a percentage) what species of fish they were intending to catch (Figure 4). In some cases, it was recorded that anglers intended to catch three different species in the same outing. Northern pike and bass were the most sought after fish species.



Anglers recorded the platforms from which they fished. Their responses were: fishing boat, ice, dock/pier, rowboat, duck boat, and pontoon. The majority of reporting anglers fished from a fishing boat (Figure 5).

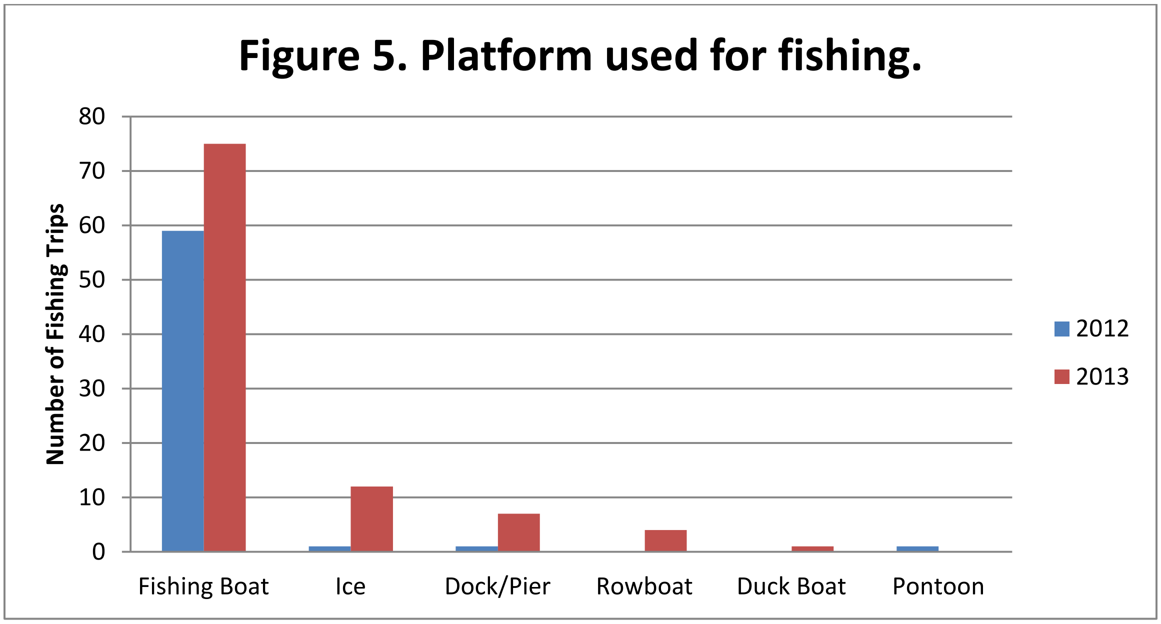
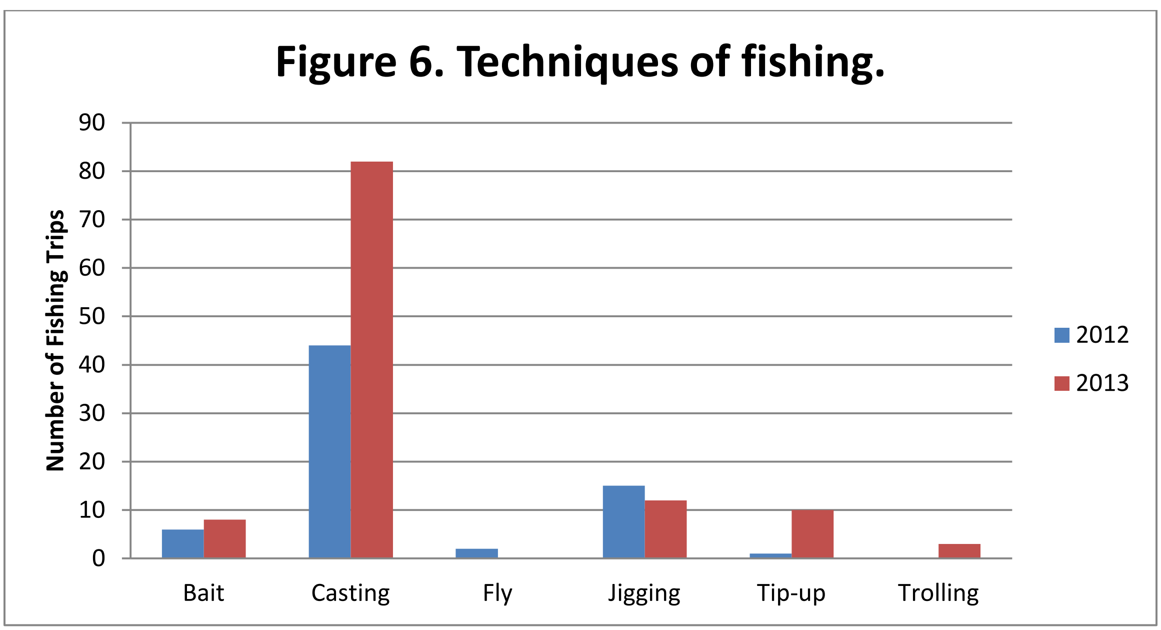
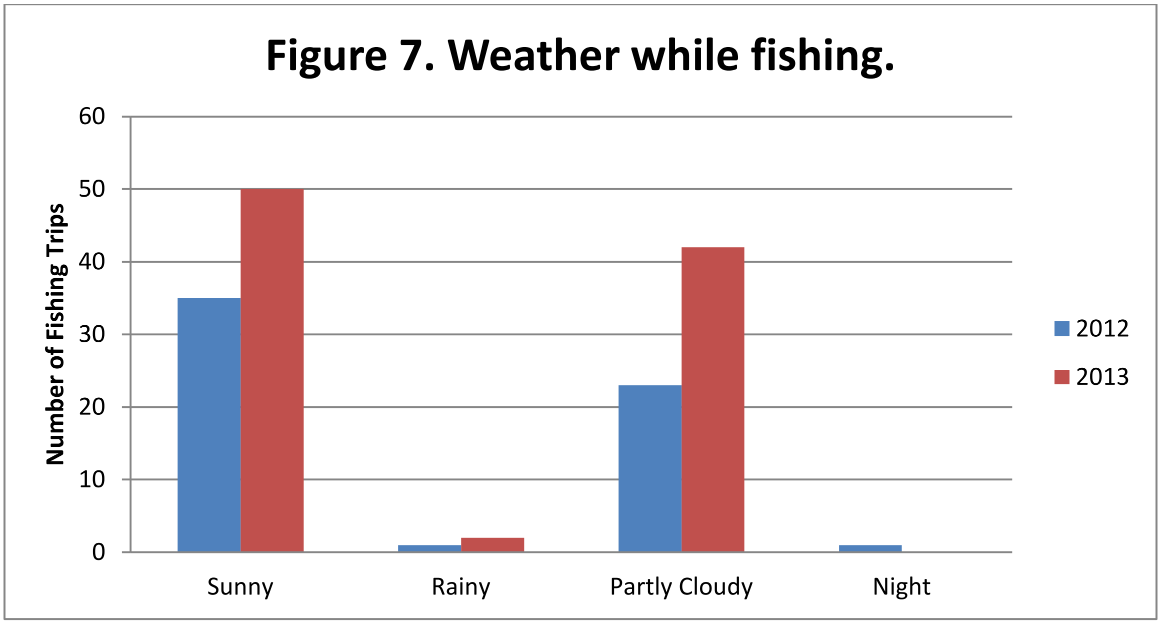


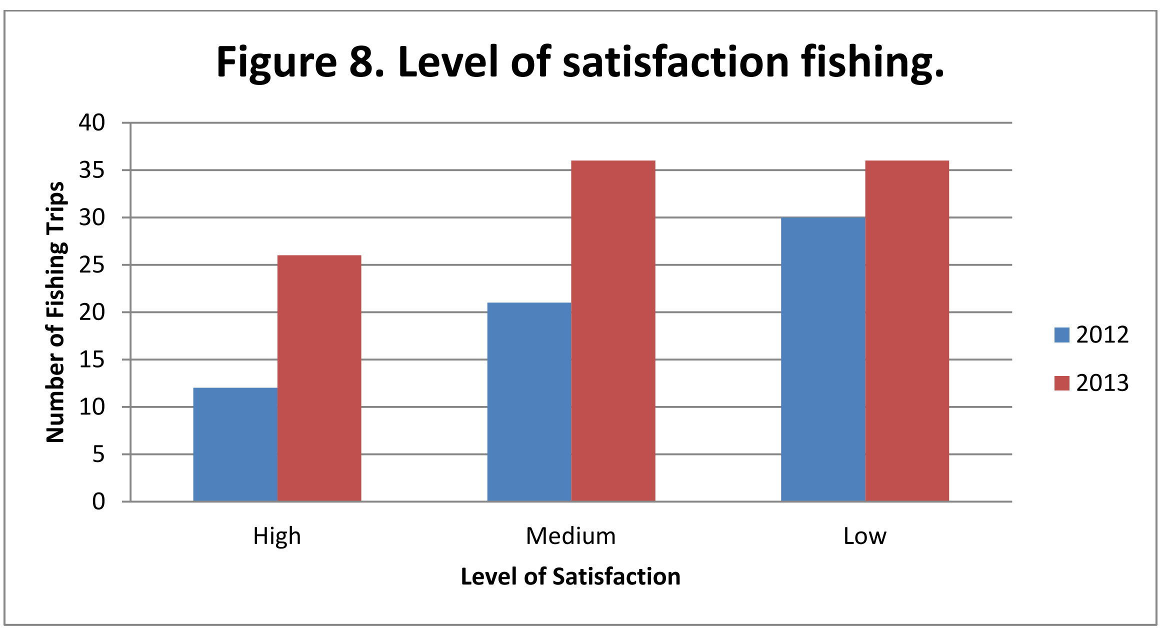
Figure 6 displays different techniques of fishing used by anglers. The most common technique was casting, followed by jigging.



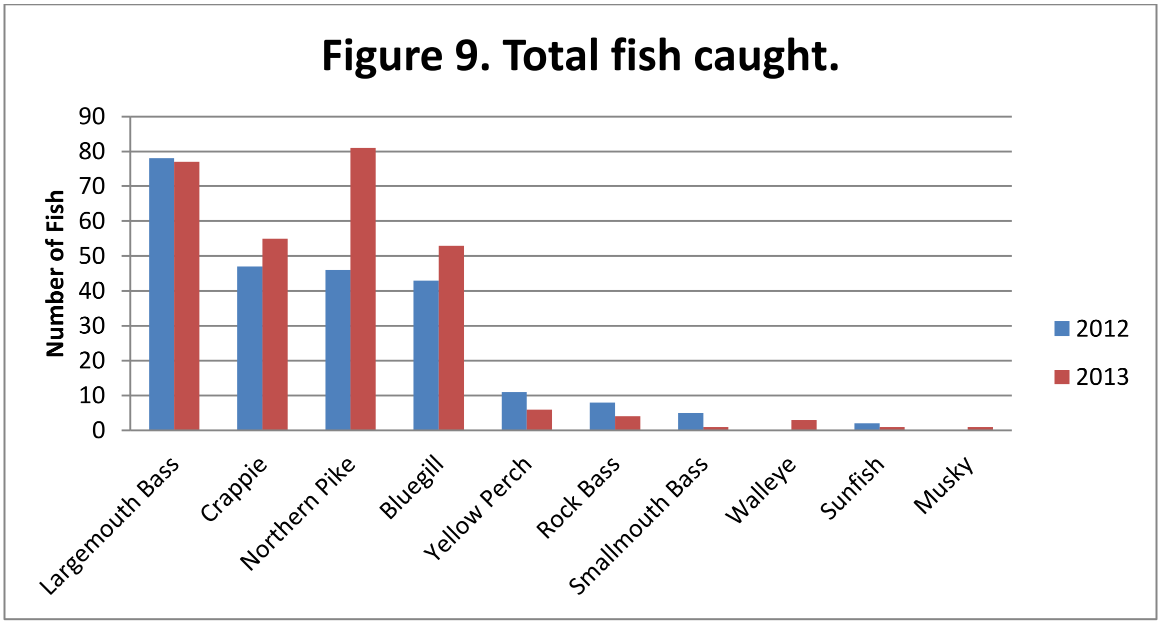
Weather data was also recorded as part of the anglers' journals. The majority of anglers fished when it was sunny (Figure 7).



Anglers rated their level of satisfaction fishing as high, medium, or low (Figure 8). In 2012, nearly half of the fishing trips rated satisfaction as low and about 20% of trips were rated as high satisfaction. In 2013, 12% of the fishing trips were rated as high satisfaction, 37% was rated medium, and 37% were rated low satisfaction.



A total of 240 fish were recorded in the anglers' journals in 2012 and 282 were recorded in 2013 (522 total fish in the two years). Largemouth bass, crappie, northern pike and bluegill were the top four fish species caught (Figure 9). Other fish species caught included: yellow perch, rock bass, smallmouth bass, walleye, and sunfish. There was one record of a 35 inch musky that was caught in October, 2012.

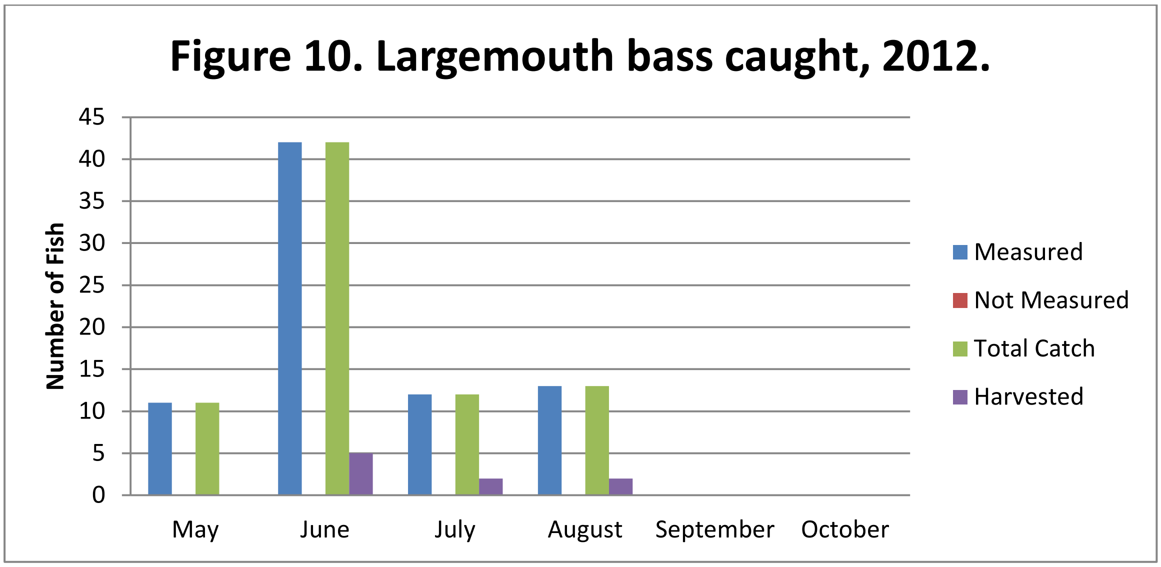


Species-specific data

For each fish species caught in North Lake, several statistics were recorded. These statistics include: number caught and harvested, average and longest length of fish both released and harvested, and length distributions. Catch and harvest numbers are the calculated number of fish (of the indicated species) caught regardless of targeted species. Average and longest length of fish caught and harvested is the monthly longest and average length of fish caught and/or harvested fish species. Length distribution is all fish of a species that were measured by the anglers from May to October. Fish species with these data are: largemouth bass, crappie, northern pike, bluegill, yellow perch, rock bass, smallmouth bass, and walleye.

LARGEMOUTH BASS

In 2012, there were 78 largemouth bass caught and 9 harvested (Figure 10). The highest catch of largemouth bass in 2012 occurred in June with 42 caught. In 2013, 77 largemouth bass were caught and 11 were harvested (Figure 11). The largest largemouth bass caught in 2012 was 21 inches (Figure 12). The largest caught in 2013 was 19 inches (Figure 13). In Figure 14 we see that the majority of largemouth bass caught in 2012 were approximately 15 inches long, and the majority of largemouth bass caught in 2013 were 13 inches long.



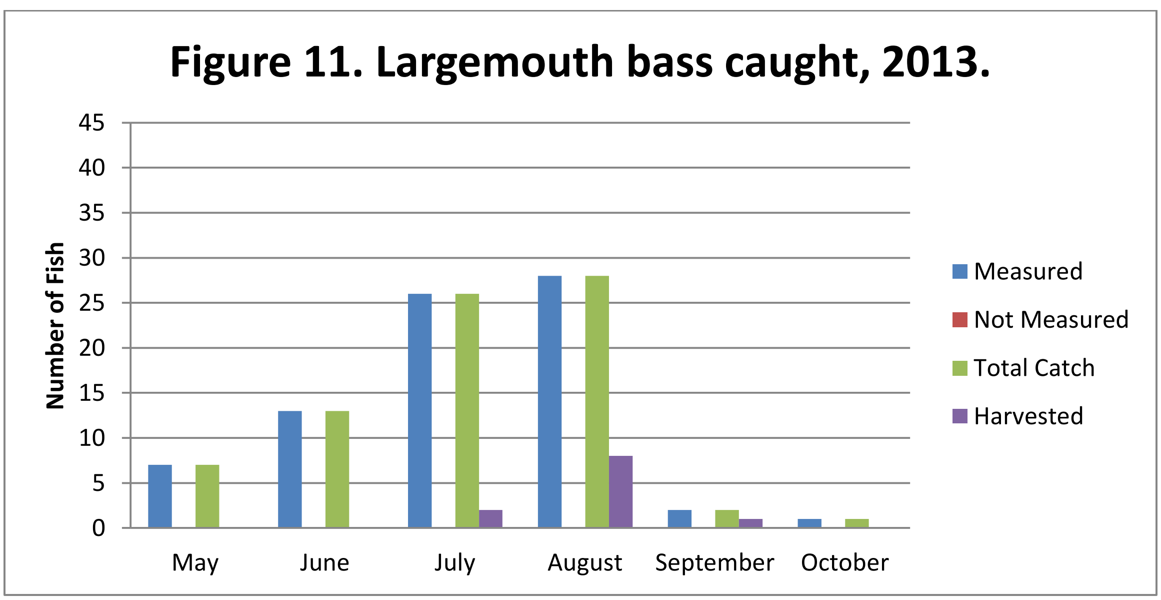


Figure 12. Average and largest length of largemouth bass, 2012.

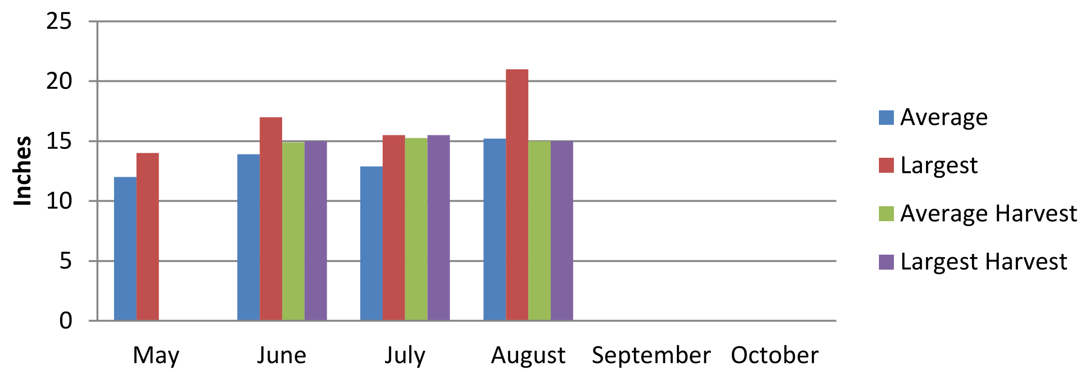


Figure 13. Average and largest length of largemouth bass, 2013.

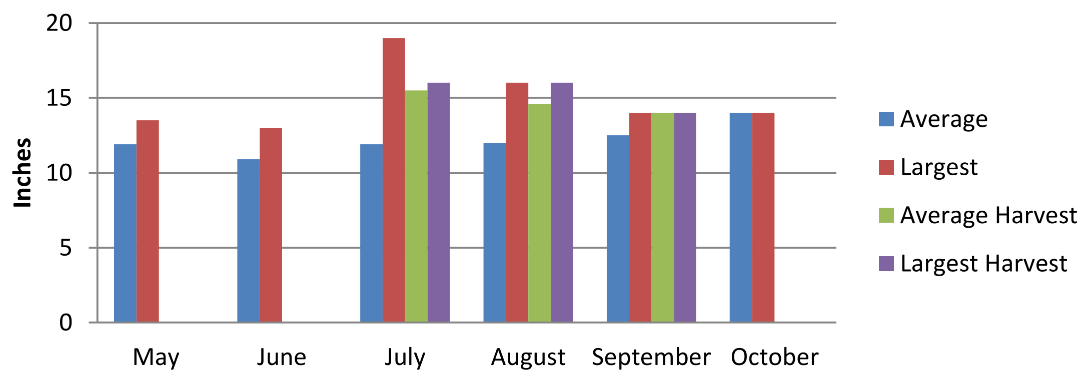
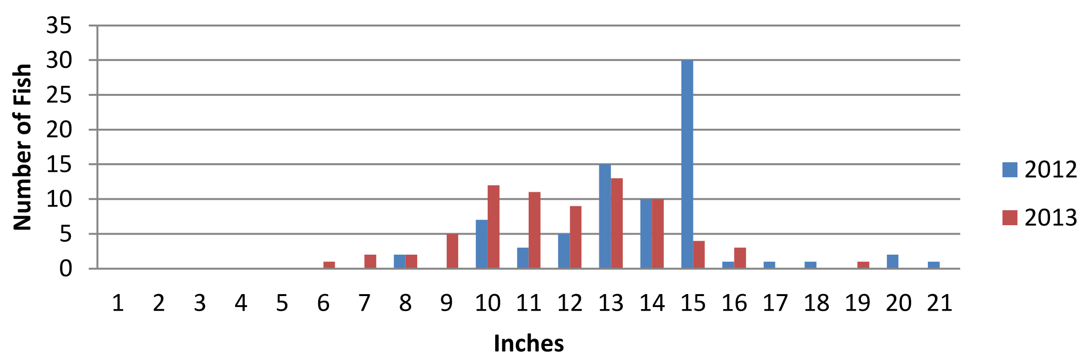
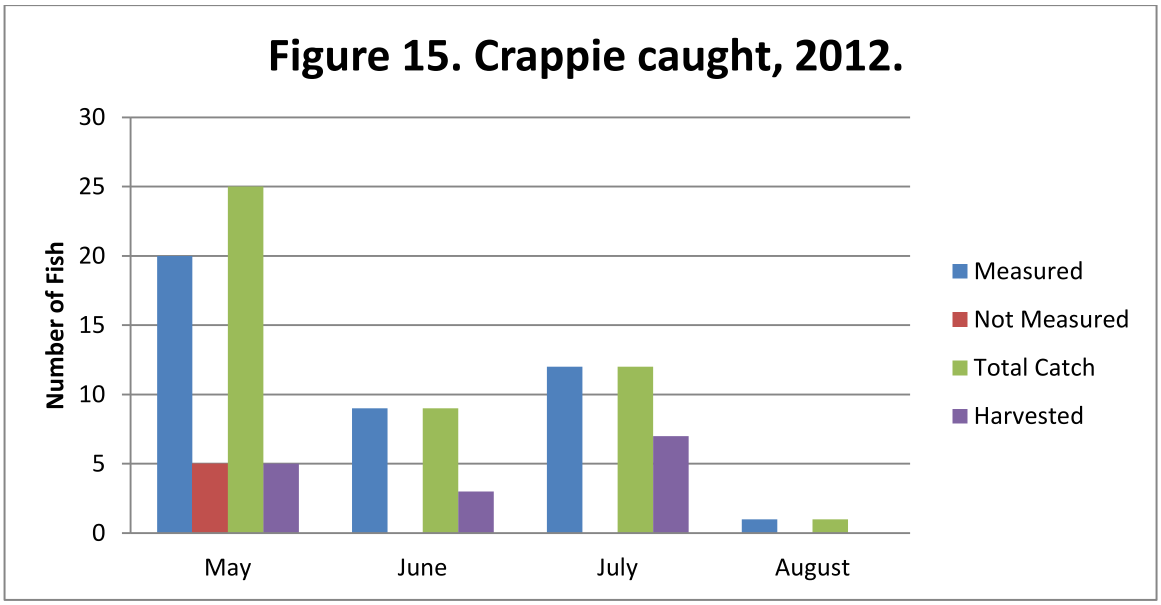


Figure 14. Length distribution of largemouth bass.



CRAPPIE

The total crappies caught in 2012 were 47 with 15 harvested (Figure 15). In 2013, 55 were caught and 39 were harvested (Figure 16). In 2012, the average lengths of crappies caught ranged from 8.2 inches (July) to 10.0 inches (August) (Figure 17). In 2013, the largest harvested crappie was 11.5 inches long (Figure 18). In 2012, crappies caught ranged from 6 to 12 inches, and in 2013, the majority of crappies caught were 10 inches long (Figure 19).



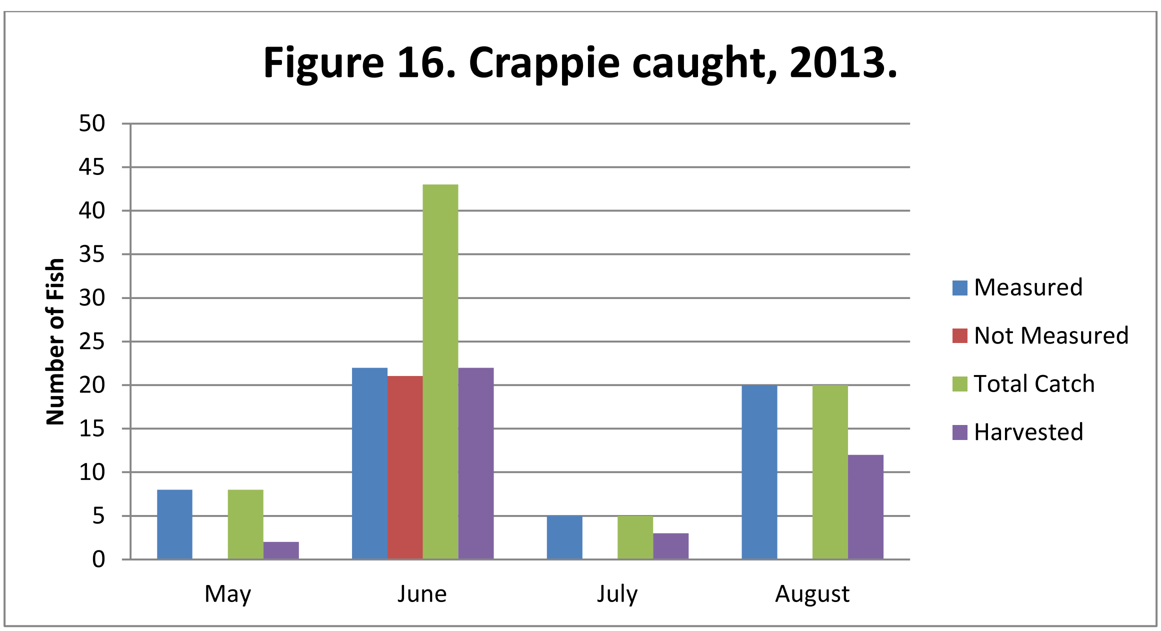


Figure 17. Average and largest length of crappie, 2012.

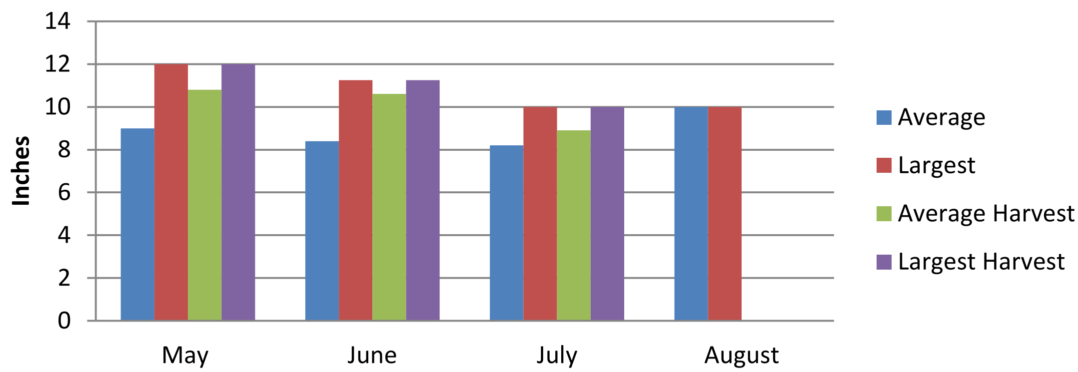


Figure 18. Average and largest length of crappie, 2013.

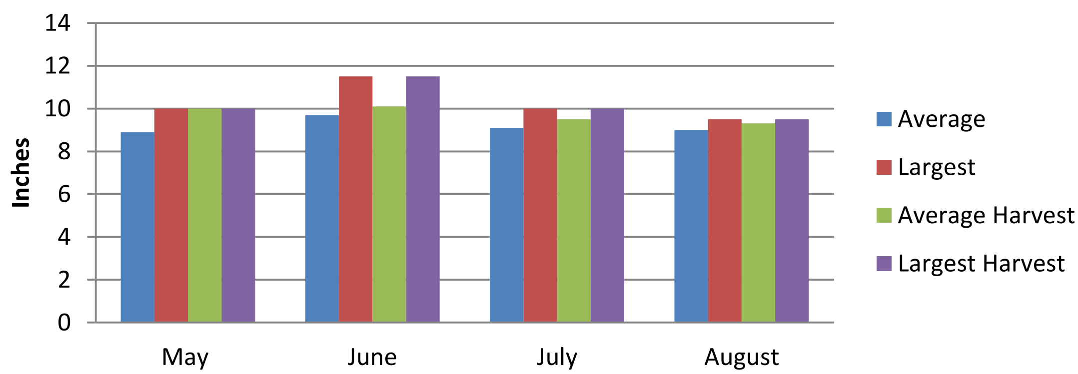
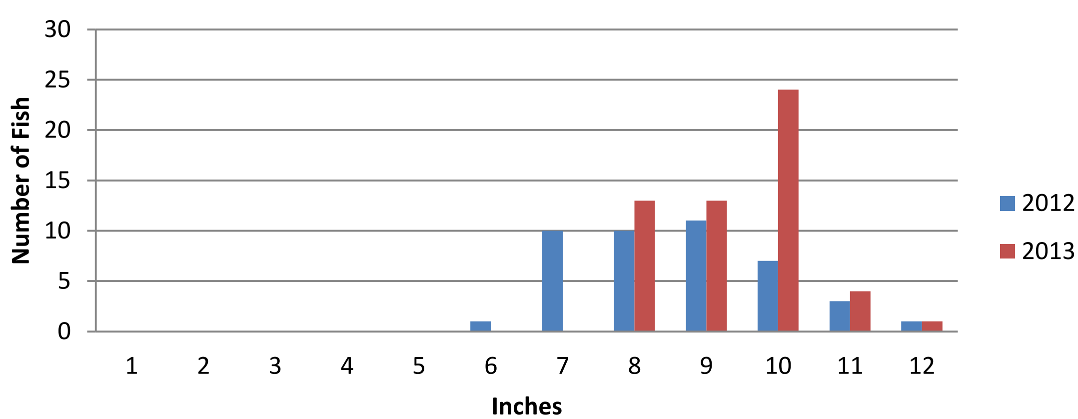


Figure 19. Length distribution of crappie.



NORTHERN PIKE

In 2012, there were 46 northern pike caught and 11 harvested, with the majority caught in June (Figure 20). In 2013, there were 81 caught and 5 harvested, with the majority caught in August (Figure 21). The largest northern pike caught in 2012 was 36 inches (Figure 22), and in 2013 the largest caught was 31 inches (Figure 23). The length of northern pike caught in 2012 ranged from 12 to 36 inches and from 9 to 31 inches in 2013 (Figure 24). In 2013, the majority of northern pike caught measured 17 inches.

Figure 20. Northern pike caught, 2012.

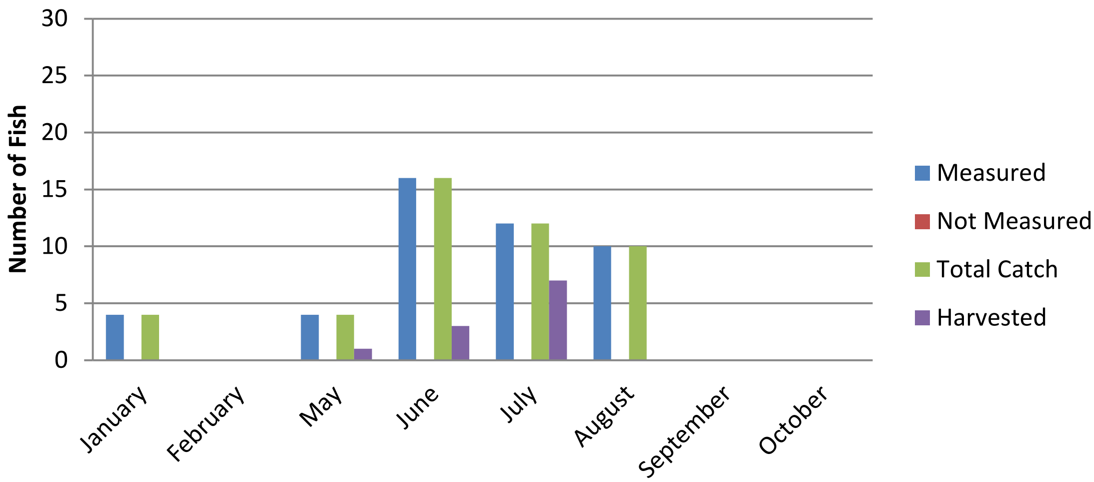
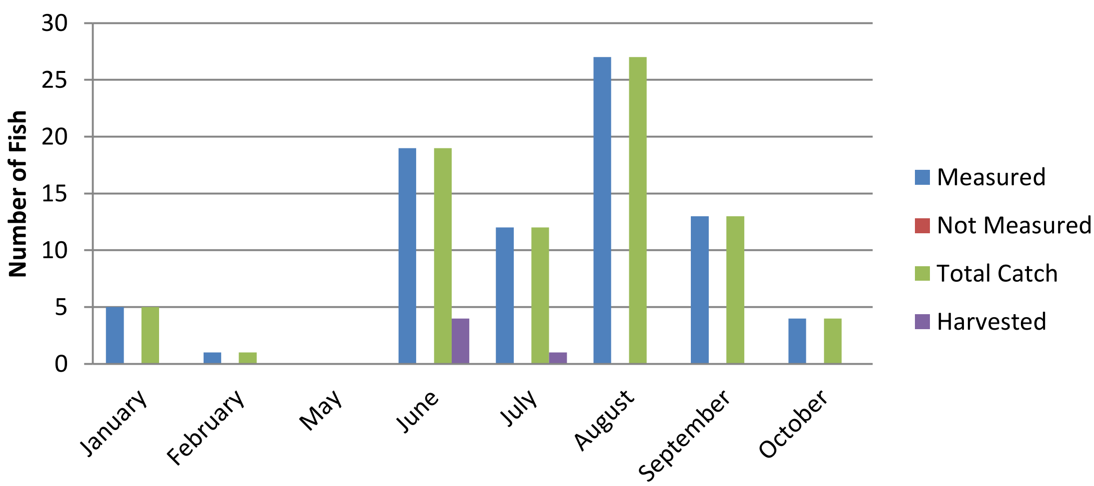


Figure 21. Northern pike caught, 2013.



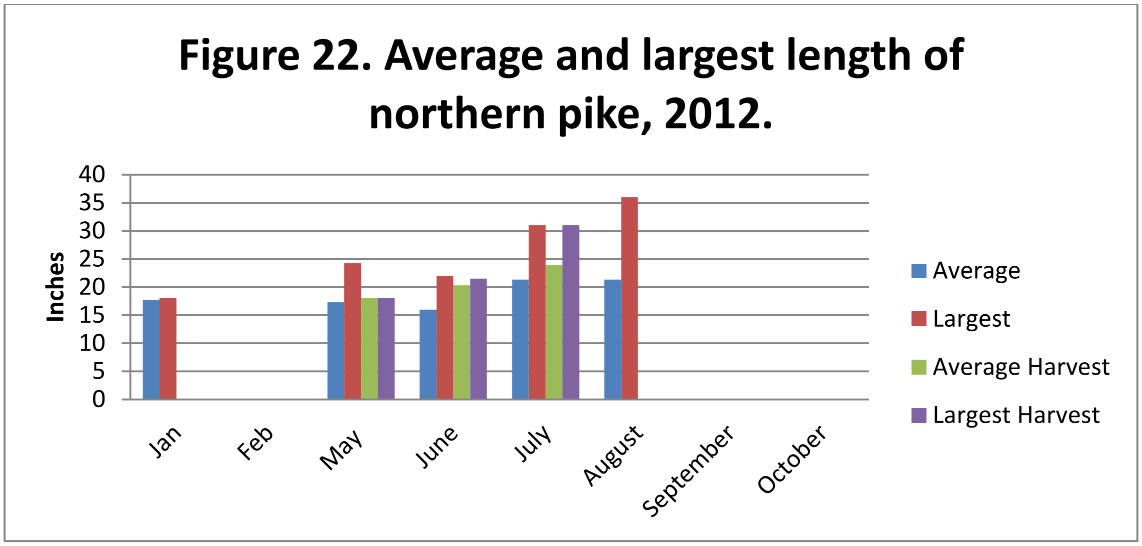


Figure 22. Average and largest length of northern pike, 2012.
Inches
40
35
30
25
20
15
10
5
0
Jan
Feb
May
June
July
August
September
October
Average
Largest
Average Harvest
Largest Harvest

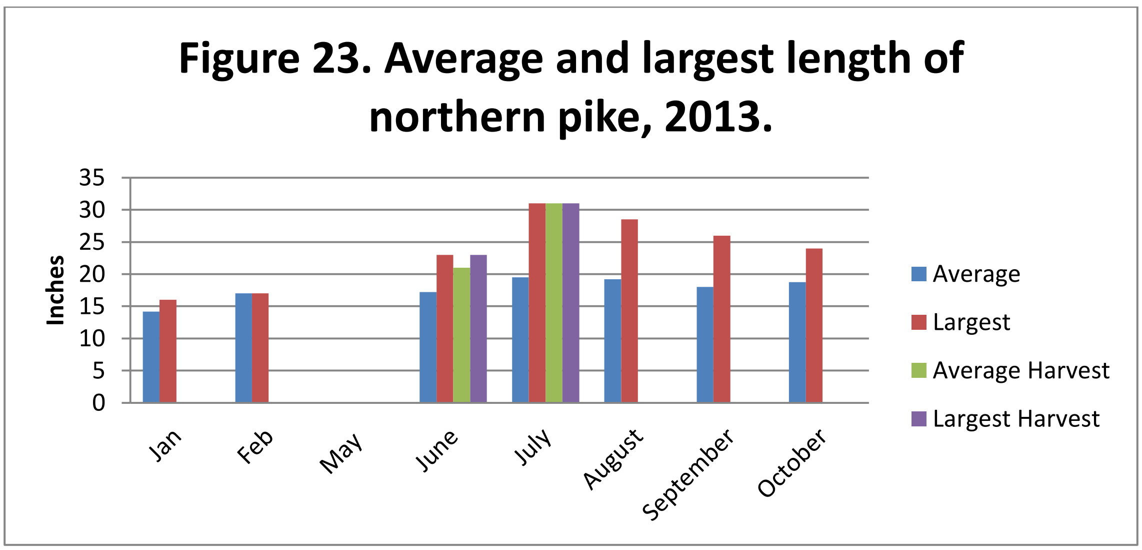


Figure 23. Average and largest length of northern pike, 2013.
Inches
35
30
25
20
15
10
5
0
Jan
Feb
May
June
July
August
September
October
Average
Largest
Average Harvest
Largest Harvest

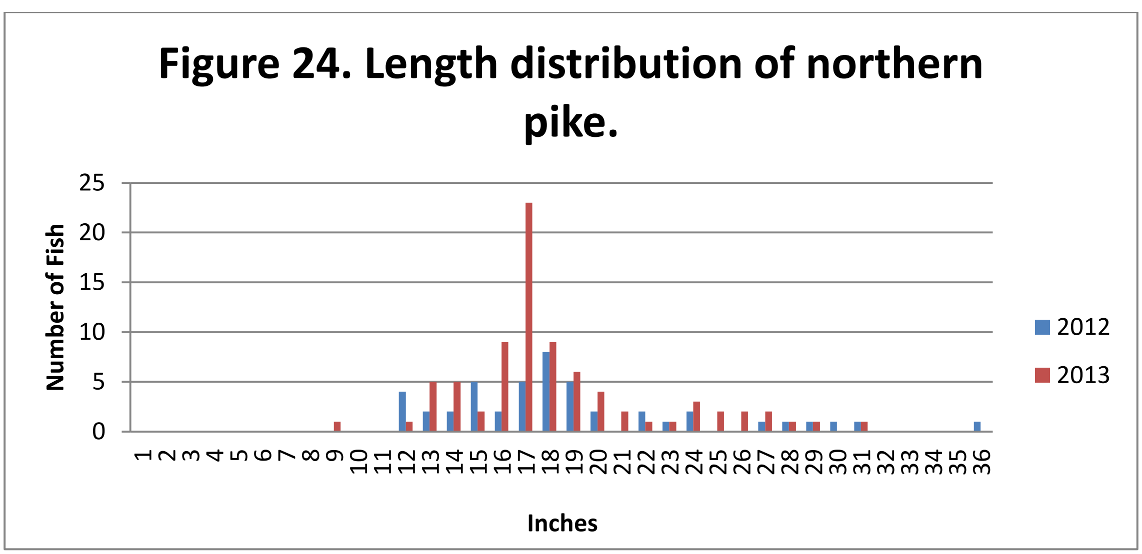


Figure 24. Length distribution of northern pike.
Number of Fish
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Inches
2012
2013

BLUEGILL

In 2012, 43 bluegill were caught and 14 were harvested (Figure 25). The total number of bluegill caught in 2013 was 210. In 2012, May, June, and July had the most bluegills caught. In 2013, July had the most catches of bluegill (Figure 26). The largest bluegill caught in 2012 was 9 inches (Figure 27). In 2013, the largest bluegill caught was 7.5 inches (Figure 28). Over both years, the size ranged from 4 to 9 inches (Figure 29).

Figure 25. Bluegill caught, 2012.

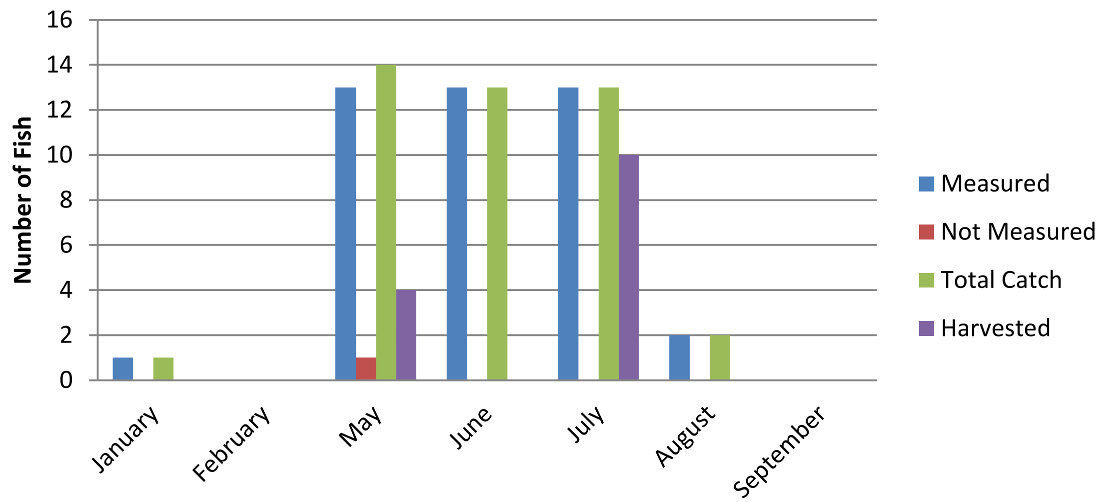


Figure 26. Bluegill caught, 2013.

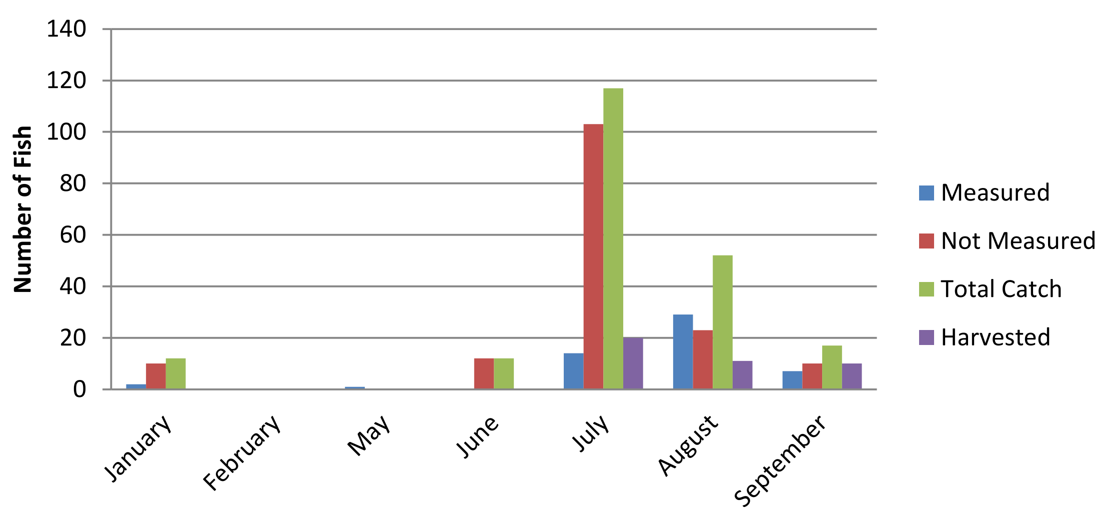


Figure 27. Average and largest length of bluegill, 2012.

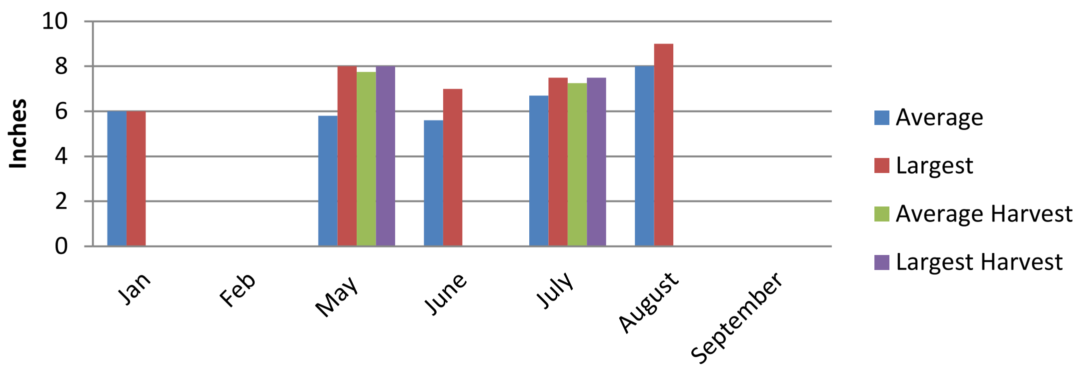


Figure 28. Average and largest length of bluegill, 2013.

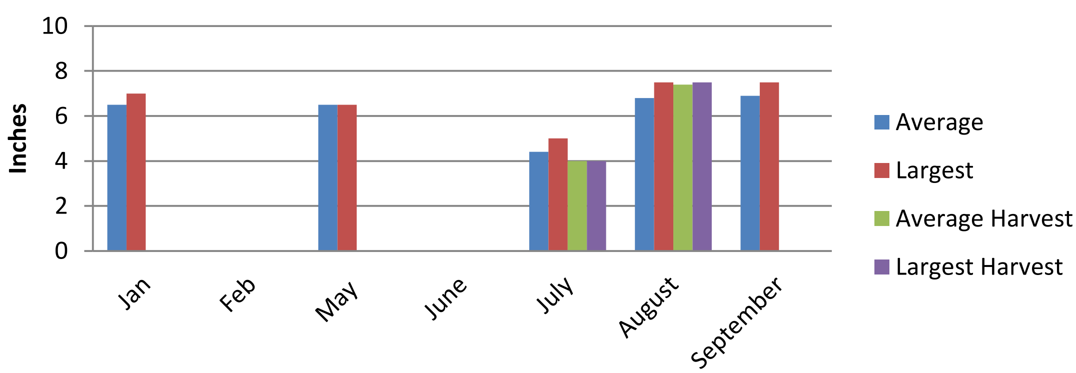
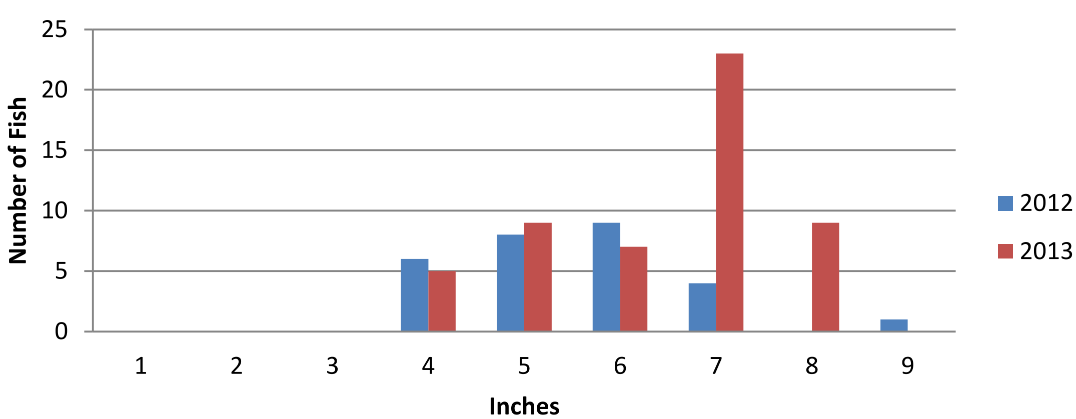


Figure 29. Length distribution of bluegill.



YELLOW PERCH

In 2012, 11 yellow perch were caught and 3 were harvested (Figure 30). In 2013, six yellow perch were caught and 5 were harvested (Figure 31). The largest yellow perch caught and harvested in both 2012 and 2013 was 10.5 inches (Figures 32 and 33). The length of yellow perch caught in 2012 ranged from 4 to11 inches and from 7 to11 inches in 2013 (Figure 34).

Figure 30. Yellow perch caught, 2012.

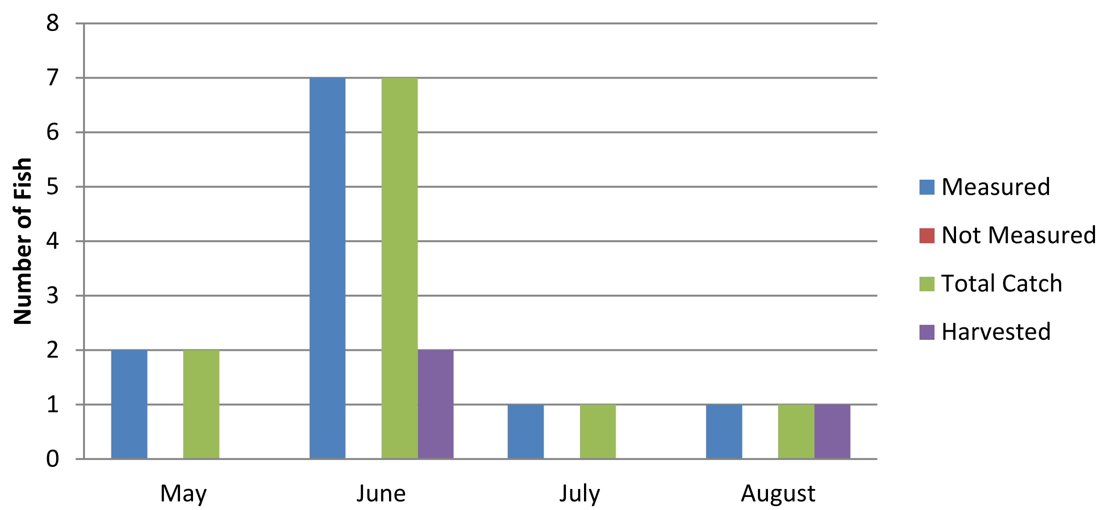


Figure 31. Yellow perch caught, 2013.

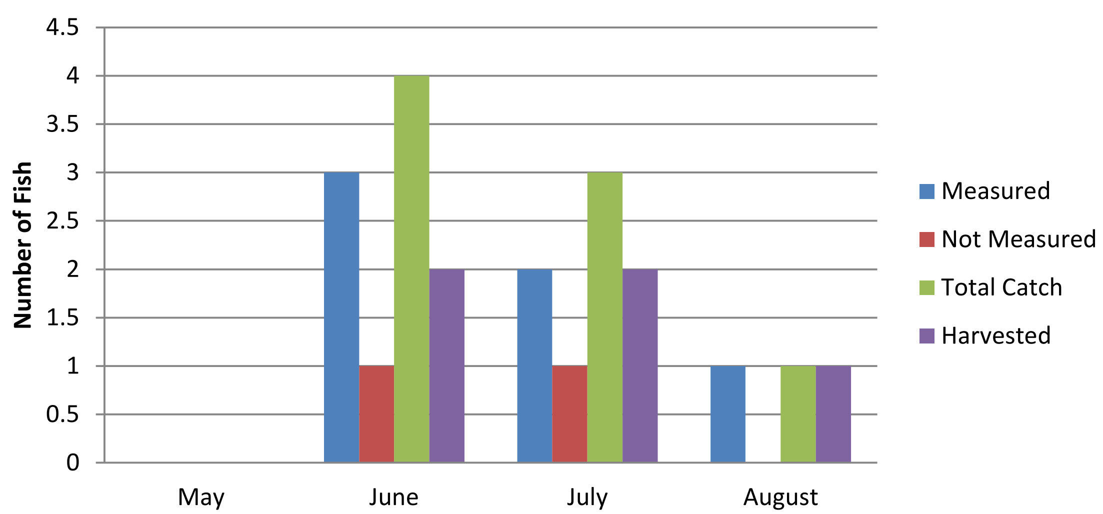


Figure 32. Average and largest length of yellow perch, 2012.

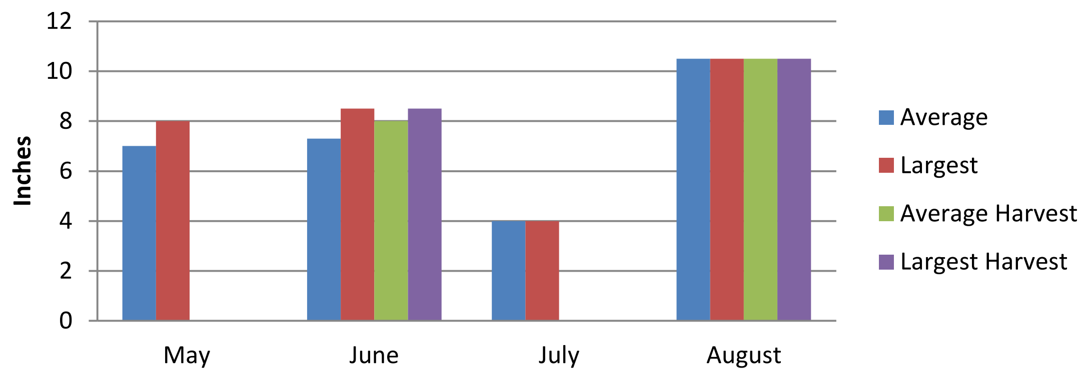


Figure 33. Average and largest length of yellow perch, 2013.

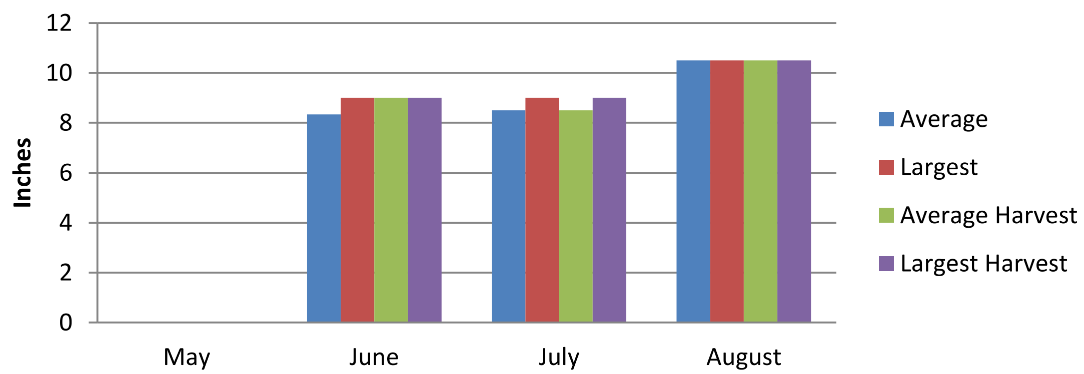
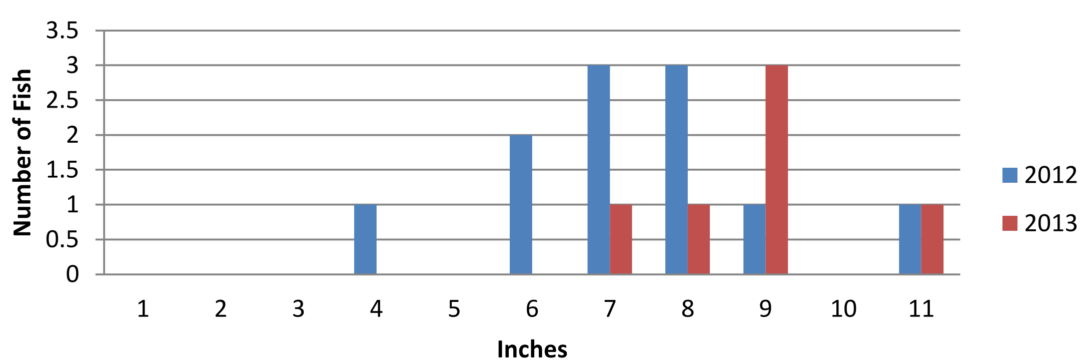
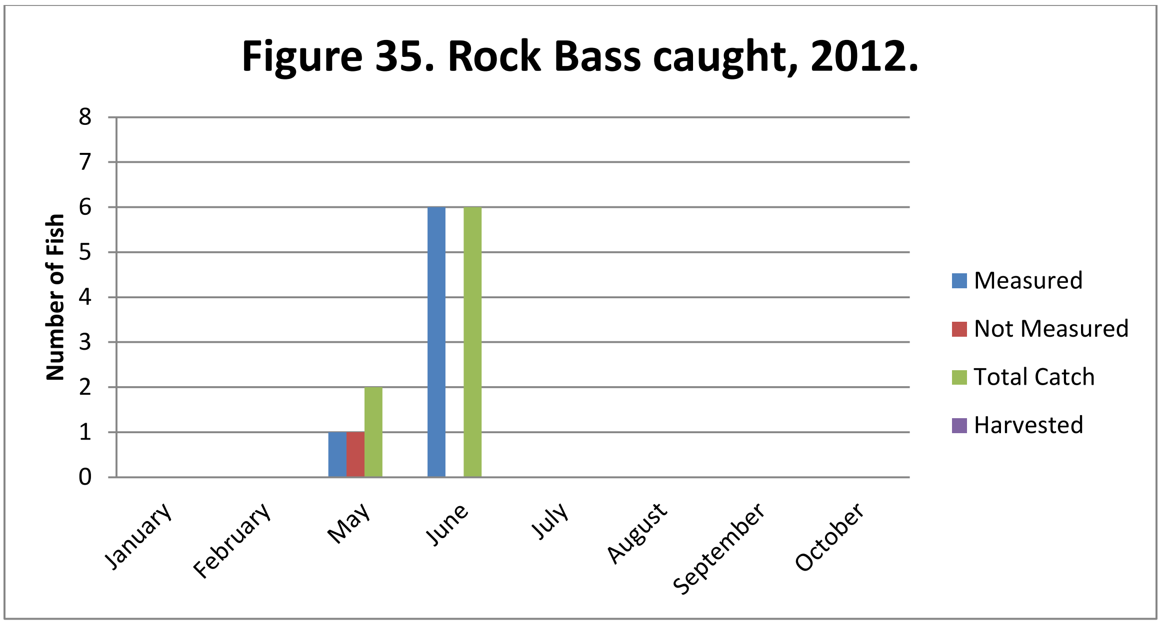


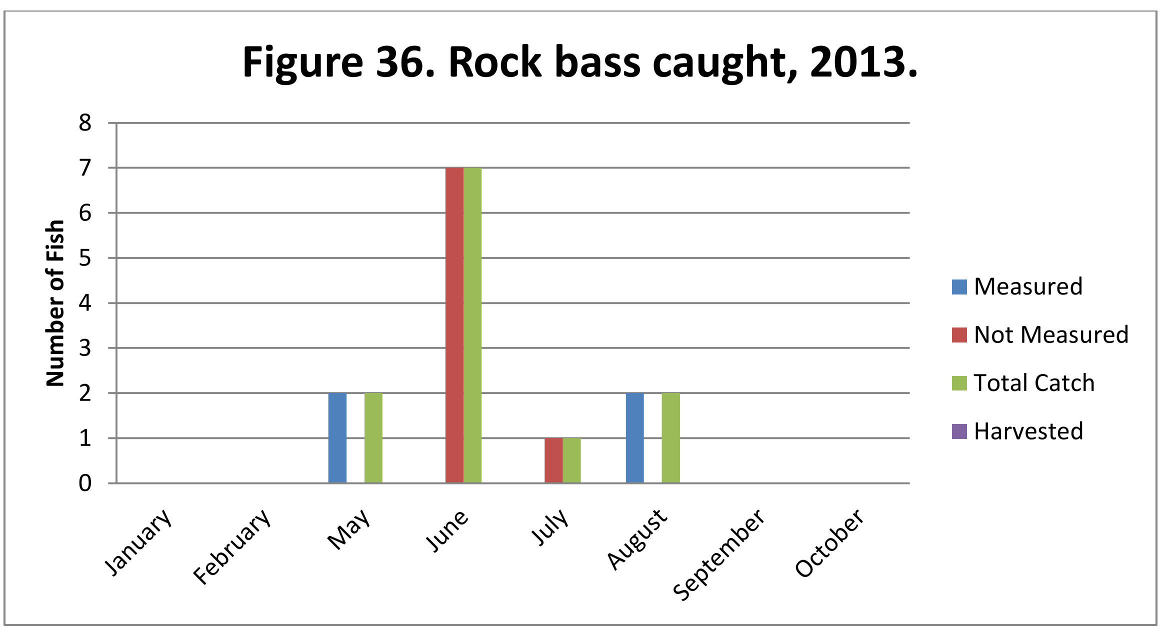
Figure 34. Length distribution of yellow perch.



ROCK BASS

Eight rock bass were caught in 2012 and 12 were caught in 2013 (Figures 35 and 36). None were harvested in either year. In 2012, the largest rock bass measured was 8 inches (Figure 37). In 2013, the largest measured 9 inches (Figure 38). The length ranged from 6 to 8 inches in 2012, and from 4 to 9 inches in 2013 (Figure 39).





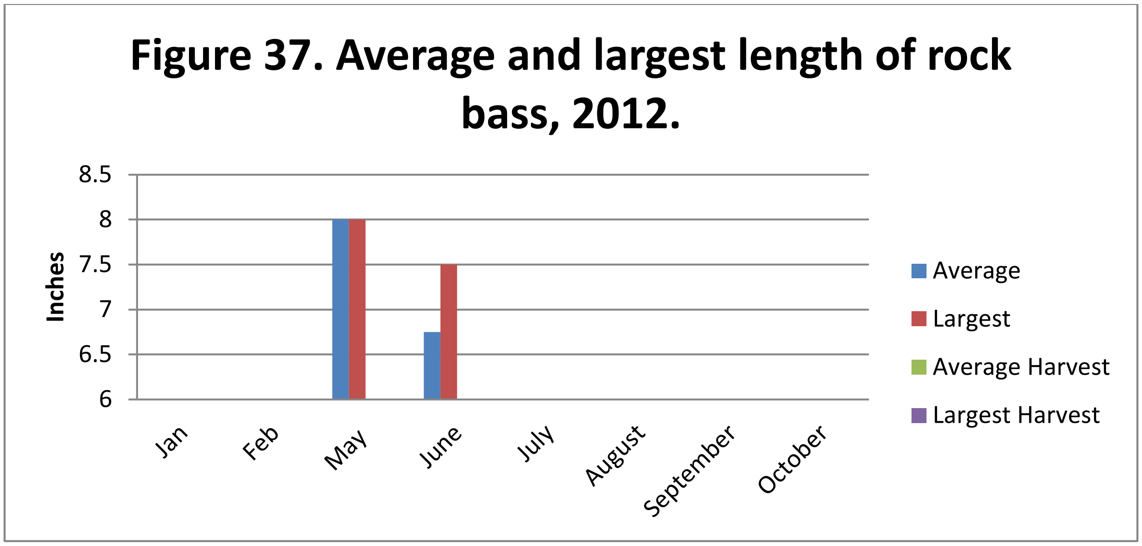


Figure 37. Average and largest length of rock bass, 2012.
Inches
8.5
8
7.5
7
6.5
6
Jan
Feb
May
June
July
August
September
October
Average
Largest
Average Harvest
Largest Harvest

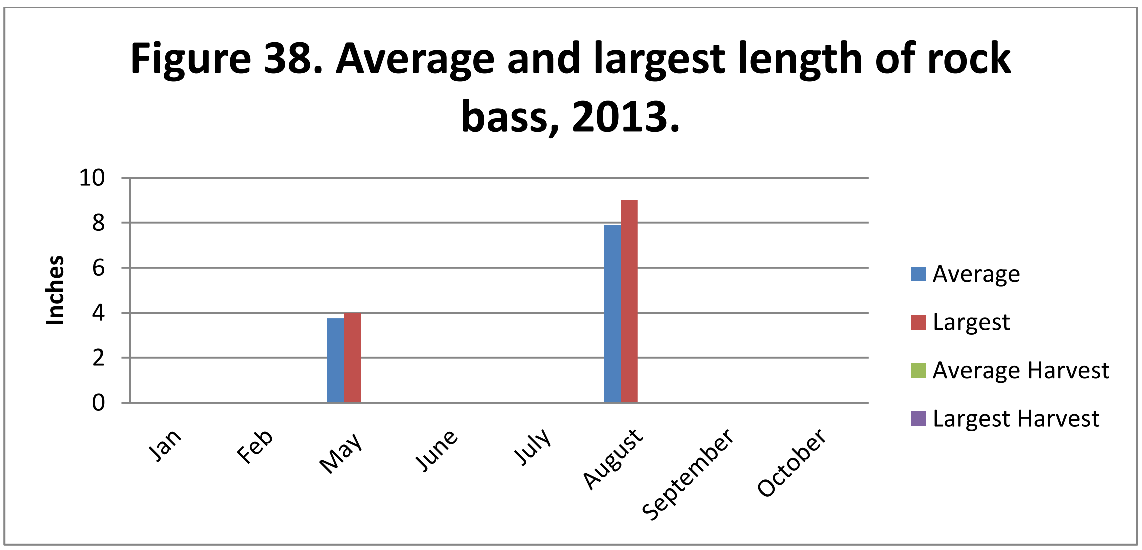


Figure 38. Average and largest length of rock bass, 2013.
Inches
10
8
6
4
2
0
Jan
Feb
May
June
July
August
September
October
Average
Largest
Average Harvest
Largest Harvest

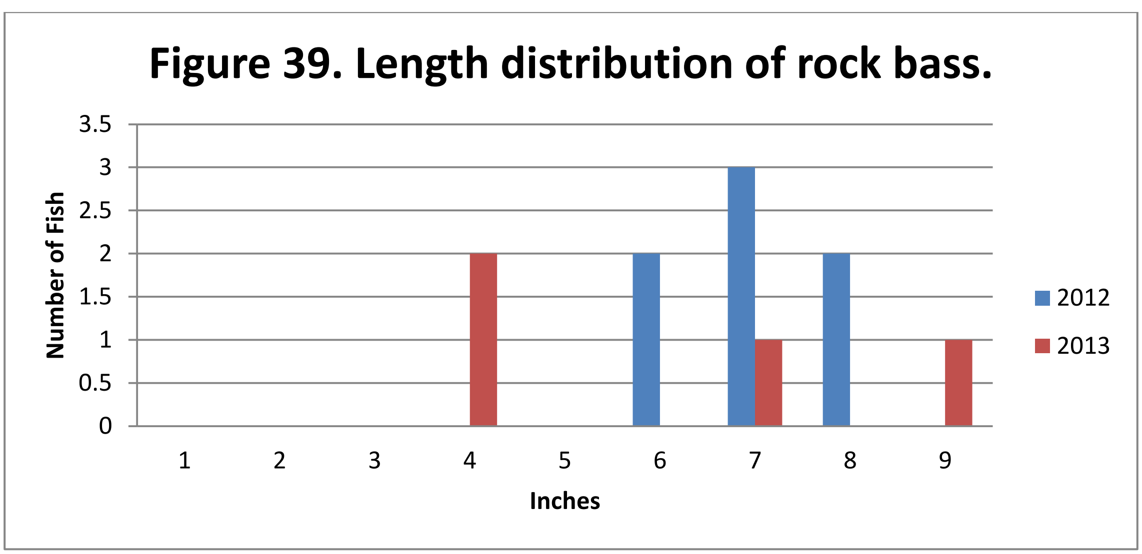


Figure 39. Length distribution of rock bass.
Number of Fish
3.5
3
2.5
2
1.5
1
0.5
0
1
2
3
4
5
6
7
8
9
Inches
2012
2013

SMALLMOUTH BASS

Smallmouth bass numbers were low in both years with 5 smallmouth bass caught in 2012 (Figure 40) and one caught in 2013. The largest smallmouth bass caught in 2012 was 15 inches (Figure 41), and the one smallmouth bass caught in 2013 was 13 inches. No smallmouth bass were harvested in either year. Length of fish caught in both years ranged from 6 to 15 inches (Figure 42).

Figure 40. Smallmouth bass caught, 2012.

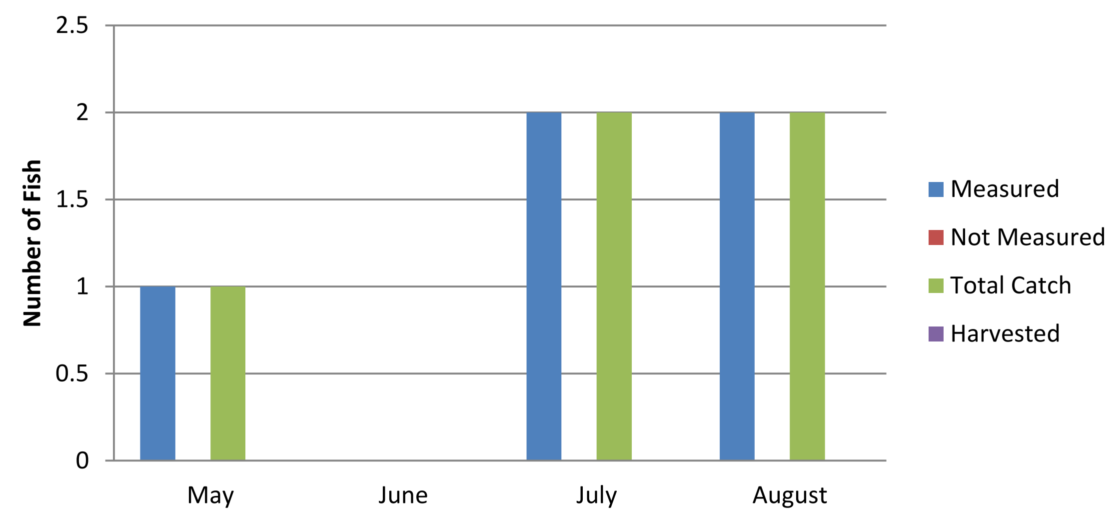
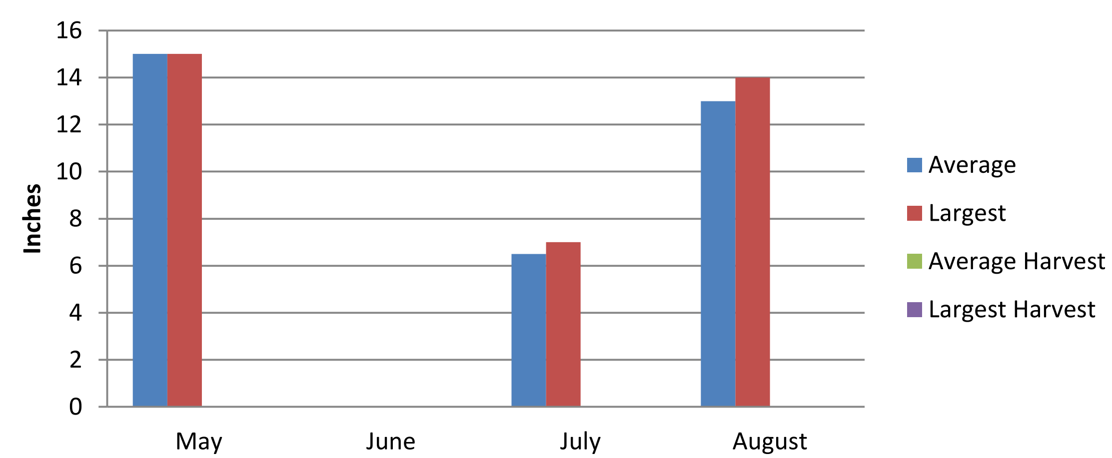


Figure 41. Average and largest length of smallmouth bass, 2012.



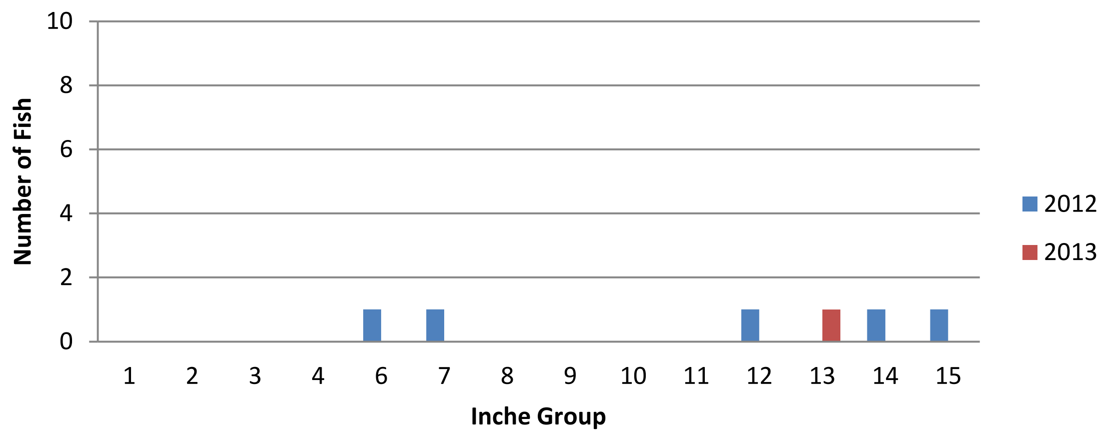


Figure 42. Length distribution of smallmouth bass.

WALLEYE

There were no walleye catches recorded in 2012. Three walleye were caught with two harvested in 2013 (Figure 43). The average walleye length in 2013 was 20.5 inches (Figure 44). Smallest and largest walleye lengths were 8 inches and 23 inches (Figure 45).

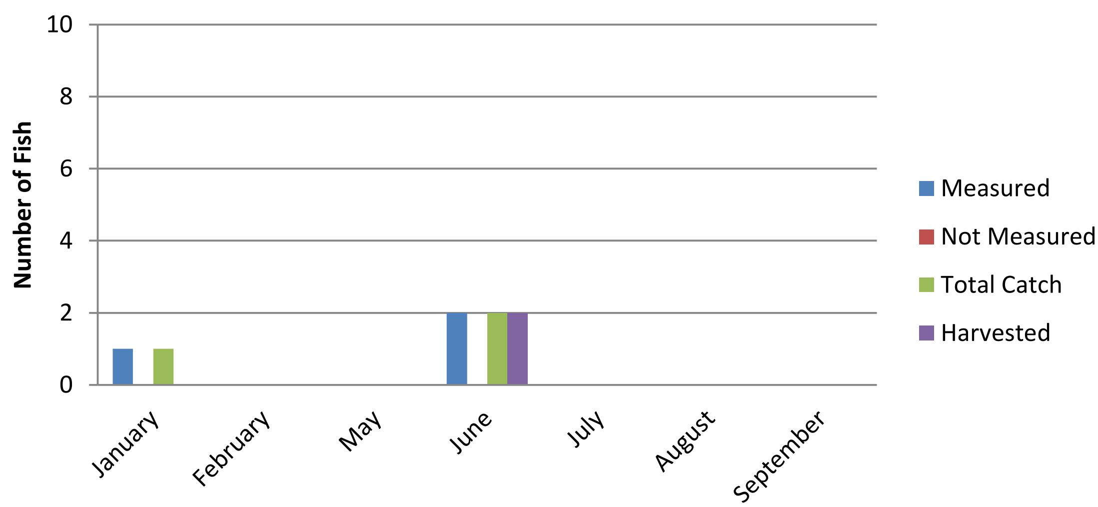


Figure 43. Walleye caught, 2013.

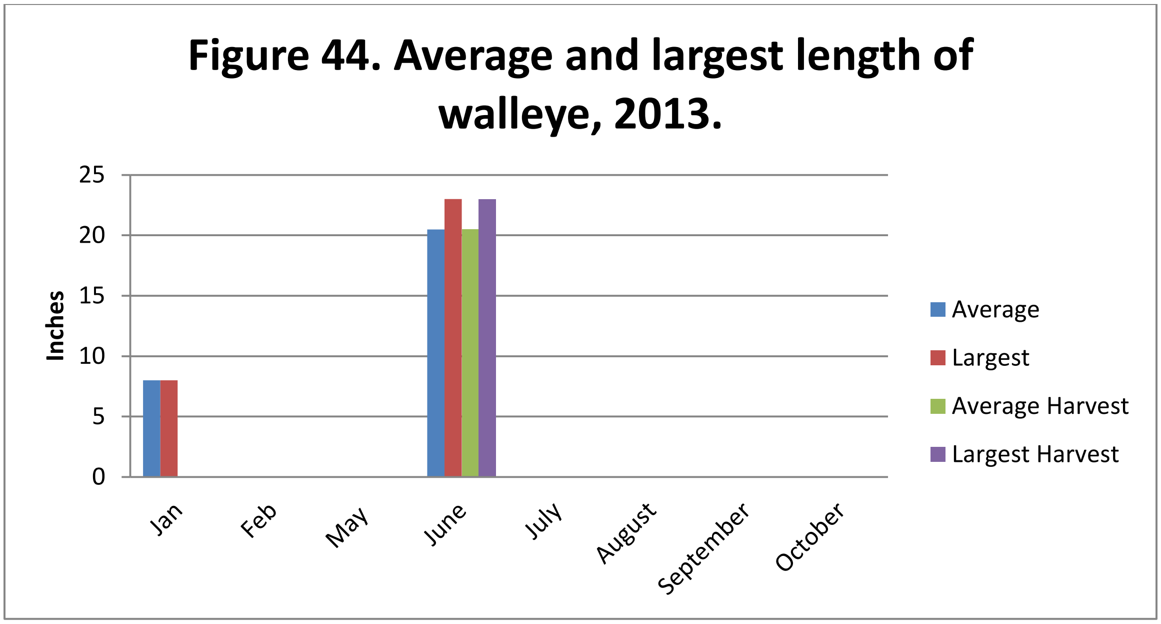


Figure 44. Average and largest length of walleye, 2013.
Inches
25
20
15
10
5
0
Jan
Feb
May
June
July
August
September
October
Average
Largest
Average Harvest
Largest Harvest

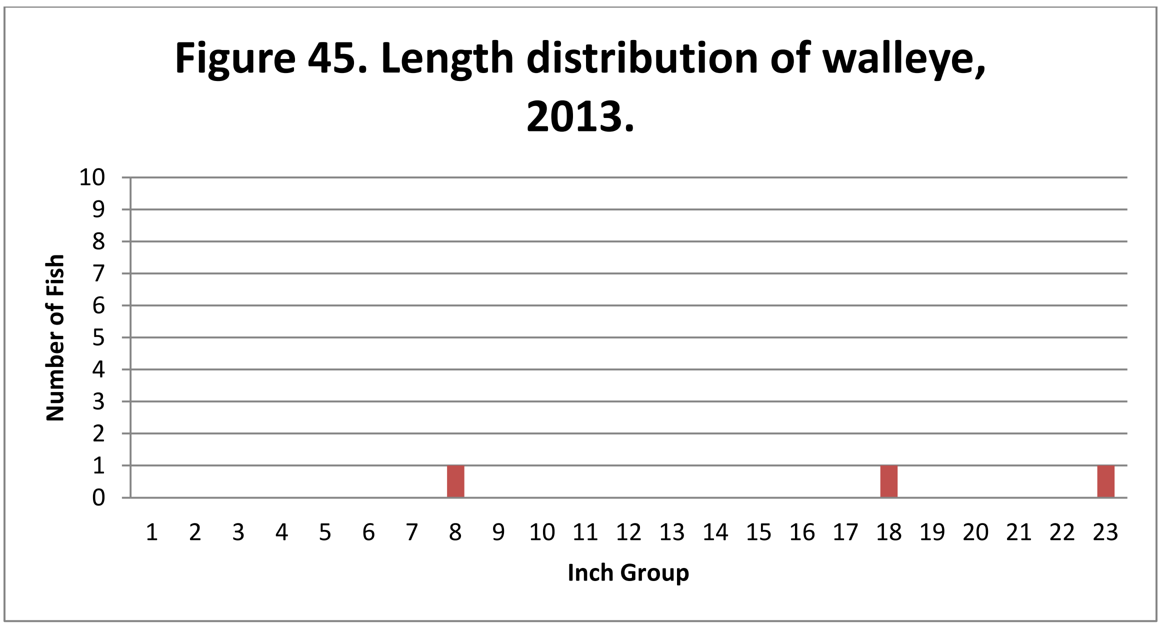


Figure 45. Length distribution of walleye, 2013.
Number of Fish
10
9
8
7
6
5
4
3
2
1
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Inch Group

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WHITE WATER ASSOCIATES, INC.

Appendix J
North Lake Frog and Toad Survey

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WHITE WATER ASSOCIATES, INC.

North Lake Stewardship Program
Frog & Toad Survey

This document is a product of a WDNR Lake Planning Grant awarded to:

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Submitted to:

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Date: November 2014

Introduction

One component of the North Lake Stewardship Program was to establish a volunteer frog and toad survey of habitats in the vicinity of North Lake. Frogs and toads are sensitive to environmental changes and are good indicators of overall ecosystem health. Monitoring frogs and toads in the vicinity of North Lake provides information about the health of the watershed. The decline of amphibian populations in many areas in North America has prompted monitoring of local frog and toad populations. Many states (including Wisconsin) have developed frog and toad survey protocols for this purpose. This report documents the methods and findings for the frog and toad monitoring around North Lake.

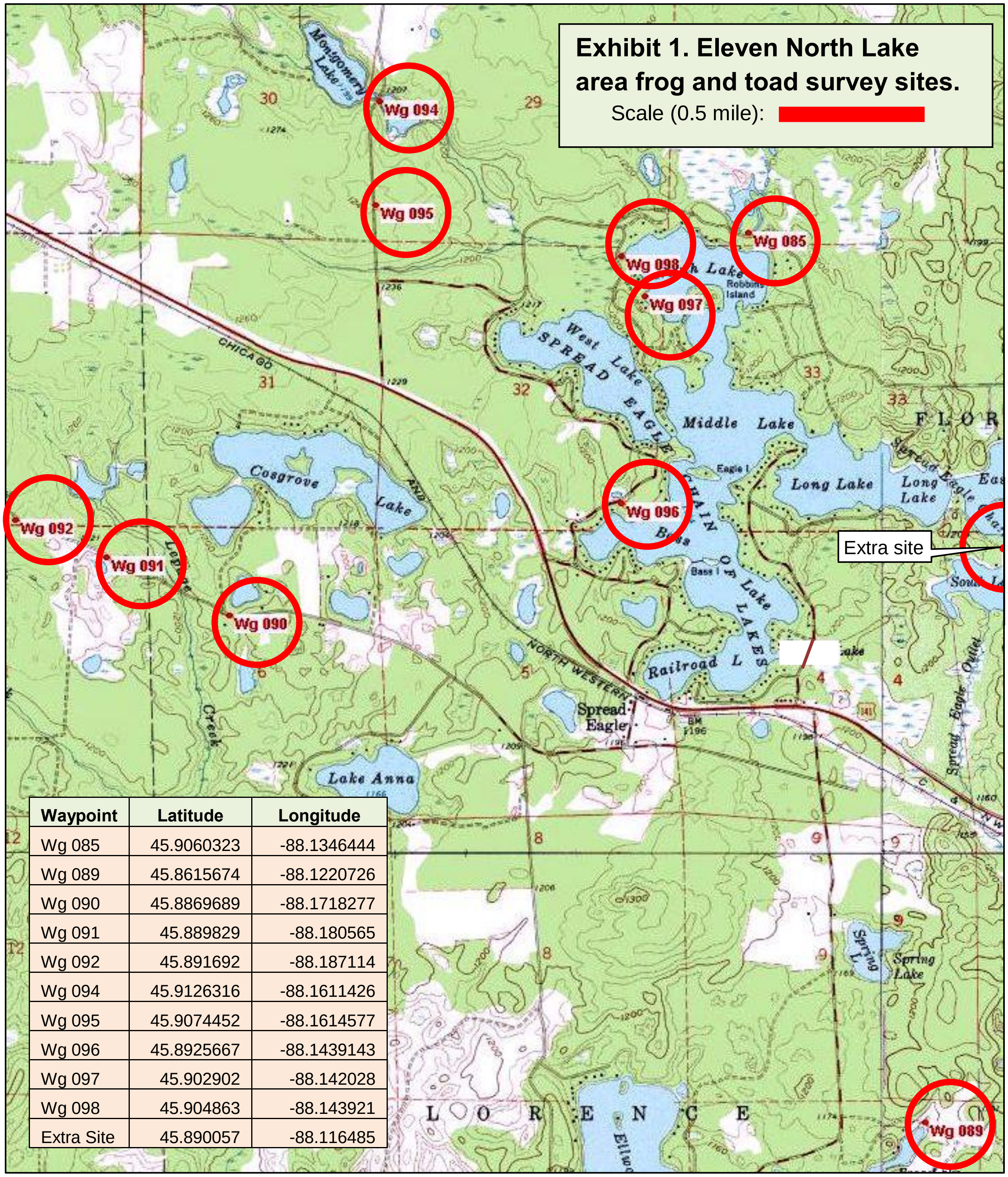
Methods

We followed the Wisconsin Frog and Toad Survey Manual[1] for site selection and field methodology. Working in consultation with lake stewardship volunteers with local knowledge of area wetlands, Dean Premo (a trained herpetologist) selected eleven sites in the immediate landscape of North Lake as prospective frog and toad survey wetlands. These sites are shown in Exhibit 1 and further described in the site summaries exhibits.

Lake steward volunteers offered their efforts for the "swing-shift" duty of surveying for frogs and toads (frog and toad monitoring typically starts after dark and may go late into the night). The volunteers were instructed by Dean Premo who also provided recordings of frog calls from which to study. *First run*, *second run*, and *third run* dates are established in an attempt to capture the breeding phenology (seasonal timing) of all frog and toad species potentially present in the area. Monitoring was conducted under weather conditions conducive to frog/toad activity and to hearing the breeding males vocalize. For this project, monitoring was conducted in 2012 and 2014. In 2012, *First Run* time period data was supplied by Dean Premo recording data

[1] Paloski, R.A. T.L.E. Bergeson, M. Mossman, and R. Hay (eds). 2006. Wisconsin Frog and Toad Survey Manual PUB-ER-649. Bureau of Endangered Resources, Wisconsin Department of Natural Resources, Madison, WI. 25 pp.

during site selection. *Second Run* sampling period data was obtained by lake steward volunteers. In 2012, no survey was done during the *Third Run* period. In 2014 all three sampling runs were by volunteer Mark Lies.



Waypoint	Latitude	Longitude
Wg 085	45.9060323	-88.1346444
Wg 089	45.8615674	-88.1220726
Wg 090	45.8869689	-88.1718277
Wg 091	45.889829	-88.180565
Wg 092	45.891692	-88.187114
Wg 094	45.9126316	-88.1611426
Wg 095	45.9074452	-88.1614577
Wg 096	45.8925667	-88.1439143
Wg 097	45.902902	-88.142028
Wg 098	45.904863	-88.143921
Extra Site	45.890057	-88.116485

According to range maps in the scientific literature and the Frog and Toad Survey Manual, eight anuran (frogs and toads) species have been documented in Florence County. Exhibit 2 provides this list. These species are the most likely anurans to be heard in the North Lake watershed. The volunteers became familiar with their vocalizations.

Exhibit 2. Florence County Frogs and Toads (Anurans).

Anurans for which Florence County Records Exist

1. Eastern American Toad (*Bufo americanus*)
2. Northern Spring Peeper (*Pseudacris crucifer*)
3. Gray Treefrog (*Hyla versicolor*)
4. Bullfrog (*Lithobates catesbeiana*)*
5. Green Frog (*Lithobates clamitans*)
6. Wood Frog (*Lithobates sylvatica*)
7. Northern Leopard Frog (*Lithobates pipiens*)*
8. Mink Frog (*Lithobates septentrionalis*)*

***** *Wisconsin's Natural Heritage Inventory current working list designates this species as SC/H=special concern/take regulated by establishment of open closed seasons*

Note: *Hyla chrysoscelis* has not been documented in Florence County, but it has been documented in the adjacent Marinette County.

Results

Field data collected is presented in the site data summary exhibits provided at the end of this report. These site summary sheets also show the location of the wetland on an aerial photograph and describe the habitat. Site photos are included for the subject wetlands.

A total of five anuran species were detected during the auditory surveys of 2012 and 2014 with six species being recorded overall. The species detected are listed in Exhibit 3. The Spring Peeper was the most widely distributed, occurring at all eleven monitoring sites. Gray treefrogs followed, being present at ten sites. Green frogs were also commonly detected at the sampling sites.

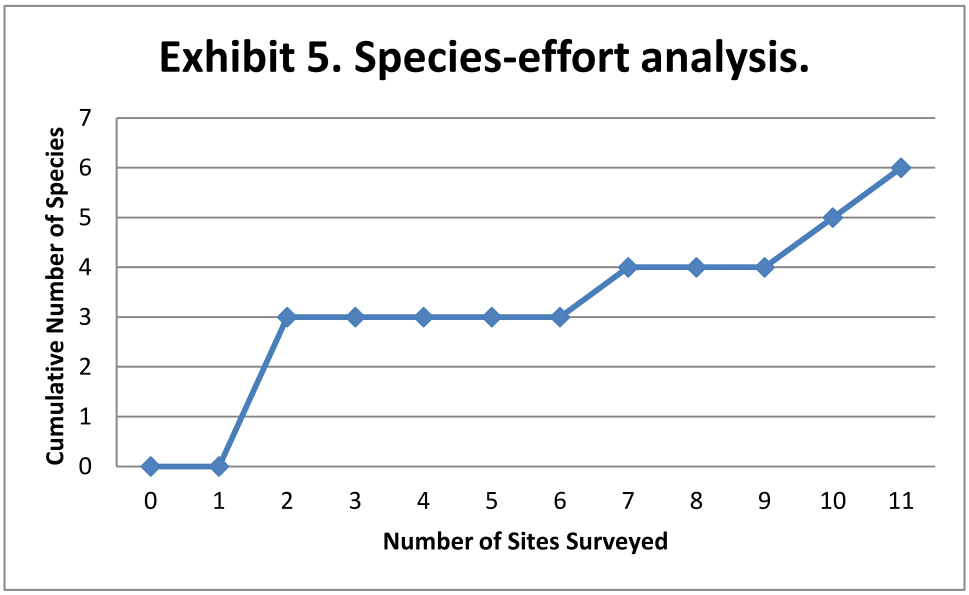
Exhibit 3. Anuran species detected in the North Lake Watershed		
Anuran Species	Number of Sites Detected	
	2012	2014
Northern Spring Peeper (*Pseudacris crucifer*)	9	11
Gray Treefrog (*Hyla versicolor*)	1	10
Wood Frog (*Lithobates sylvatica*)	1	0
Northern Leopard Frog (*Lithobates pipiens*)	1	2
Green Frog (*Lithobates clamitans*)	7	3
Eastern American Toad (*Bufo americanus*)	0	1

Exhibit 4 displays the species detected at each of the eleven study sites in 2012 and 2014. One site (086) had five species detected (considering both years). The mean number of species per site in 2012 was 1.7 and the mean number of species per site in 2014 was 2.6. The mean number of species per site considering both years was 3.

Exhibit 4. Anuran species distribution across North Lake watershed study sites.

Site	Total Species			Spring Peeper		Gray Treefrog		Green Frog		Wood Frog		Leopard Frog		American Toad	
	2012	2014	Both	2012	2014	2012	2014	2012	2014	2012	2014	2012	2014	2012	2014
085	3	3	4	X	X		X	X				X	X		
089	0	2	2		X		X								
090	3	2	3	X	X	X	X	X							
091	2	2	3	X	X		X	X							
092	3	2	4	X	X		X	X		X					
094	1	2	2	X	X				X						
095	1	2	2	X	X		X								
096	2	2	3	X	X		X	X							
097	2	3	4	X	X		X	X					X		
098	0	2	2		X		X								
086	2	4	5	X	X		X	X					X		X

Finally, as a measure of survey thoroughness, we present an analysis of species detected and effort expended (as measured by the number of sites surveyed). Exhibit 5 shows a graph of cumulative number of species plotted against number of sites visited. The actual site numbers were randomly arranged for this analysis. The curve continues to incrementally climb indicating the thoroughness of the survey is less than ideal. This could be remedied by adding more monitoring sites, but in fact the curve will likely level off as more survey bouts are run on these eleven monitoring sites.



The habitats for each of the eleven monitoring sites are described in Exhibits 6-16. These exhibits include a photo of each site and a list of species detected in 2012 and 2014.

Exhibit 6. North Lake Frog & Toad Survey - Site Summary.

Site Number: 085

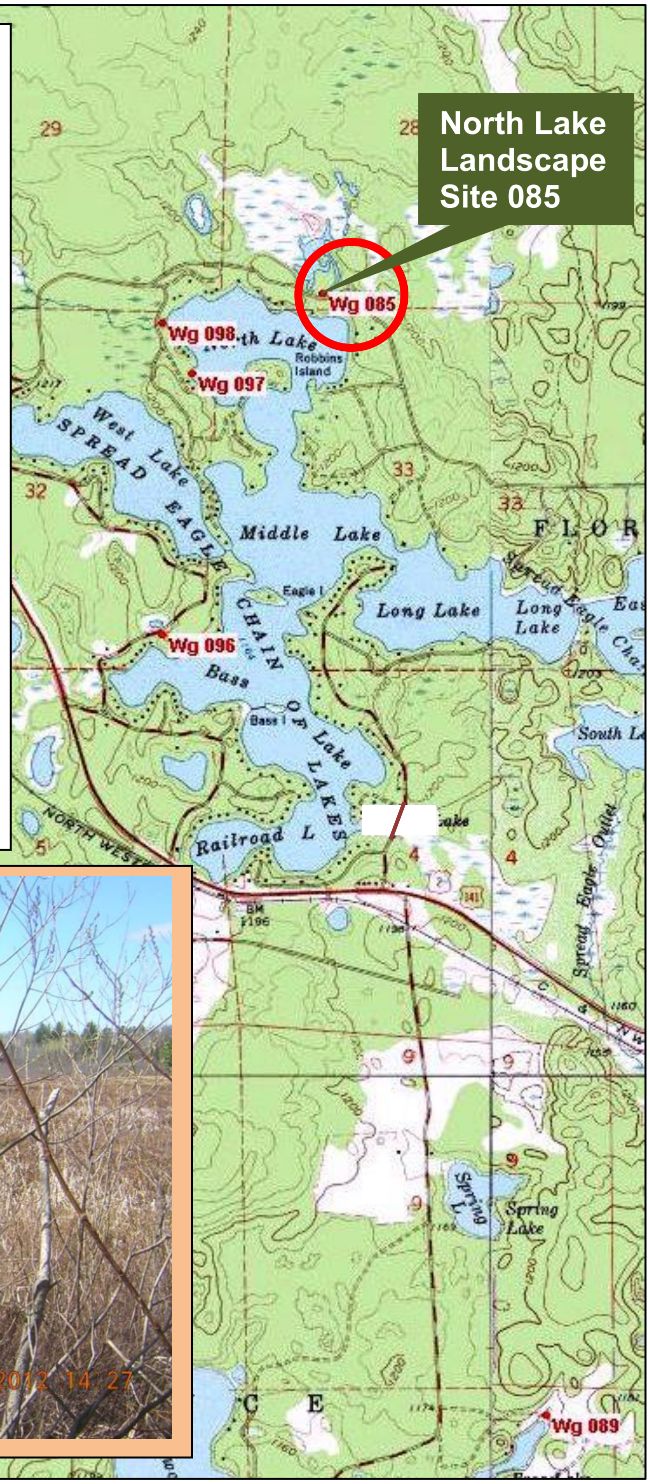
Site Location: North Lake Road

Site Coordinates: 45.9060323
-88.1346444

Habitat Description: Marsh with permanent water. Some cattail and leatherleaf present. Mixed conifer-hardwood riparian area.

Species Detected:

- Spring peeper
- Gray treefrog
- Green frog
- Northern leopard frog



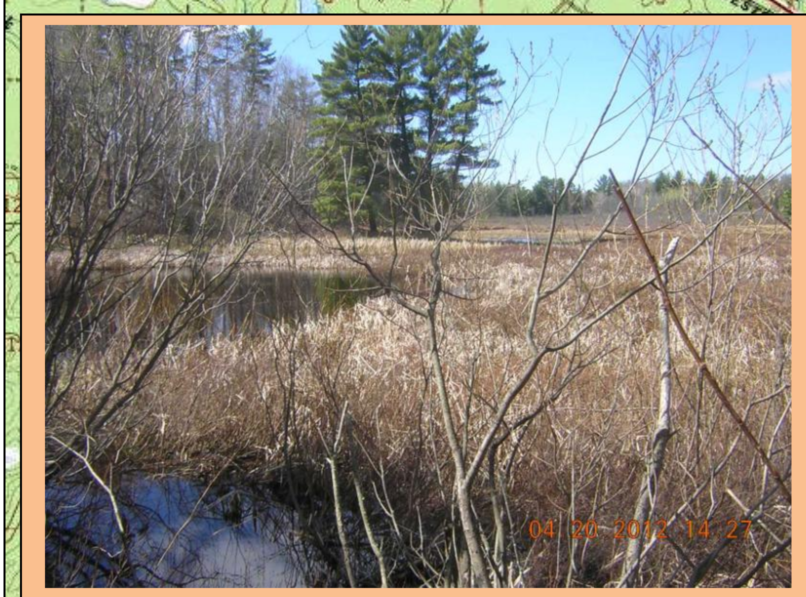


Exhibit 7. North Lake Frog & Toad Survey - Site Summary.

Site Number: 089

Site Location: North Frog Lake Road

Site Coordinates: 45.8615674 -88.1220726

Habitat Description: Marshy, shallow water northern-most extension of Frog Lake. Conifer and hardwoods uplands surrounding this habitat. This pond has some characteristics of an ephemeral (vernal) pond.

Species Detected:

- Spring peeper
- Gray treefrog

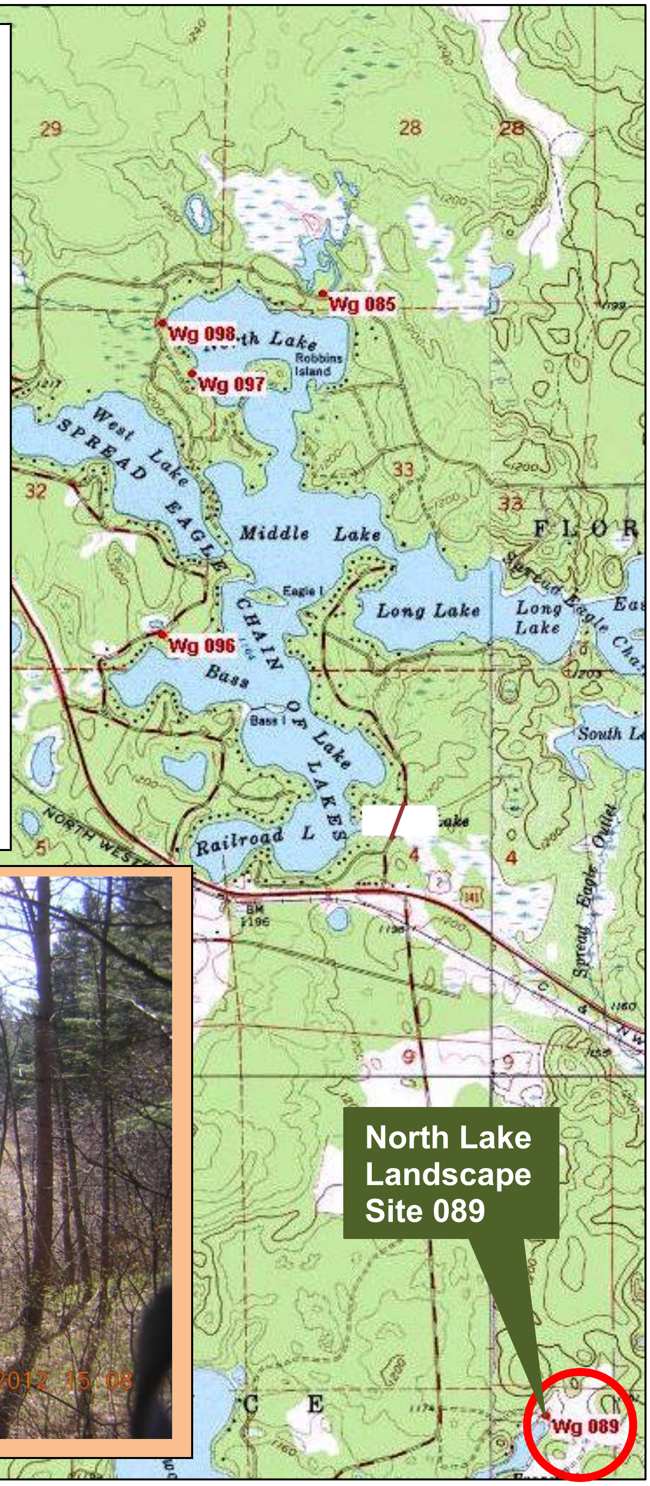
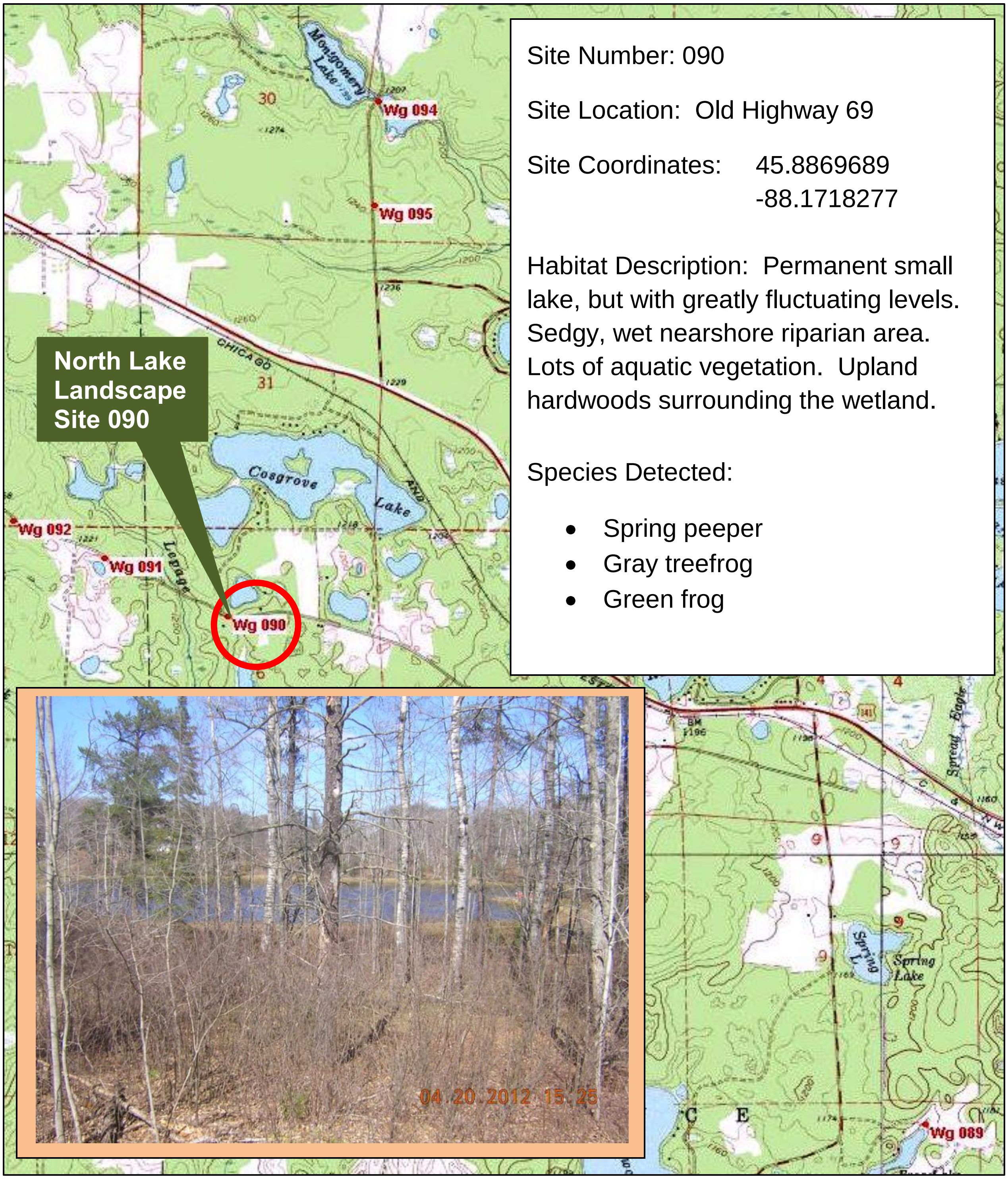


Exhibit 8. North Lake Frog & Toad Survey - Site Summary.



Site Number: 090

Site Location: Old Highway 69

Site Coordinates: 45.8869689 -88.1718277

Habitat Description: Permanent small lake, but with greatly fluctuating levels. Sedgy, wet nearshore riparian area. Lots of aquatic vegetation. Upland hardwoods surrounding the wetland.

Species Detected:

- Spring peeper
- Gray treefrog
- Green frog

Exhibit 9. North Lake Frog & Toad Survey - Site Summary.

Site Number: 091

Site Location: Old Highway 69

Site Coordinates: 45.889829 -88.180565

Habitat Description: Small lake with permanent water. Surrounded by sedge and grass area that gives way to conifer and hardwoods uplands.

Species Detected:

- Spring peeper
- Gray treefrog
- Green frog

Exhibit 10. North Lake Frog & Toad Survey - Site Summary.

Site Number: 092

Site Location: Old Highway 69

Site Coordinates: 45.891692 -88.187114

Habitat Description: Vernal pool in hardwoods habitat. Likely good salamander breeding area.

Species Detected:

- Spring peeper
- Gray treefrog
- Green frog
- Wood frog

Exhibit 11. North Lake Frog & Toad Survey - Site Summary.

Site Number: 094

Site Location: N. Montgomery Lake Rd

Site Coordinates: 45.9126316
-88.1611426

Habitat Description: Permanent water pond below outlet of Montgomery Lake. The fringe of the pond is marshy-sedge wetland surrounded by conifer-hardwoods upland.

Species Detected:

- Spring peeper
- Green frog

Exhibit 12. North Lake Frog & Toad Survey - Site Summary.

Site Number: 095

Site Location: N. Montgomery Lake Rd

Site Coordinates: 45.9074452
-88.1614577

Habitat Description: Seasonal wetland with sedges and grasses. Surrounded by northern hardwoods with some white pine.

Species Detected:

- Spring peeper
- Gray treefrog

Exhibit 13. North Lake Frog & Toad Survey - Site Summary.

Site Number: 096

Site Location: Tall Pines Road

Site Coordinates: 45.8925667 -88.1439143

Habitat Description: Small bog lake (permanent water). Leatherleaf, tag alder, and black spruce in the surrounding wetland. Northern hardwoods and white pine in surrounding upland.

Species Detected:

- Spring peeper
- Gray treefrog
- Green frog

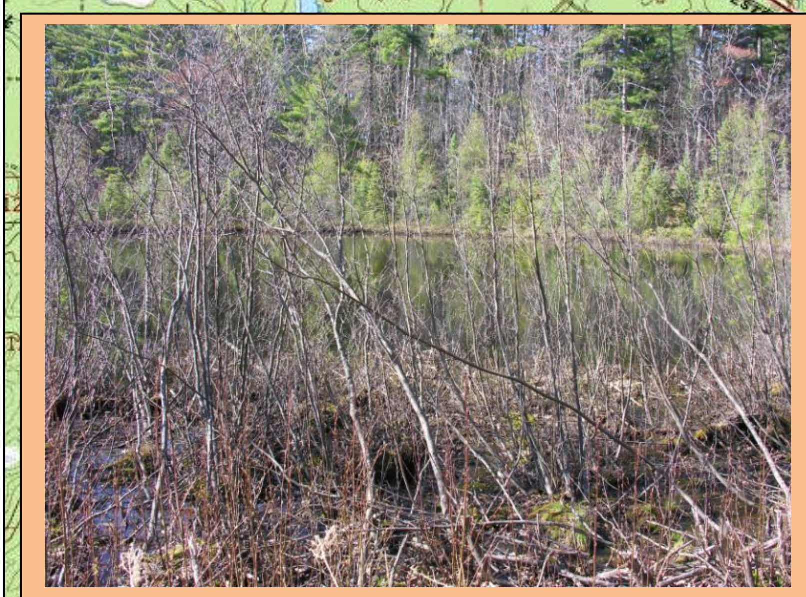


Exhibit 14. North Lake Frog & Toad Survey - Site Summary.

Site Number: 097

Site Location: Roosevelt Lane, North Lake Public Access

Site Coordinates: 45.902902 -88.142028

Habitat Description: North Lake at public access site. Narrow wetland fringe on the lake at this point with tag alder, cattails, and sedges.

Species Detected:

- Spring peeper
- Gray treefrog
- Green frog
- Northern leopard frog

Exhibit 15. North Lake Frog & Toad Survey - Site Summary.

Site Number: 098

Site Location: Dunn's Point Road

Site Coordinates: 45.904863
-88.143921

Habitat Description: Seasonally wet swamp along road. Willow, tag alder, northern white cedar, and sedges are present.

Species Detected:

- Spring peeper
- Gray treefrog

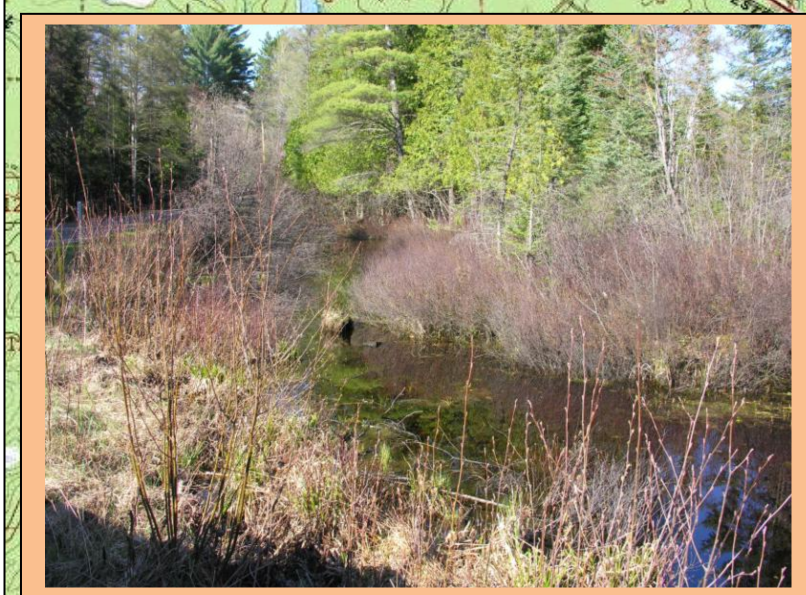


Exhibit 16. North Lake Frog & Toad Survey - Site Summary.

Site Number: Site 086 (Extra Site)

Site Location: Polk Lane (channel between East Lake and South Lake)

Site Coordinates: 45.890057 -88.116485

Habitat Description: Permanent water connecting East Lake and South Lake. Sedge and tag alder fringe. Northern hardwood and white pine in surrounding uplands.

Species Detected:

- Spring peeper
- Gray treefrog
- Green frog
- Northern leopard frog
- Eastern American toad

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Appendix K
North Lake Invasive Species

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WHITE WATER ASSOCIATES, INC.

North Lake Invasive Species

Zebra Mussels (by Dean Premo)

Table of Contents

Introduction

Extensive aquatic invasive species (AIS) monitoring has taken place on North Lake since 2006. This work has been conducted by the Wisconsin Department of Natural Resources (WDNR), private citizens, Florence County staff, and White Water Associates. Table 1 summarizes the recent history of AIS monitoring on North Lake. Table 2 summarizes the monitoring events for specific AIS in North Lake since 2007.

Table 1. AIS Monitoring in North Lake (2014).

Date	Organization	Invasive looked for	Invasive found
7/5/2006, 8/28/2006	DNR AIS Monitoring	Spiny water flea Fish hook water flea	None
8/25/2007, 7/1/2008	Citizen AIS Monitoring	Zebra Mussel Adult	None
6/18/2009	AIS Monitoring Florence	All	Freshwater Jellyfish
7/21/2009	Citizen AIS Monitoring	Zebra Mussel	No Zebra Mussel
8/12/2009	Citizen AIS Monitoring	Zebra Mussel	No Zebra Mussel
12/31/2009	NA	NA	Banded Mystery Snail
6/1/2010	Citizen AIS Monitoring	EWM, Rusty Crayfish, and Zebra Mussel	None
6/14/2010	AIS Monitoring Florence	All	Banded mystery snail
7/5/2010, 6/5/2011, 8/5/2011	Citizen AIS Monitoring	Zebra Mussel	No Zebra Mussel
6/21/2012	AIS Monit. Florence Co	All	Banded mystery snail
9/5/2012	DNR AIS Monitoring	Spiny water flea Fishhook water flea, Zebra Mussel veliger	Zebra Mussel veliger and adults;
9/6/2012, 9/11/2012	AIS Incident Report	Zebra Mussel	Adult Zebra Mussel and Eurasian water-milfoil
9/7/2012	Citizen AIS Monitoring	Zebra Mussel	Zebra Mussel
9/12/2012	DNR AIS Monitoring	Zebra Mussel	None
9/16/2012	DNR AIS Monitoring	Zebra Mussel	Yes, Zebra Mussel veligers
9/4/2013	Citizen AIS Monitoring	Zebra Mussel	Yes, adults
9/16/2013	DNR AIS Monitoring	Spiny Water Flea and Zebra Mussel veliger	Yes, Zebra Mussel veligers
9/18/2013	AIS Monitoring	Zebra Mussel	Yes, adults
6/16/2014	White Water Associates	Yellow Iris	Flowering

Table 2. North Lake AIS Monitoring History by Species – **BOLD/Underlined** text indicates invasive found.									
Banded Mystery Snail	Zebra Mussel	Rusty Crayfish	Spiny & Fishhook Water Flea	Curly-leaf Pondweed	Hydrilla	Freshwater Jellyfish	Yellow Iris	European Marsh Thistle	Eurasian Water-Milfoil
6/18/2009	8/25/2007	6/18/2009	6/12/2006	6/18/2009	6/18/2009	**6/18/2009**	**6/16/2014**	**7/30/2012**	6/18/2009
6/14/2010	7/1/2008	6/14/2010	7/5/2006	6/14/2010	6/14/2010	6/2010			6/12/2009
7/7/2011	7/1/2009	6/1/2010	8/28/2006	6/21/2012		6/2011			6/1/2010
6/21/2012	6/18/2009	6/14/2010	6/18/2009			6/2012			6/14/2010
	8/18/2009	**8/23/2011**	6/14/2010						6/5/2011
	6/1/2010	6/21/2012	7/2012						6/21/2012
	6/14/2010		6/21/2012						**9/5/2012**
	7/5/2010		9/5/2012						**9/18/2013**
	6/5/2011								**6/11/2014**
	8/5/2011								6/16/2014
	8/19/2011								**7/24/2014**
	6/21/2012								**9/24/2014**
	9/5/2012								
	9/7/2012								
	9/12/2012								
	9/16/2012								
	9/4/2013								
	9/16/2013								
	9/18/2013								

Seven AIS have been recorded in North Lake. These AIS have been found in recent years and include: (1) rusty crayfish (*Orconectes rusticus*) discovered in 2008, (2) banded mystery snail (*Viviparus georgianus*) discovered in 2009, (3) freshwater jellyfish (*Craspedacusta sowerbii)* discovered in 2009, (4) zebra mussels (*Dreissena polymorpha*) discovered in 2012, (5) Eurasian water-milfoil (*Myriophyllum spicatum)* discovered in 2012, (6) European marsh thistle (*Cirsium palustre*) observed in the 2012 point-intercept study, and (7) yellow iris (*Iris pseudacorus*) discovered in 2014. It was also noted that pink water lily was observed in the 2012 point-intercept study (Figures 1 and 2). This is a cultivated color-variation of the native white water lily (*Nymphaea odorata*). It is not invasive, however, it is not native to northern Wisconsin lakes, and was likely introduced by someone into North Lake.

Figure 1. Pink water lily (color variation of white water lily, *Nymphaea odorata*).

Figure 2. Location of pink water lily in North Lake.

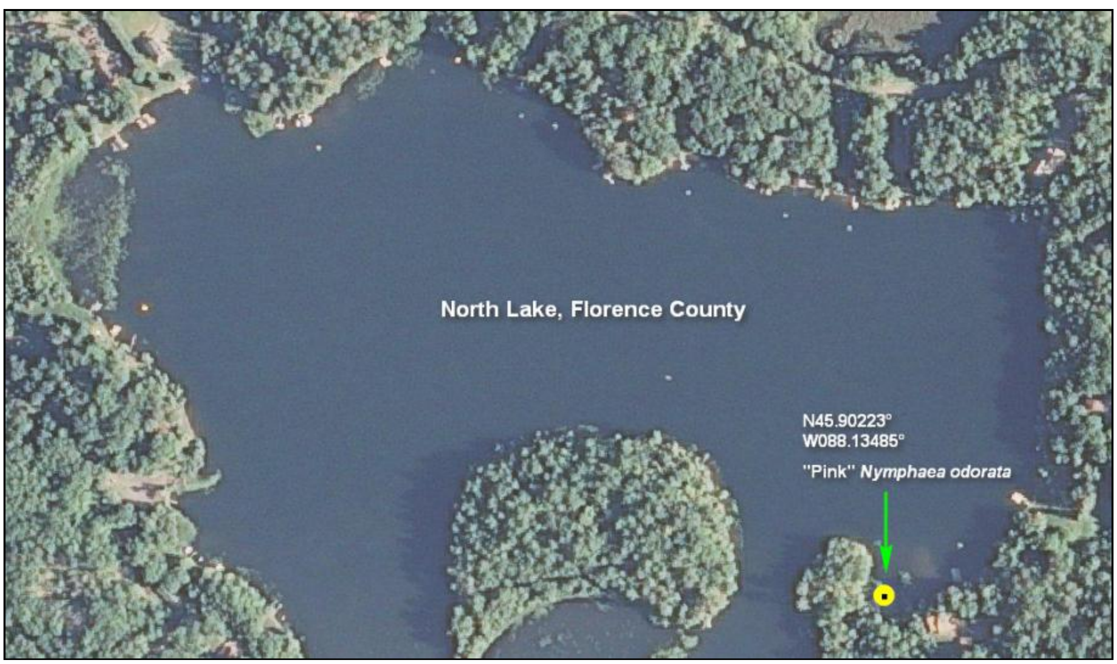


Table 3 shows the invasive species present in North Lake, the year they were discovered, and their status in the state of Wisconsin or Florence County.

Table 3. Aquatic invasive species found in North Lake (WDNR, 2014).

Invasive Species	Year Discovered	Status (WI or County)*
Rusty crayfish (*Orconectes rusticus*)	2008	Restricted
Banded Mystery Snail (*Viviparus georgianus*)	2009	Proposed Restricted
Freshwater jellyfish (*Craspedacusta sowerbii*)	2009	Non-regulated
Zebra Mussel (*Dreissena polymorpha*)	2012	Restricted
Eurasian water-milfoil (*Myriophyllum spicatum*)	2012	Restricted
European marsh thistle (*Cirsium palustre*)	2012	Restricted (Florence Co.)
Yellow Iris (*Iris pseudacorus*)	2014	Proposed Restricted

*__Prohibited__: an invasive species that is not currently found in Wisconsin, with the exception of small pioneer stands of terrestrial plants and aquatic species that are isolated to a specific watershed in the state or the Great Lakes, but which, if introduced into the state, are likely to survive and spread, potentially causing significant environmental or economic harm or harm to human health
Restricted: an invasive species that has already been established in the state and causes or has the potential to cause significant environmental or economic harm or harm to human health
Non-restricted: A non-restricted species is one that may have some beneficial uses as well as negative impacts on the environment but are already integrated into Wisconsin's ecosystems so that control or eradication is not practical or feasible.
Caution: Caution species are ones that cannot be placed in other categories such as prohibited, restricted or non-restricted because they are not currently found in the state, appear to be invasive only regionally, or their potential for invasiveness in Wisconsin is unknown.
Non-regulated: A non-regulated species is one that is not currently regulated by Chapter NR 40 of the Wisconsin Administrative Code.

Species Information

Rusty crayfish

Rusty crayfish are native to parts of Ohio, Tennessee, Kentucky and Indiana, and were likely introduced to Wisconsin waters by fishermen using the crayfish as bait (Gunderson, 2008). Rusty crayfish can negatively affect other native crayfish species, cause destruction to aquatic plant beds, reduce fish populations by eating eggs, and cause shoreland owners recreational problems (Gunderson, 2008). It is illegal to possess both live crayfish and angling equipment simultaneously on any inland Wisconsin water (except Mississippi River) (WDNR, 2012). It is also illegal to release crayfish into a water body without a permit (WDNR, 2012).

Banded mystery snail

Banded mystery snails are native to northeastern United States down to Florida, the Gulf of Mexico, and some states along the Mississippi River. Records show that an amateur conchologist (scientist of sea shells and the animals that inhabit them) intentionally released banded mystery snails into the Hudson River, which led to its dispersal throughout the Great Lakes area (Kipp et al., 2013b). There is no known negative impact caused by the snails in the Great Lake region (Kipp et al., 2013b).

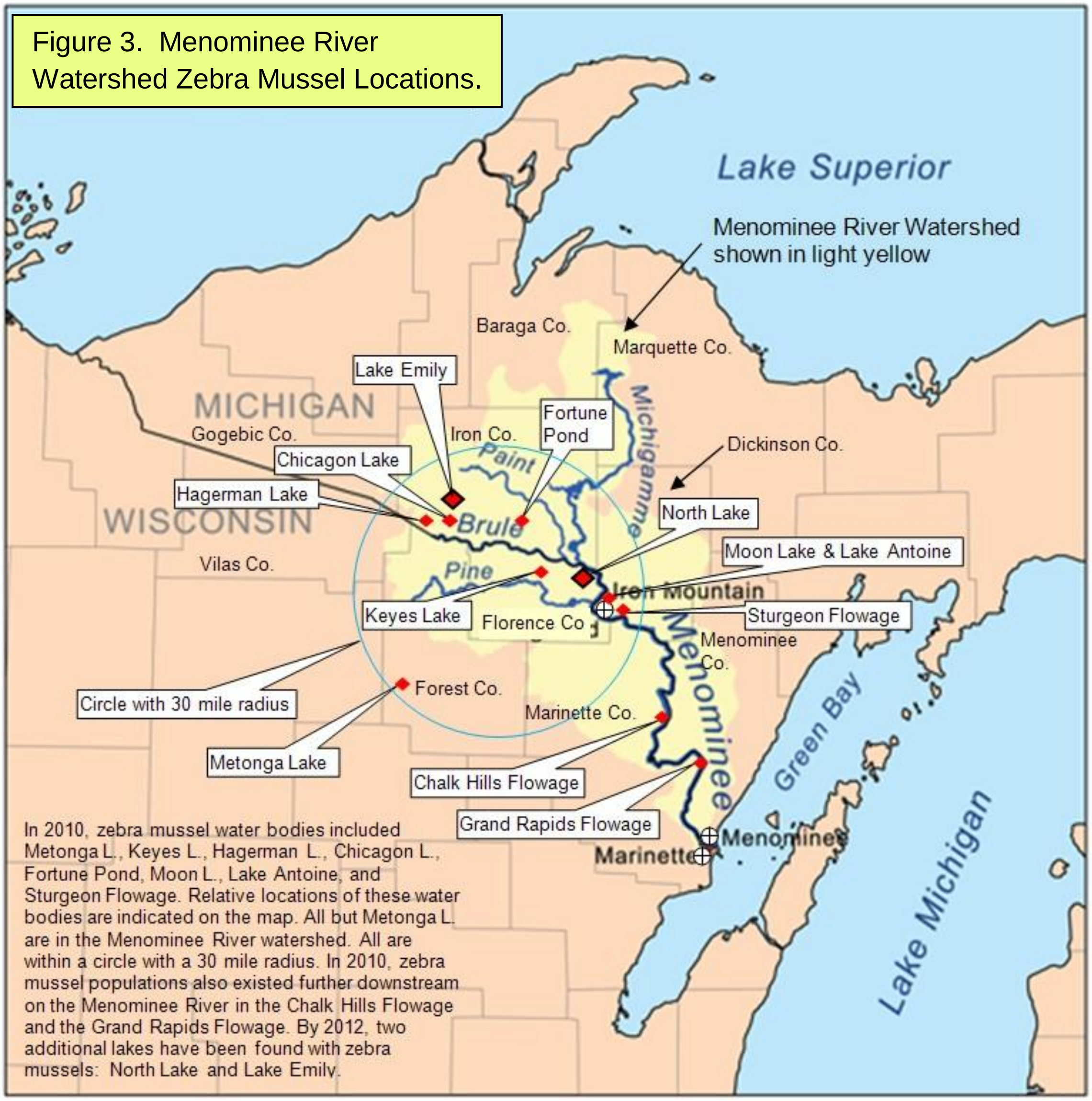
Freshwater jellyfish

Freshwater jellyfish are native to the Yangtze River Valley in China (McKercher et al., 2013). It is likely that they were introduced into northern waters by transportation of ornamental plants, water fowl or fish stocking (McKercher et al., 2013). It is unclear what the jellyfishes' impact is on native plant and animal species, but it is possible that they prey on fish eggs and other zooplankton (McKercher et al., 2013). Freshwater jellyfish are not considered dangerous to humans.

Zebra mussels

The zebra mussel is native to the Black, Caspian and Azov Seas in Eastern Europe and the Middle East. This species was likely introduced by ballast water from a cargo ship traveling from these seas to the Great Lakes (Benson et al., 2013). Because zebra mussels can become extremely abundant in a lake and a single zebra mussel can filter up to one liter of water a day, water clarity and chemistry can be affected. Water quality of lakes infested with the zebra mussels should be analyzed closely (Benson et al., 2013). Zebra mussels can attach themselves to any hard surface (rocks, pipes, boats, other native clams and mussels, crayfish and even plants) and thereby cause great economic and environmental impact. Growth on plants and other mollusks can impact native species populations. Growth on things like pipes for public water supply or irrigation can reduce the amount of flow into such systems. Adults can produce up to 500,000 eggs per year (Benson et al., 2013). Eggs hatch into the larval stage (veliger). Zebra mussels spread from area to area by transfer of veligers in ballast water or bait buckets and by transfer of adult mussels growing on boats or other solid surfaces.

In 2010, nine bodies of water within the Menominee River Watershed had records for zebra mussels. These include Keyes Lake (Florence Co., Wisconsin); Hagerman Lake, Chicagon Lake, and Fortune Pond (all in Iron Co., Michigan); Lake Antoine, Moon Lake, and Sturgeon Flowage (all in Dickinson Co., Michigan); and Grand Rapids Flowage and Chalk Hills Flowage (both on the Menominee River in Menominee County, Michigan and Marinette County, Wisconsin). A tenth water body (Metonga Lake in Forest County) also had zebra mussels. Metonga Lake is about 15 miles southwest of the Menominee River watershed. Since 2011, two additional lakes have zebra mussel records (Lake Emily in Iron County, Michigan and North Lake in Florence County, Wisconsin). The relative locations of these water bodies are shown in Figure 3.



The twelve bodies of water with zebra mussel records mentioned in the previous paragraph are popular fisheries. Almost all have public accesses and considerable boat and trailer traffic. Tourism is a principal economy in the region and the area is less than a half-day drive from large metropolitan areas. All the affected water bodies are very short drives from other bodies of water that at this point have no zebra mussel records. All lakes in the region are at risk because of the zebra mussel populations that exist in these northern lakes.

Eurasian water-milfoil

Eurasian water-milfoil (EWM) can be an aggressive AIS. Eurasian water-milfoil is identified by having whorls of finely divided leaves. EWM usually has 14 or more leaflets on each side of the leaf axis. Native water-milfoils usually have fewer than 12 pairs of leaflets. EWM is detrimental to lakes because it can form dense mats, preventing light from reaching other native plants and can interfere with boating and other recreational activities. EWM reproduces by buds, rhizomes and by mechanical fragmentation (such as being chopped up by boat engine propellers). The high level of boating traffic in the Spread Eagle Chain of Lakes increases the chances for this species to disperse throughout the chain.

European marsh thistle

European marsh thistle is an herbaceous biennial plant. It can grow up to 4-5 feet tall (Cao et al., 2014). Thistles are easily recognized by spines that protrude from leaves and stems. Small purple flowers bloom in June and July (Cao et al., 2014). Feathery tufts are attached to the seeds making wind a common method of dispersal. One thistle can produce up to 2,000 viable seeds per plant (Cao et al., 2014). European marsh thistle prefers moist to wet soils. It can spread aggressively which leads to reduced biodiversity and compromised ecological integrity, especially in the wetland ecosystems of the Great Lakes (Cao et al., 2014).

Yellow Iris

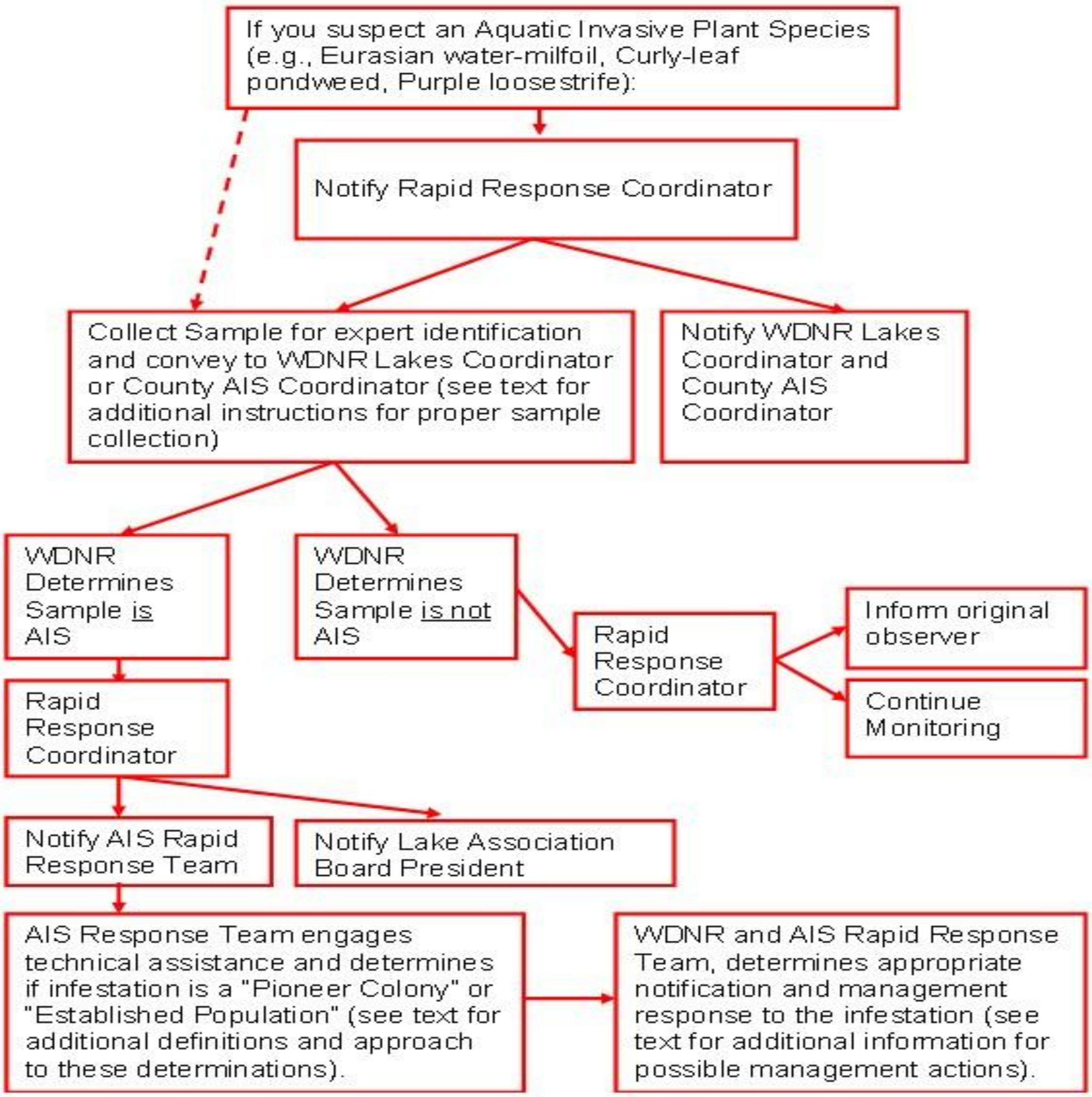
The yellow iris is native to parts of Europe, North Africa and the Mediterranean region. It was introduced to the United States as an ornamental plant; as a control method for erosion, and to remove metals in sewage treatment plants (as it is effective at removing nutrients from the sediment) (USFWS, 2006). Yellow iris produces many seeds which can float, allowing new colonies to form. The yellow iris can also spread via rhizome fragments. All parts of the plant are poisonous, which results in lowered wildlife food sources in areas where it dominates (USFWS, 2006). The yellow iris can also trap sediments, causing changes in a lake’s hydrology. Currently, the yellow iris is a non-regulated invasive species in Wisconsin, however, it proposed to be Restricted (WDNR, 2013).

What do we do next?

Users of North Lake and the rest of the Spread Eagle Chain of Lakes have not likely noticed much change in their lake experience resulting from the presence of the rusty crayfish, banded mystery snail, and the freshwater jellyfish. With the recent discoveries of Eurasian water-milfoil (EWM) and zebra mussels, however, changes may become more obvious. Action steps need to be initiated to protect North Lake from additional AIS and protect regional lakes from AIS introductions that emanate from North Lake.

The North Lake Adaptive Management Plan and the North Lake Aquatic Plant Management Plan were products of the North Lake Stewardship Program. Parts of these plans address action items related to aquatic invasive species. White Water Associates has conceived an approach for responding to a new discovery of aquatic invasive plants. This approach is illustrated in Figure 4 and is included in the *North Lake Aquatic Plant Management Plan* (Premo et al., 2014). Response to newly discovered AIS will be most efficient if an AIS Rapid Response Team has already been established and is familiar with the contingency plan. Before an AIS is found it is beneficial to have a rapid response plan and a rapid response coordinator in place.

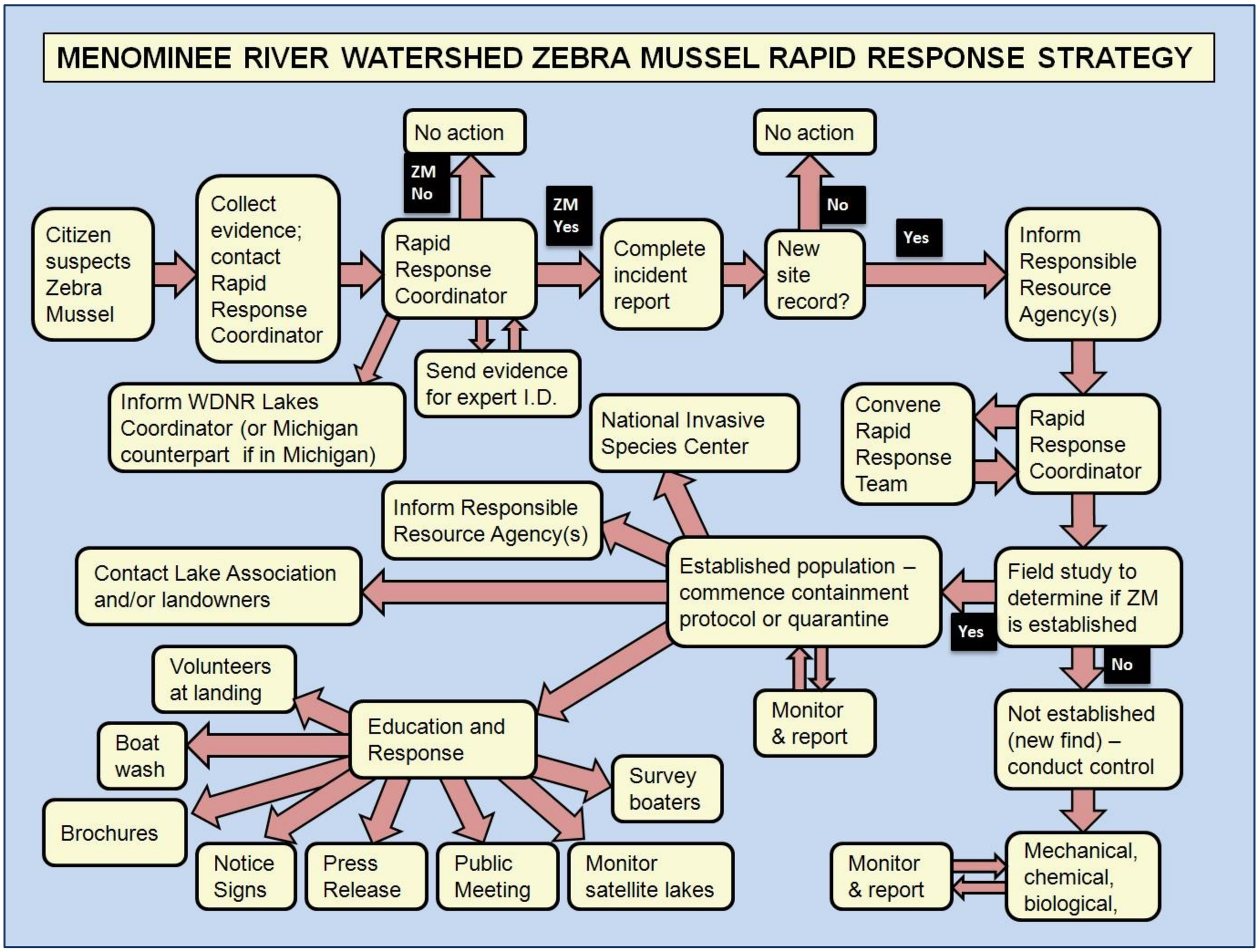
Figure 4. Aquatic Invasive Plant Species Rapid Response.



Similar to the rapid response flow chart for discovery of invasive plant species, White Water also created a rapid response strategy for the discovery of the invasive zebra mussels (Figure 5).

Having a rapid response strategy like this takes out the guess work in trying to determine what should be done next. Although both EWM and zebra mussels have been discovered in North Lake, other AIS are possible and similar rapid response strategies could be followed in the event of their introduction.

Figure 5. Rapid Response Strategy for invasive mussels (White Water Associates, 2013).



Early Detection and Response

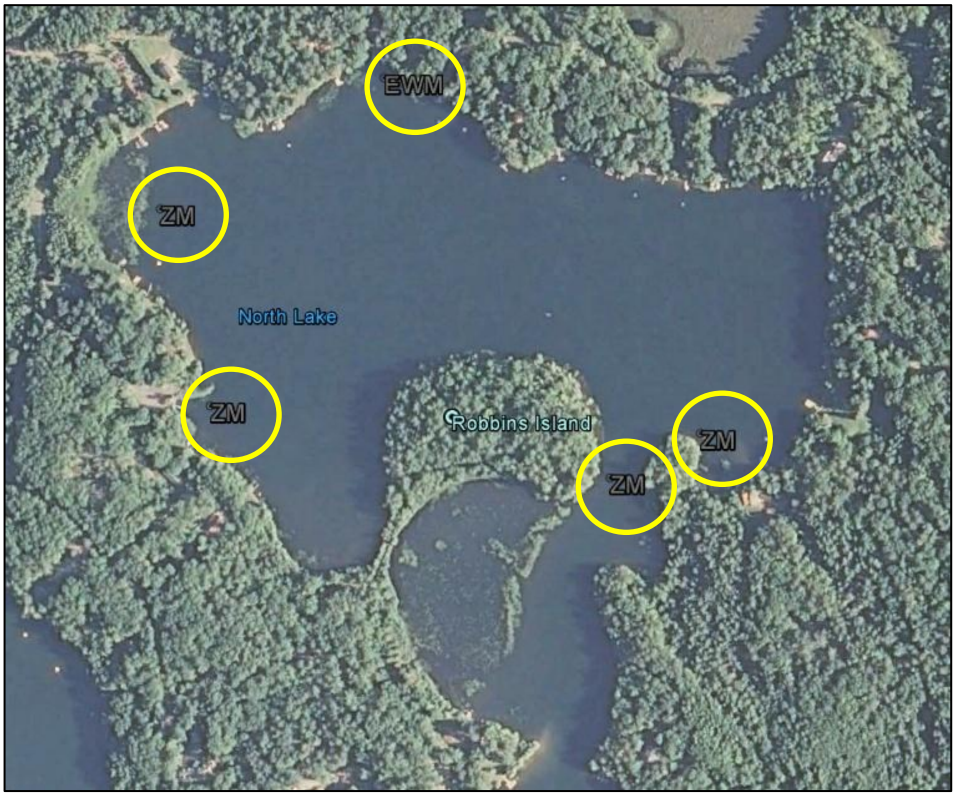
This section documents the discoveries of EWM and zebra mussels and the rapid response actions that have occurred since those discoveries. Several organizations and citizens have been involved in this process.

A Wisconsin Department of Natural Resources Aquatic Invasive Species Early Detection Monitoring bout was conducted on North Lake on September 5, 2012 by Mathew Hager. The boat landing area was snorkeled for 30 minutes (per 1 person) covering an area of 200’ out to the maximum depth of plant growth (or 100’ from shore, whichever comes first). They looked for snails and mussels on any emergent macrophytes and for any invasive plant species. Five sites were pre-selected for viewing. Mid-lake samples included a Secchi depth, conductivity reading and phosphorus (if no data has been taken the last five years). Three plankton net tows for spiny water fleas were collected. Zebra mussel veliger tows were also collected. A meander survey was then conducted by boat searching between established sites for AIS stopping at 50 random locations while boating around the lake to do rake pulls looking for invasive aquatic plants and D-net to look for invasive snails and/or mussels (WDNR, 2011). Results of the September 5 Early Detection Monitoring in 2012 are described in a September 6, 2012 e-mail from Matt Hager (WDNR), stated below.

> *I just wanted to let you know that I found Zebra Mussels and Eurasian Water Milfoil today in North Lake on the Spread Eagle Chain. The patch of EWM was fairly small and I hand pulled as much as I could find. The water got stirred up pretty bad, so there may be some that was missed. I found 1-2 adult ZM at four locations around the lake. I also have the GPS coordinates for these sites. Adult ZM's and veliger tow samples were already sent in to be verified. I will also press the EWM and get it sent in soon for verification. The coordinates for the EWM are 45.90604, -88.13928. The patch is directly behind a boat lift. I believe I got most of the EWM when I pulled it, but there may be some I missed once the water was stirred up.*
>
> *The coordinates for the ZM are 45.90222, -88.13619; 45.90264, -88.13496; 45.90478, -88.14233; and 45.90290, -88.14162. It was quite a shock when I found the first ZM. I only found a couple of ZM at each of these sites and I had to really look hard to find some of them. I first noticed them near an old, red boathouse by the channel going to Middle Lake.*

Figure 6 displays the locations of Eurasian water-milfoil and zebra mussels discovered during this 2012 early detection monitoring bout. Plankton tow samples collected by Matt Hager on September 5, 2012 on North Lake had 1,146 zebra mussel veligers/m^3.

Figure 6. Locations of EWM and zebra mussels found by 2012 early detection monitoring.



A proposal was written and approved for funding of an ***Early Detection and Response Project*** from the Wisconsin Department of Natural Resources (WDNR) Aquatic Invasive Species (AIS) Planning Grants program for response to the simultaneous discoveries of Eurasian water-milfoil (*Myriophyllum spicatum*) and Zebra Mussel (*Dreissena polymorpha*) in North Lake of the Spread Eagle Chain of Lakes in Florence County, Wisconsin. Specific objectives in the North Lake early detection and rapid response project are to: (1) investigate the extent of Eurasian water-milfoil in North Lake by field investigations in 2012 and 2013, (2) hand-pull (if feasible) any Eurasian water-milfoil discovered in field investigations, (3) summarize findings of zebra mussel research by University of Wisconsin – Stevens Point graduate student Maureen Ferry as they relate to North Lake and the Spread Eagle Chain of Lakes, and (4) meet with the WDNR and representatives of the SECOLA to create a unified and educated response to zebra mussel and Eurasian water-milfoil for the purpose of protecting North Lake, the Spread Eagle Chain of Lakes, and other water bodies in the region. In the next several paragraphs, we summarize the progress toward these objectives.

Objective 1. Investigate the extent of Eurasian water-milfoil (EWM) in North Lake by field investigations in 2012 and 2013.

Task 1A: Monitor North Lake for EWM distribution targeting the site of the original find as well other areas of the lake.

The 2012 field work component of this project has been completed. Matthew Hager surveyed the entire shoreline of North Lake on the day he made the original EWM discovery (September 5) and hand-pulled all EWM he observed. On September 7, Angie Stine (White Water Associates) and Carl Sundberg (SECOLA volunteer) spent the afternoon carefully examining the vicinity of the EWM find and observed no additional EWM plants (this included over an hour of snorkeling by Stine). On this same outing, Stine snorkeled in the areas of zebra mussel finds to confirm these localities. On September 8, graduate student Maureen Ferry and SECOLA volunteers Bill Frisque and Carl Sundberg snorkeled around some other lakes in the Spread Eagle Chain (Middle Lake, Bass Lake, and the outlet of East Lake). They did not observe any zebra mussels in the downstream lakes. On September 10, Angie Stine assisted Maureen Ferry and Bill Frisque in SCUBA survey work on North Lake transects for zebra mussels. On the evening of September 10, 2012, Dean Premo and Angie Stine (both of White Water Associates) presented the status of the rapid response project to a SECOLA board meeting and followed up the next day with a detailed summary to the WDNR (principally, Jim Kreitlow). The WDNR conducted veliger sampling in all lakes on the Spread Eagle Chain on September 12, 2012.

Further monitoring was conducted by Carl Sundberg and Angie Stine on June 7 and July 15, 2013. The perimeter of the lake was snorkeled for 1.5 hours in search of any EWM in North Lake and no suspect plants were observed.

On September 18, 2013, Caitlin Clarke (White Water Associates) teamed with a Carl Sundberg to inspect North Lake for Eurasian water-milfoil. Most of the effort was spent near points where Eurasian water-milfoil had been previously observed. The shoreline of the lake was also monitored. Native milfoils were abundant, but no Eurasian water-milfoil was observed. During this September 18, 2013 survey, a small patch of EWM located just south of Robbins Island was identified. Specimens were pressed and sent to Robert Freckmann at the University of Wisconsin-Stevens Point, where its identification was confirmed.

On June 11, 2014, White Water Associates field staff Angie Stine, Caitlin Clarke and Lindsay Peterson surveyed North Lake for Eurasian water-milfoil (EWM). Searches were conducted in areas were previous EWM populations had been found, and along shorelines near these sites.

EWM plants were observed in the area where they had observed in fall, 2013 (south of Robbins Island). While surveying, small floating markers were placed in the water to mark EWM plants. After surveying, Angie put on her snorkel gear and manually pulled EWM plants. Two coordinates were recorded to show the general area of plants (45.90123, -88.13736; EWM6) (45.90122, -88.13731; EWM7). EWM plants were clumped within a 15 foot radius of these points.

EWM plants were removed manually. Angie carried a mesh bag with her and placed uprooted plants in the bag in order to minimize loss of fragments. Angie collected approximately 26 rooted plants (72 stems with a wet weight of 2.6 lbs.). Because sediment is very fine in this area and it is difficult to see after pulling plants. In general, EWM plants observed from the boat appeared darker than the native milfoils. The apexes of the EWM plants were distinctly redder than the native milfoils. On June 16, 2014, the White Water field crew returned to EWM hand-pulled site, but did not observe any remaining EWM plants.

On the June 16, 2014 outing, the White Water field crew also observed the yellow iris (*Iris pseudacorus*). One location (45.89908, -88.13768) was at a residence on Middle Lake; another location (45.90497, -88.13528) was on the northeast shore of North Lake, and a third location was along the northwest shoreline of North Lake (45.904846, -88.143467).

On July 24, 2014, White Water staff Angie Stine and Lindsay Peterson surveyed North Lake for EWM. They included the area south of Robbins Island. No EWM were found at that location. As they continued search the North Lake shoreline for EWM, Stine and Peterson observed one Eurasian water-milfoil plant near a boat lift in the northeast corner of North Lake (45.90485, -88.13362; EWM8). The plant was found at 8-9 feet deep. Angie was able to dive down and remove the plant, placing it in a mesh bag. She continued to snorkel the area, but found no other EWM plants. Stine and Peterson also snorkeled the area where a suspicious EWM plant had been found earlier in the season (EWM11). No other EWM plants were seen in that location.

The crew continued to boat out toward the middle of North Lake. Here, they spotted a large clump of EWM. The area seemed to be about 3 feet wide and deep enough where depth was 14 feet. There were many other large clumps in the same area. Realizing how deep and large the area of EWM was, it was decided to come back at a further date to hand pull the plants (see description below under Objective 2).

On August 7 and 8, 2014, Angie Stine and Caitlin Clarke returned to the Spread Eagle Chain to survey all lakes for EWM. Last year, they surveyed following a path parallel to the shoreline. After the July 24, 2014 find of a new population of EWM at 14 feet (see previous paragraph), they decided to scan deeper areas of the Chain by looping in to shore and then looping out to a depth of 15 feet. In this way, they were able to view of any satellite populations of EWM had begun in deeper sites. Weather for the two survey days was perfectly calm and mostly sunny with a few hours of partial cloud cover.

On August 7, Caitlin and Angie returned to the newest EWM location (45.90511, -88.14153; EWM10). Angie, who had seen the site nearly two weeks earlier, said the area of EWM had increased. On August 7th, it was estimated that the area was about 30x30 feet. Plants were reaching to the surface which means they were at least 10 feet tall. It was estimated that there were about 40 plants that were branching heavily. No other EWM plants were observed in North Lake or in the area south of Robbins Island. Over the duration of the August 7 and 8 monitoring, no EWM were observed in Middle Lake, West Lake, Bass Lake, Railroad Lake, Lily Pond Lake, Long Lake, and East Lake. South Lake was not surveyed.

Task 1B: Document the distribution of the EWM by using global positioning units (recording latitude and longitude).

The EWM found south of Robbins Island was documented using GPS. We documented the location of these plants as we removed them. Table 4 provides the locations of EWM plants that were removed from the area south of Robbins Island. Figure 7 shows the location of these plants.

Table 4. Locations of Eurasian water-milfoil south of Robbins Island.

Point Number	Latitude/Longitude	Comments
EWM1	45.90135, -88.13724	These are the locations of the original EWM finds on 9/18/13 south of Robbins Island by Caitlin Clarke and Carl Sundberg. Specimens from EWM1 were sent out for verification.
EWM2	45.90090, -88.13726	
EWM3	45.90125, -88.13728	This is the site of an additional find made by Angie Stine and Caitlin Clarke (White Water Associates) on 9/23/13 during a Spread Eagle Chain of Lakes EWM monitoring bout.
EWM4	45.90121, -88.13731	On 9/25/13 Clarke and Stine returned to the EWM to conduct hand-pulling while snorkeling. These two additional points were marked where EWM plants were removed. About 100 plants (stems) were removed from these five sites.
EWM5	45.90119, -88.13736	

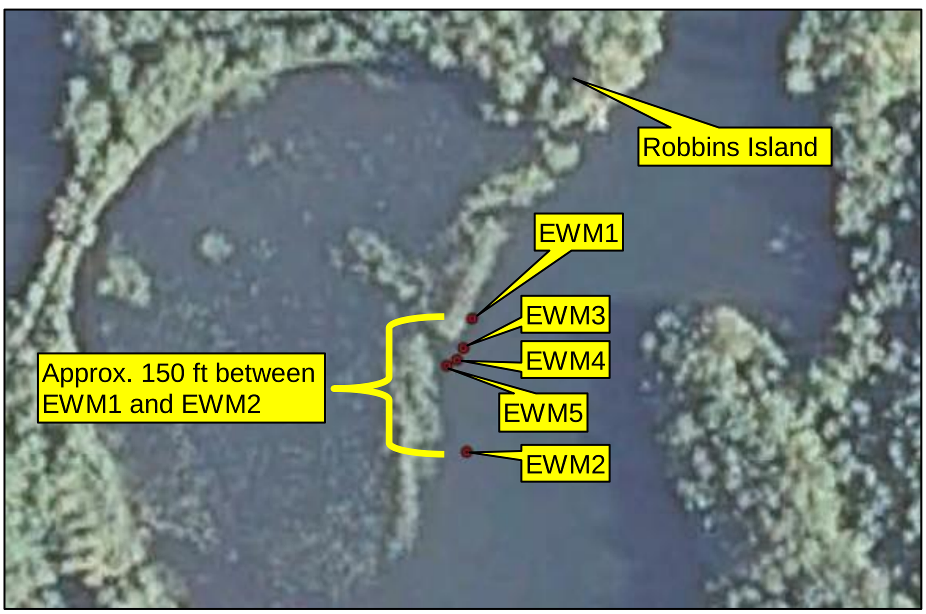


Figure 7. Locations of Eurasian water-milfoil found and removed in 2013.

Additional locations of North Lake EWM are given in Table 5 and illustrated in Figure 8.

Table 5. Locations of Eurasian water-milfoil found in 2014 *(mapped on Figure 8).*		
Point Number	Latitude/Longitude	Comments
EWM6	45.90123; -88.13736	south of Robbins Island
EWM7	45.90122; -88.13731	south of Robbins Island
EWM8	45.90485; -88.13362	NE corner of North Lake. Double-garage door boat house
EWM9	45.90545; -88.13846	north of Robbins Island
EWM10	45.90511; -88.14153	large clump, in open water north of boat landing
EWM11	45.90565; -88.14156	near Darlin Verley's house

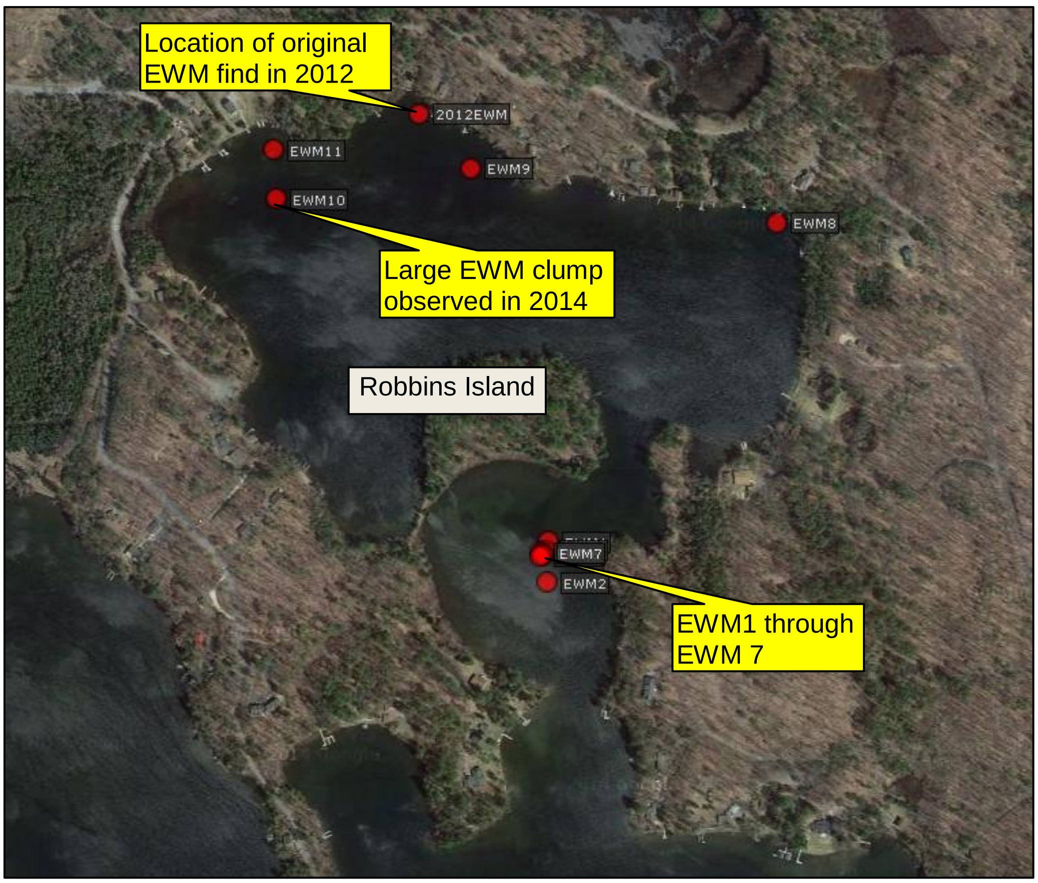


Figure 8. Locations of Eurasian water-milfoil found and removed in 2014.

Task 1C: Record observations on EWM density.

The 2012 EWM find in North Lake by Matt Hager was described as a small patch. During the fall 2013 survey, five small patches of EWM were found by White Water Associates biologists south of Robbins Island. Approximately 100 plants (stems) were removed from these five sites. White Water Associates surveyed the entire shoreline of all lakes in the Spread Eagle Chain during the fall 2013 (as part of a separate rapid response grant) and did not find any other EWM plants. The 2014 monitoring efforts and finds were reported under Task 1A. The large EWM location (EWM10) was estimated to cover an area was about 30x30 feet and contained 40 large plants.

Task 1D: Train North Lake volunteers to participate in 2013 EWM and beyond.

The SECOLA Citizen Invasive Species Monitor, Carl Sundberg, was present for all the EWM surveys on North Lake. White Water Associates conducted a field trip in summer 2014 on North Lake. During that outing, Angie Stine did a workshop on EWM identification for participants.

Task 1E: Produce a map of EWM beds in North Lake.

Figures 6, 7, and 8 are maps of the 2012, 2013, and 2014 Eurasian water-milfoil finds.

Objective 2. Hand-pull (if feasible) any EWM discovered in field investigations.

Task 2A: Using snorkel gear or SCUBA, hand-pull any reasonably sized colonies of EWM found during North Lake monitoring.

As stated previously, White Water Associates staff conducted hand-pulling of EWM in the area south of Robbins Island. EWM was marked by a weighted floating marker prior to removal so that the sites could be revisited in case plants were missed during the initial removal. A mesh bag was carefully placed over the EWM and a trowel was used to release the roots from the sediment. Another biologist was at the surface in a kayak with a net to locate any floating fragments. The bag of EWM was then emptied into a bucket in the boat and was disposed of appropriately. Approximately 100 plants (stems) were pulled by snorkeling. Wet weight of removed EWM was 9.4 pounds.

On August 13, 2014, Angie Stine, Caitlin Clarke, and Lindsay Peterson (White Water Associates) conducted SCUBA and snorkeling hand-pulling of the large and deep patch of EWM (EWM10). Angie had her SCUBA gear ready with 3000 psi and began removing plants. Angie indicated that there were a few individual plants, but that most of the EWM seen from the boat were large plants with many branches. The plants were easy to fragment, so Lindsay was also in the water assisting. A minnow seine with floats was anchored on the downwind side of the Eurasian water-milfoil patch to help capture fragments. Lindsay and Caitlin were also capturing fragments with nets from the water and the boat. Silty, black sediment also made viewing the plants very difficult. Angie would follow the EWM stalk down to the sediment, pull out the root mass and would fill her mesh bag. She would then give Lindsay the full mesh bag and get a new bag to return to the plants. Lindsay would then bring the mesh bag full of EWM to the boat where Caitlin would put the EWM in garbage bags and record weight. On August 14, 2014, Angie, Caitlin and Lindsay returned to North Lake EWM10 location and completed that hand-pulling task. A total of 377 pounds (wet weight) of EWM was removed from this patch in the two days of hand removal. Follow-up monitoring on 9/24/2014 showed no EWM.

Task 2B: Target areas where hand-pulling of EWM was conducted with additional monitoring to check for efficacy of the treatment.

The location of the initial EWM find (in the north part of North Lake) was monitored several times for the reoccurrence of EWM. No EWM plants were found. Other areas where EWM were removed have been monitored. We recommend this continue in 2015 and beyond.

Task 2C: Evaluate feasibility of chemical treatment of EWM.

In an email (9/19/2012) to the SECOLA President, Glen Johnson, Dean Premo (White Water Associates) outlines his recommendation regarding chemical treatment of EWM on the Spread Eagle Chain sites:

It is **not** appropriate to do an herbicide treatment at the site of the Eurasian water-milfoil find in North Lake for several reasons. I outline some of the most salient reasons in the following bullets:

- The hand-pulling may have been successful and this can be determined by follow up monitoring;
- "spot" treatment means that you need to see living plants to treat and we found none;
- Resting stages of plants (such as seeds) are not suitably treated via herbicides;
- Any treatment with herbicide will also affect native plants that are an important line of defense against the Eurasian water-milfoil establishment. A treatment could leave an open patch of habitat that would be more easily colonized by Eurasian water-milfoil.

Currently, hand-pulling seems to be controlling the EWM. Monitoring over the future years will help determine whether other control modes are warranted.

Objective 3. Summarize findings of zebra mussel research currently ongoing by UWSP graduate student as they relate to North Lake and the Spread Eagle Chain of Lakes.

Task 3A: For purposes of education and monitoring, summarize information on zebra mussel population in North Lake and the Spread Eagle Chain of Lakes.

University of Wisconsin Stevens Point graduate student Maureen Ferry wrote a thesis titled *Zebra Mussel Habitat Selection, Growth and Mortality in Lakes of Northeastern Wisconsin and the Upper Peninsula of Michigan* described below (Ferry, 2013). North Lake was one of the study lakes in Ferry's investigation of zebra mussel habitat preference, growth, and mortality in and near the Menominee River Watershed. Ferry's work was part of a larger project that partnered with the Keyes Lake Improvement Association, Lumberjack RC&D, White Water Associates, Inc., the Wild Rivers Invasive Species Coalition, and the Florence County Land Conservation Department.

Ferry used SCUBA diving to sample quadrats along transects in several lakes to evaluate zebra mussel habitat selection, growth, and mortality. Each transect extended perpendicular from the shoreline into the lake center until the thermocline was reached or half way across the lake if a thermocline was not reached. On each lake, ten sampling quadrats were spaced evenly along each of twelve transects for a total of 120 quadrats per lake. Within each quadrat, depth, available substrate, and zebra mussel use of substrate was recorded. Zebra mussels were collected from one quadrat along each transect. The length of each collected zebra mussel was measured and age was estimated to evaluate zebra mussel growth and mortality. These protocols were implemented on eight study lakes in June and August 2012. The study lakes are presented in Table 6 (taken from Table 2 of Ferry, 2013).

Table 6. Locations of zebra mussel populations in northeastern Wisconsin and upper Michigan lakes (originally Table 2 in Ferry (2013).

Table 2. Locations of zebra mussel (*Dreissena polymorpha*) populations in northeastern Wisconsin and upper Michigan lakes that were assessed in 2012 for zebra mussel habitat selection, growth, and mortality. A dash (-) indicates that the data was not found.

Lake name	Location (County, State, Latitude/Longitude)	Year First Detected	Area (hectares)	Maximum depth (m)	Calcium (mg/L)	pH	Chlorophyll *a* (µg/L)	Secchi disk depth (m)
Metonga Lake	Forest, WI, 45.5409, -88.9041	1999	806	24.0	17	7.8	2.4	6.6
Lake Antoine	Dickinson, MI, 45.8374, -88.0360	2001	303	8.0	19	8.8	3.9	-
Lake Noquebay	Marinette, WI, 45.2566, -87.9083	2006	975	15.5	37	8.2	3.5	2.5
Chicagon Lake	Iron, MI 45.0591, -88.5030	2007	445	32.0	28	8.0	-	-
Moon Lake	Dickinson, MI 45.8516, -88.0572	2007	38	16.0	32	-	-	-
Keyes Lake	Florence, WI 45.8990, -88.3061	2010	85	23.0	18	8.1	2.2	6.0
Lake Emily	Iron, MI 45.1144, -88.5013	2011	130	9.8	29	8.4	7.0	2.3
North Lake	Florence, WI 45.9040, -88.1384	2012	32	13.0	25	8.5	1.5	4.5

In her study, Ferry (2013) states that zebra mussels consistently selected substrates that were hard (rock, wood, and shells), avoided soft substrates (silt, organic, and sand), and exhibited no selection toward aquatic plants and this pattern was similar across lakes. Zebra mussels had the strongest affinity for wood and shells and also exhibited a strong avoidance of silt and organic substrate (Ferry, 2013). Ferry's zebra mussel habitat model predicts that the relative probability of zebra mussel occurrence will be greater in habitats with rock and wood and will increase with increasing depth (Ferry, 2013). The maximum depth that zebra mussels may occur is uncertain (Ferry, 2013).

Ferry (2013) states in her study, zebra mussel selection of hard substrates and hard substrates as a predictor of zebra mussels was expected as zebra mussel shell morphology and byssal threads allow firm attachment to solid surfaces (Morton, 1993). In addition to providing a solid substrate for zebra mussel attachment, rock, wood, and shells offer a textured and porous surface that provides stronger byssal adhesion (Hebert et al., 1991; Ackerman et al., 1992). Byssal threads can work their way into these pores, increasing adhesion (Ferry, 2013).

Ferry (2013) states the significant positive correlation of depth with mussel occurrence is a likely indicator that oxygen and food exert limitations on zebra mussel distribution both of which are correlated to depth. Studies in Keyes Lake and North Lake are consistent with oxygen availability affecting distribution (Ferry, 2013). Zebra mussels in Keyes Lake and North Lake occurred in a band around the perimeter of the lake with few occurrences in shallow water (<1 m) and were absent deeper than 5 m and 4 m in Keyes Lake and North Lake, respectively (Ferry, 2013). The maximum depth of zebra mussels in these two lakes is consistent with the oxygen availability (Ferry, 2013).

Zebra mussel growth and mortality curves were not developed for North Lake as only two age classes (age zero and 1) were observed at the time of her work (Ferry, 2013).

There was an opportunity for lake stewards to describe their experience, in regards to the rapid response project, at the April 2013 Wisconsin Lakes Partnership Convention. Carl Sundberg and Bill Frisque (SECOLA volunteers) along with Angie Stine (White Water Associates) presented at the Convention in Green Bay, Wisconsin and discussed the rapid response approach.

During Maureen Ferry's monitoring work in 2012, she found that most zebra mussels encountered were in the "0" year age bracket. She found a few 1-year old zebra mussels, a single 2-year zebra mussel and two 3-year old zebra mussel. These finds are plotted in Figure 9 in order to understand the size age relationship of zebra mussels in North Lake.

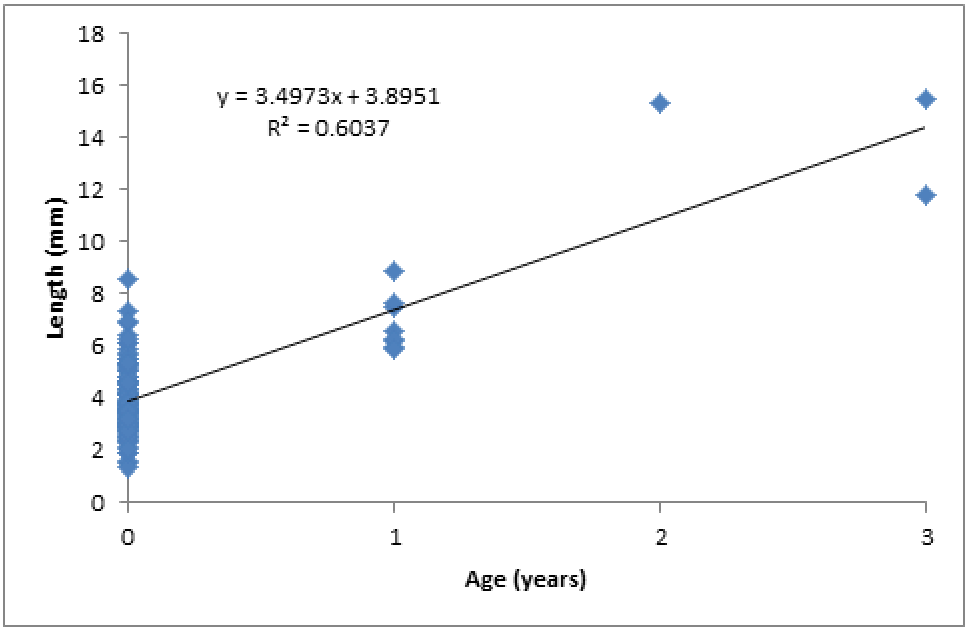


Figure 9. North Lake Zebra Mussel Growth (Ferry, 2013).

Florence County Land Conservation Department conducted a survey for zebra mussels in the Spread Eagle Chain of Lakes on June 19, 2013 (Richard et al., 2013). Zebra mussels were found in North Lake, Middle Lake, West Lake, Long Lake, Bass Lake, and Railroad Lake.

Task 3B: Develop long-term monitoring plan for zebra mussels in the Spread Eagle Chain.

It would be possible to replicate Maureen Ferry's sampling procedures on North Lake to track changes in zebra mussel populations over time in North Lake and the rest of the Spread Eagle Chain would be beneficial. SECOLA volunteers should continue to monitor using zebra mussel substrate samplers (Figure 10) throughout the Spread Eagle Chain of Lakes following the WDNR sampling procedures. All monitoring results should be recorded in the SWIMS database http://www4.uwsp.edu/cnr/uwexlakes/clmn/AIS-Manual/6mussels12.pdf. Ferry (2013) suggests testing different types of substrate samplers such as cedar shakes. Water clarity values should be regularly obtained to track whether zebra mussel filtering is affecting that water quality parameter.

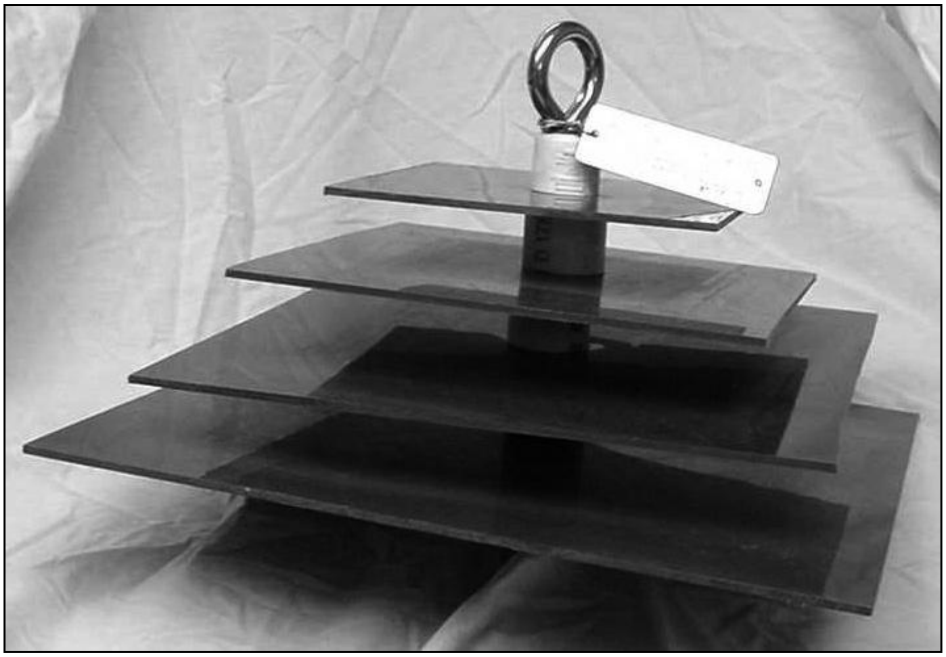


Figure 10. Zebra Mussel Substrate Sampler (WDNR, 2010).

Objective 4. By meeting with the WDNR and representatives of the SECOLA, create a unified and educated response to zebra mussel and EWM for the purpose of protecting North Lake, the Spread Eagle Chain of Lakes, and other water bodies in the region.

Task 4A: Meet with the SECOLA board and WDNR staff to develop a response plan for preventing movement of AIS to and from North Lake.

Dean Premo and Angie Stine, White Water Associates, attended the SECOLA Board Meeting on September 10, 2012 to discuss the original (2012) find of EWM and zebra mussels, and the steps that need to be taken. Dean Premo presentation notes for this meeting are included as Appendix 1 of this document. A newsletter posting by the SECOLA President Glen Johnson is included at the end of Appendix 1.

A Strategic Plan to Address Zebra and Quagga Mussels in the Menominee River Watershed (White Water Associates, 2013) provides information on zebra mussel dispersal from lake to lake and on how this movement can be diminished. It also provides a model of how to respond if a new population of zebra mussels is encountered. The response to the discovery of zebra mussels in North Lake followed that model.

The SECOLA website provides some links to education materials on AIS. The 2013/2014 SECOLA Fall/Winter Newsletter informed members of the EWM and zebra mussel discoveries in North Lake. It also described to the SECOLA members how to clean, drain, and dry boats to minimize transport of AIS.

Task 4B: Incorporate ideas generated from the SECOLA-WDNR meeting in the North Lake Adaptive Management Plan (funded under a large-scale lake planning grant).

Education, stopping any new infestations, early detection of new aquatic invasives, and containment of the zebra mussel are important components of the adaptive management plan. This Appendix (K) and other components of the North Lake Adaptive Management Plan address these issues. Additional information can be gleaned from *A Strategic Plant to Address Zebra and Quagga Mussels in the Menominee River Watershed* (White Water Associates, 2013).

Task 4C: Investigate and purchase a boat wash station to be deployed at the North Lake boat landing.

At the time the rapid response grant was awarded, there was keen interest in obtaining a boat wash station for the North Lake boat landing. White Water Associates communicated with the SECOLA board members regarding boat wash issues. The SECOLA investigated the possibility of permanent boat wash station by working with Florence County Land Conservation Department (Margie Yadro) and the Forestry and Parks Administration. Margie Yadro convened a meeting of stakeholders on 11/14/2012 to discuss the boat wash station at the public access on North Lake. Those present included: Margie Yadro, Dean Premo, Glen Johnson, Ray Burgess, and Darlin Verley. Specific designs were discussed. Important questions were raised: Who has the authority to approve use of location for the boat wash station? What accommodations are needed for a boat wash station? How do you select the right boat wash? Other issues such as who will run it, maintenance, insurance, legislation, signage, etc. Additional funding was another topic discussed.

Margie Yadro commented that the county owns the land and the town paved the boat landing area. It was mentioned that traffic flow is a concern. It was suggested that our first priority should be signage at the sight. Both Dean Premo (White Water Associates) and Darlin Verley (SECOLA) confirmed that some of the money provided in the current grant for the boat wash could be used for the signage and this was confirmed by the WDNR (Jim Kreitlow). White Water Associates and Margie Yadro provided some examples for signage. Educational opportunities (Awareness) at local High Schools were also suggested. Dean Premo recommended using the SECOLA website to provide lake geography, history, and education. Regarding funding sources a $4,000 stand-alone grant may be available to pay for Limited Time Employees (LTE). Margie has indicated that the County does not see having boat wash employees on their payroll as their first choice. She recommends the services of WRISC – 10% cost to hire, schedule, handle payroll, and keep books. The training could possibly come out of Margie's budget. Glen Johnson (SECOLA) intends to investigate several aspects of the boat wash station further.

A November 16, 2012 e-mail correspondence from Margie Yadro (2012) to SECOLA President Glen Johnson follows summarizes some of the discussions and actions:

Nov. 16, 2012

Hi Glen,

I enjoyed meeting with you yesterday at the boat landing to continue the discussion on what makes the best fit for a boat wash scenario at Spread Eagle. I do believe that the boat wash location in the graveled area in the center of the turnaround seems like the obvious choice for the portable "decontamination station." That may also provide the best access for washing boats coming or going.

I had a request in to our state engineer for a visit to the site to consider runoff and drainage, and it looks like she will make her way here on December 11th. (Perhaps that will also fit with Dave's schedule or others.) I think that Ray also had some good ideas on that topic, so we can compare notes and options on that afterwards.

The Forestry & Parks Administrator Pat Smith will be available the last week of November to ask for his input regarding County boat landing maintenance, such as tree removals or trimming. I would also want him to comment on what type of equipment, materials or labor could be used to do any digging, landscaping, or asphalt striping in the parking area.

You and I felt that daily transport of the boat wash and the frequent need to fill the water tank would be items requiring constant need. If a storage unit could be placed at the entrance to the center turnaround, it could provide secure storage for the unit and make an obvious single lane on each side for boats entering or exiting the landing. (Signage could be considered for a message to clean before entering on one lane, and clean before exiting on the other lane.) There appears to be about 75 to100 ft of "pull over" space for washing that could perhaps be designed to have 2 boaters lined up for washing at a time, on each side of the turnaround, or if 2 wash units are parked together on heavy traffic days. The collection of runoff from the wash lanes already appears to be gently sloping down to the end of the wash lanes if placed in the center turnaround. Wash water will likely need to be slowed long enough for groundwater infiltration or something other. There are some boat wash systems (probably much more expensive) that recycle water. Not sure if we should look at that, but it would be great if White Water or WDNR could weigh in on groundwater infiltration and influence.

A groundwater source seems that it would be the best fit for filling the water wash tank. I have not heard of anyone attempting lake water or dry hydrant use for washing (I assume that it could be filtered and heated sufficiently to kill veligers and remove any plant fragments). This is another area for someone to comment with more scientific or practical understanding.

As far as administering a boat wash operator position, I have recommended requesting that of the Wild Rivers Invasive Species Coalition (WRISC) to consider this role. It could be discussed at their December meeting. I also met with Jane Malischke of the DNR earlier this week and asked if a Clean Boats/Clean Waters grant could be requested to also fund a boat wash operator. She thought so. I have copied the link for that application which has been streamlined for the public's benefit. Again, if WRISC is able to take this on, there would be a small administrative fee that should also be part of this budget.
http://dnr.wi.gov/files/PDF/forms/8700/8700-337.pdf

Sorry about the length of this e-mail, but it also helps me to follow the steps of developing this project into a reality. I will plan to meet with Pat when he is available in a couple of weeks and share that schedule.

Everyone, have a great Thanksgiving, and stay tuned as the engineer and others add thoughts and resources to the design.

Thanks.

Margie Yadro

In Fall 2014, the SECOLA purchased a NorthStar Pressure Washer (NorthStar Hot Water Pressure Washer, Honda Engine, 4 GPM@4000 PSI, Trailer Mounted). This unit will be ready for use in spring 2015.

Task 4D. Verify that appropriate signs are posted at the North Lake public landing.

White Water Associates staff consulted with Florence County Land Conservation Department (Margie Yadro) in content and design of an educational sign for the North Lake boat landing. Yadro and her staff did some additional content and design work on the sign. Their design is for a 4 foot by 8 foot billboard type (Figure 11). The smaller inside boxes should have the ability to be customized to each boat landing need. The WDNR suggested putting stakeholder logos on to show project partners. Yadro (2013) consulted with United Sign of Iron Mountain to provide sign materials/dimension suggestions and cost estimates. The sign was installed in 2014 (Figure 11).

Figure 11. Aquatic invasive sign at the North Lake boat landing.

Upon discovery of a second population of Eurasian water-milfoil in the Spread Eagle Chain of Lakes (south of Robbins Island), funds were obtained through an ***Early Detection and Response Grant*** through the Wisconsin Department of Natural Resources (WDNR) Aquatic Invasive Species (AIS) Planning Grants program.

The specific objectives in the project are to: (1) investigate the extent of Eurasian water-milfoil by fall 2013 field investigation and follow-up checks in 2014, (2) hand-pull (if feasible) any Eurasian water-milfoil discovered in field investigations, and (3) educate SECOLA volunteers to carry on Eurasian water-milfoil monitoring and containment in the future. The actions taken under this grant have been described throughout this Appendix. We strongly recommend follow-up monitoring for the entire Spread Eagle Chain of Lakes in the future.

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APPENDIX 1
SECOLA BOARD MEETING – SEPTEMBER 10, 2102
PRESENTATION NOTES - DEAN PREMO
WHITE WATER ASSOCIATES, INC.

Chronology:
What has transpired (starting with Matt's observations on Wednesday) - Timeline
Wednesday, September 5 – Matt Hager discovered ZM & EWM and informed Bill Tuck, Jennifer Steltenpohl (WDNR, Specialist, Aquatic Invasive Species - Great Lakes Basin Outreach Coordinator (GLRI)); and Brenda Nordin (WDNR, Northeast Region Specialist)

Thursday, September 6 – Bill Tuck informed FCLARA (Cary Anderson), SECOLA (Carl Sundberg and Glen Johnson), Tim Plude (WDNR, Water Resource Specialist), Laura Herman (WDNR Lakes Specialist), Jim Kreitlow (WDNR Lakes Coordinator), and Margie Yadro.

Thursday, September 6 – on return email to Bill Tuck, Matt Hager Cc'd: Kevin Gauthier, Maureen Ferry, and Jennifer Steltenpohl.

Thursday, September 6 – 10:30 PM Maureen emailed several of the above folks and Cc'd me (an email I read at 5AM on Friday morning.

Friday, September 7 – Dean Premo spent the day communicating via email and phone with participants (tracking down information, mapping GPS points, communicating with SECOLA members, WDNR). Angie Stine spent half day reviewing voucher plant specimens for juvenile zebra mussels and half day with Carl Sundberg following up on the EWM locations and ZM finds.

Saturday, September 8 – Maureen Ferry, Bill Frisque, Carl Sundberg, and Glen Johnson snorkeled around Middle, Bass, and the outlet of East Lake. They did not see any zebra mussels in the downstream lakes. Maureen started transects on North Lake on Saturday.

Sunday, September 9 – Maureen continued with effort on North Lake

Sunday/Monday – Maureen contact the Florence Mining News

Monday, September 10 – Angie Stine and Bill Frisque assisted Maureen with SCUBA sampling on North Lake and Middle Lake. Dean spoke with Angie and Maureen at noon and 4PM

Monday, September 10 – Early afternoon – Dean Premo had conference call with Jim Kreitlow and Kevin Gauthier discussing possible next steps.

Monday, September 10 (7PM) – SECOLA Board Meeting.
White Water Associates, Inc. – Dean Premo speaking notes for September 10, 2012 SECOLA Meeting Page 2

Detailed Observations EWM:
On Friday, Angie Stine and Carl Sundberg found no additional EWM in the vicinity of the original find. The sampling technique was GPS unit and snorkeling by Angie. There was a significant amount of northern water-milfoil and other plants.

Show the maps of this find. This is sort of an unusual spot for a colony to establish (far from landing, lots of native plants). Attached aerial photo (at end of document illustrates both EWM and ZM finds by Matt Hager)

Show the proximity of our PI points. 60-70 feet to our nearest PI points.

Dean Premo spoke with Matt Hager Monday morning (September 10, 2012) regarding his original observations and to confirm that Angie Stine had looked in the exact area. Matt indicated that he saw about 12 small plants, none had grown up to the surface. The patch was about 10 feet across and in about 4 foot depth. He described the area and proximity to the boat lift. Angie Stine covered this area thoroughly.

Matt collected voucher specimens of the EWM and will send them to UW Stevens Point Freckmann Herbarium for confirmation. He felt confident about the identification.

Detailed Observations ZM:
On Friday, Angie Stine found a couple very tiny bivalves attached to our plant voucher specimens from this summer's PI survey. These will be sent for confirmation of ZM. She found some ZM in North Lake at sites where Matt Hager had found them.

On Saturday, Maureen Ferry, Bill Frisque, Carl Sundberg, and Glen Johnson snorkeled Middle, Bass, and the outlet of East Lake and saw no ZM.

On Sunday and Monday, Maureen Ferry and Bill Frisque (with Angie Stine on Monday) used SCUBA to work on North L. According to Maureen, the great majority of ZM she has seen is <1year old (hatched this year). She has found on her transects only a couple that are age 1.

It is likely that this is a 2-3 year old infestation. They are not very numerous at this time.

Most ZM that have been observed in North Lake have been in the depth range of 5-10 feet.

On Monday afternoon, Maureen, Bill, and Angie's SCUBA work on Middle Lake – found no ZM down to depth of 18 feet (including a fish crib).
White Water Associates, Inc. – Dean Premo speaking notes for September 10, 2012 SECOLA Meeting Page 3

What do we know?

- ZM are here to stay. They will impact the chain.
- EWM may be removed, but could show up again.
- Other AIS are on the doorstep and should be of continued concern in terms of education and prevention approaches.

Next Steps:
Short Term:
Get the word out to all of SECOLA members and other riparians to closely examine their piers as they are removed this season for ZM.

Wash your boats and follow all other sanitation precautions if you transport to another lake

We need to get signage at the landing.

Contact Sandy Wickman (WDNR-lake monitoring) to get ZM substrate samplers and training session for monitors.

WDNR – Jim Kreitlow and another WDNR person will come out this week and do veliger tows on the entire chain.

Maureen Ferry – will return next Friday to complete her sampling on North Lake over the weekend.

As of today (Monday, September 10), Jim Kreitlow reserved a rapid response grant (retroactive to September 6). This would be focused on containment (a boat wash station) and education. He indicated that the WDNR was coordinating response activities with White Water.

We need to continue monitoring for EWM
White Water Associates, Inc. – Dean Premo speaking notes for September 10, 2012 SECOLA Meeting Page 4

Mid-Term:
Grants – Rapid Response Grant – no deadline, but must create a proposal (White Water)

Grants – AIS Planning Grant or Lake Planning Grant – Including the entire chain for PI plant surveys, native mussel surveys, water quality monitoring, etc. – February 1, 2013 deadline.

It is SECOLA's and all riparian owners' interest to develop this better understanding of the lakes and create a management plan (maybe one over all the lakes with sub-parts).

Long Term:
- Continue monitoring for EWM
- Get permanent boat wash installed and staffed
- Education and containment
- Continue studies of the chain
- Prepare plans for the chain

In conclusion:
I'm proud of the team and the amount of effort that has been demonstrated in just a few days. It takes a team effort and good coordination with private and public resource professionals.

SECOLA Website 2013, http://www.spreadeaglechain.org/index.html– Glen Johnson:

I started drafting this letter reflecting on the great summer season, how the weather was getting cooler, how the color of fall was starting and our lakes were still clean. My high school English Composition teacher would have been impressed. Unfortunately, that letter was scrapped. At 10 am on September 6th, I received a call from Bill Tuck, the Florence County Invasive Species Coordinator. After years of thinking we had avoided most of the invasive species found in others lakes, he informed that they found Eurasian water-milfoil and zebra mussels in North Lake. It will take me a while to forget the shock I felt as I was given this news. For years people said that it is not a case of "if we get them," but rather "when we get them." Still, throughout this summer the local biologists could not give a good explanation why we were spared, given that we have the highest outside usage of all the lakes in Florence County with both fishing and recreational pressure.

Some of the zebra mussels in North Lake were initially believed to be at least a year old. This past August, Maureen Ferry, a research assistant at the University of Wisconsin/Stevens Point, gave an update on the research of zebra mussels in Keyes Lake. Her presentation included slides depicting the location of zebra mussels in the Great Lakes Basin in 5 year intervals from 1980 to the present. The spread of this invasive species depicted on these slides left one wondering how this infestation could ever be controlled.

With this news, the SECOLA Board met on September 10th to map out a plan of action. We have money in our invasive species fund which we anticipated using in such an emergency if required to quickly react until grant money becomes available. We heard the results of a dive team that worked September 7th to 9th. Maureen, Bill Frisque and Angie Stine of White Water Associates snorkeled and dove in various areas in North Lake as well as the channels between North and Middle Lakes, Middle and Bass Lakes, Long and Middle Lakes, and East Lake by the South Lake channel. So far, nothing was found outside North Lake. We are fortunate to have a healthy normal Northern water-milfoil population which should help slow the spread by crowding out the Eurasian water-milfoil.

The 12 plants that were identified were pulled. We have the experience of what happened in Lake Elwood and other local lakes to use the best practices. Zebra mussels are another story. We anticipate being added to the research currently being done at Keyes Lake. There are experimental treatments but no easy solution at this time. The quick reaction by the State of Wisconsin to the Keyes Lake situation tells me that the state is very concerned about the quality of our lakes. We will be applying for emergency grant money that is available from the state. We will keep you informed as more information becomes available.

While we did not win this battle, I want to thank all of you who volunteered for the Clean Boats/Clean Waters inspection at the public landing during the peak holiday usage. Special thanks to Carl Sundberg for coordinating the volunteer effort. Beyond a doubt, Spread Eagle sees the highest outside usage of all the lakes in Florence County with both fishing and recreational pressure. For a number of years we have been working with the Florence County Land Conservation Committee and the Florence County Lakes and Rivers Association (FCLARA) for funding through State Grants for a Florence County Invasive Species Coordinator with an emphasis on education. We have had access from time to time to a portable boat wash and operator that was also funded through state grants. The State also provided funding for research almost immediately once Zebra Mussel were discovered at Keyes Lake.

Within this newsletter is a report from our Grant Committee (Darlin Verley, Carl Sundberg, Jack Fortier and Ray Burgess) on our study of North Lake. This study is over and above the work going on at the county level. While these actions are all positive steps, several members at the annual meeting expressed the sentiment and frustration that an education effort in and of itself is not enough. One action would be to have more coverage at the public landing, not just the peak holiday periods. Some suggested that maybe we should have our own boat wash and operator. The Board has undertaken an investigation on feasibility of such action. David Pasahow has joined the Board as Chair of the Special Committee to help with our research. One of the first steps we have taken has been to join with the FCLARA to support a county ordinance that, if a boat wash and operator were on duty at a public landing at any lake in Florence County, require the boat and trailer to be washed. Failure to comply would result in a fine. As I write this, the ordinance is working its way through the County Board process.

We have also had discussions with the County Board on having the county take responsibility for payroll and management of a summer operator. Throughout the winter we will identify a suitable configuration of the type of wash that would serve our needs, review the grading and drainage issues at the public landing and determine the required signage. There will be new signage at the landing in the spring. We will continue to have a dialogue with the County Board on any other defensive measures to prevent further damage to our lakes and the other lakes in the county.

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Appendix L
Review of Water Regulations and Planning Relevant to North Lake

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WHITE WATER ASSOCIATES, INC.

Review of Water Resource Regulations and Planning Relevant to North Lake

In this appendix, we provide reviews of documents created to preserve and protect Wisconsin waters, including North Lake. These reviews were developed from documents created by a variety of sources, including: the Environmental Protection Agency, the Wisconsin Administrative Code, the Wisconsin Department of Natural Resources, the Florence County Planning and Zoning Department, the Florence County Land Conservation Department, and the Florence County Board.

The first part of this appendix is a review of the federal, state and county regulations and ordinances that influence the water quality of North Lake. Second is a review of the *Headwaters Basin Integrated Management Plan*. This plan describes issues of concern within the Headwaters Basin (where North Lake is located), and provides examples of how the WDNR strives to preserve and restore the land and water resources. The third part of this Appendix is a letter sent to the Florence County Land and Water Conservation Department, providing recommendations to enhance an already well-documented and comprehensive *Florence County Land & Water Resource Management Plan.*

Regulations and Ordinances that Protect the Water Quality of North Lake

Federal

The Army Corps of Engineers oversees projects that alter waterways-including discharges to wetlands. The Environmental Protection Agency (EPA) regulates water quality pollution and drinking water standards. The EPA revised The Clean Water Act in 1972 in order to reduce pollutant discharges into waterways and mange polluted runoff. It has set waste water standards for industries, and for all contaminants in surface waters. The Clean Water Act deemed it unlawful to discharge any pollutant from a point source into navigable waters, unless a permit was obtained. You can view parts of the Clean Water Act at the EPA's website (http://www.epa.gov/npdes/pubs/cwatxt.txt).

State

For any given lake in Wisconsin, shoreland protection regulations can be set by the county, town or lake association; however, they must *at least* follow the regulations listed under the State of Wisconsin's Administrative Code, Chapter NR115: Wisconsin's Shoreland Protection Program. The purpose of this Program is to: "establish minimum shoreland zoning standards for ordinances…and to limit the direct and cumulative impacts of shoreland development on water quality; near—shore aquatic, wetland and upland wildlife habitat; and natural scenic beauty" (State of Wisconsin Legislature-a). This document states that a setback of 75 feet from the ordinary high-water mark (OHWM) of any navigable waters is required for all buildings and structures. It also states that the county will be in charge of establishing ordinances that consider the effect of vegetation removal on water quality, including soil erosion, and the flow of effluents, sediments and nutrients. Lastly, it says that a minimum of 35 feet vegetative buffer zone is required from the OHWM (State of Wisconsin Legislature-a).

Changes to the Wisconsin Administrative Code have limited the amount of phosphorus running off into waterbodies. Chapter 151 now restricts the amount of phosphorus farmers can have come off their fields. Moreover, in 2009-2010, Wisconsin legislatures passed laws so that fertilizers with phosphorus would be banned from use on lawns or turfs, and that phosphorus levels in dishwater detergent were reduced considerably (State of Wisconsin Legislature-b).

The Wisconsin Department of Natural Resources (WDNR) has developed the Wisconsin Pollutant Discharge Elimination System (WPDES) program. This program regulates the discharge of pollutants into waters. Types of permits issued are: individual, general (including ballast water discharge, pesticide pollutant discharge, etc.), storm water and agricultural (WDNR, 2012a).

The WDNR also requires permits for specific aquatic plant control techniques. Permits are required for aquatic plant control when: chemicals are used, biological controls are used, and physical techniques (such as barriers) are used; when wild rice is involved; when plants are mechanically removed, or when plants are removed from an area greater than 30 feet in width along a shoreline (WDNR, 2014).

Personal Watercrafts (PWCs) are restricted to slow, to no-wake speed when within 200 feet of a shoreline, while boats must be at slow, to no-wake speed within 100 feet. These regulations can be more stringent under county or town ordinances (WDNR, 2011).

County

Regulations and ordinances set by Florence County can be found in Chapter 10, Subchapter 2, Code of Ordinances of the County of Florence, Wisconsin, Shoreland and Wetland Ordinance (Bay Lake Regional Planning Commission, 2003). This document provides detailed information about zoning and planning near shoreland and wetland areas. The following is a brief summary of some of these regulations that inherently protect the water quality of North Lake.

According to the Ordinance, shorelands are defined as lands within 1,000 feet from a lake, pond or flowage; and 300 feet from a river or stream (BLRPC, 18.02). Chapter 5 requires livestock housing to be located no less than 100 feet from navigable waters (BLRPC, 5.04). Dumping and disposal of any fluids that could create health hazards must be placed more than 300 feet from the water (BLRPC, 5.06). Similarly, private sewage treatment and disposal systems (as used by motels, resorts, laundromats, restaurants, and buildings employing 50+ persons) must also be placed more than 300 feet from the water (BLRPC, 5.08). These regulations are set in place to prevent these pollutants and contaminants from running off into the water.

To prevent erosion, boathouses cannot be constructed where there is a slope of 20% or more, so that soils do not erode into the water (BLRPC, 5.03). In addition, stairs, walkways and lifts, if allowed by the zoning administrator, must avoid environmentally sensitive areas, and vegetation that stabilizes slopes cannot be removed (BLRPC, 5.09). Likewise, removal of dead, diseased or dying vegetation must be replaced with other vegetation that is equally effective in retarding runoff, preventing erosion and preserving natural beauty (BLRPC, 8.02). In general, on each lot, a vegetation protection area is established by the ordinary high-water mark, and a line 35 feet from the ordinary high-water mark (BLRPC, 8.02). By keeping this vegetation, soils are less likely to erode and pollutants and contaminants are less likely to enter the water.

Local

The Town of Florence Ordinance #4-26-10 (2010) provides exemption from no-wake speeds in the channels between lakes within the Spread Eagle Chain of Lakes.

Resources

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State of Wisconsin Legislature-a. NR 115. Wisc. Admin. Code § 115.01. *Wisconsin's Shoreland Protection Program, Purpose*. Page 145.

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Review of *Headwaters Basin Integrated Management Plan* Relevant to North Lake

The *Headwaters Basin Integrated Management Plan* provides information about the conditions of the land and water resources found in the basin, and addresses the programs that strive to preserve and restore those resources. In this section, we will discuss the programs that provide assistance and protection to the water quality of Wisconsin lakes, including North Lake.

Of the 15,057 lakes in Wisconsin, 34% are located within the Headwaters Basin. The Basin spans Forest, Florence, Lincoln, Langlade, Oneida and Vilas Counties. There are 29 Outstanding Resource Waters (ORW) located within the Basin. Outstanding Resource Waters support valuable fisheries and wildlife habitats, have good water quality and are not significantly impacted by human activities (WDNR, 2013a). Although North Lake is not considered an ORW, one lake within 10 miles of North Lake is considered an ORW: Keyes Lake. In contrast, two waterbodies within 10 miles of North Lake are listed as Impaired Waters (303 (d)): Sand Lake, and the Brule River Flowage. These waterbodies are considered impaired because of mercury contamination in fish tissues. Nearby Emily Lake and Sea Lion Lake were previously listed as impaired because of mercury levels, but were delisted in 2006 and 2008 respectively (WDNR, 2013b). Because of North Lake's qualities, it is important to maintain that level of water quality and protect the lake from adverse impacts.

The Fisheries Management branch of the WDNR Water Division protects Wisconsin lakes by processing permits required for protecting shorelines, by helping interpret ordinances and regulations, and by providing biological and technical expertise to local units of government. They also help monitor lake levels, assist landowners in learning about lake ecology, process applications for lake management grants, and review licenses and inspections of dams (WDNR et al., 2002).

The Watershed Management branch of the WDNR Water Division, following the standards set by the Federal Clean Water Act, protects Wisconsin surface waters by writing plans for watersheds, such as: facilities plans, 305 (b) water quality reports to Congress, and aquatic nuisance and exotic species reports. They also create water quality modeling, such as: streams and lakes water quality modeling, contaminated sediment monitoring, and wasteload allocations. The Watershed Program also proposes water quality standards and policies, such as: surface water quality classification and standards, contaminated sediment investigation, total maximum daily loads, and designation of 303 (d) water bodies (WDNR et al., 2002).

The Wastewater branch of the WDNR Water Division, following the standards set by the Federal Clean Water Act, protects Wisconsin surface waters by issuing Wisconsin Pollutant Discharge Elimination System (WDPES) permits, by reviewing industrial and municipal baseline and annual reports, and by providing information to communities about their program and its benefits (WDNR et al., 2002).

The Nonpoint Source Pollution Abatement Program, following the standards set by the Wisconsin Administrative Code, protects Wisconsin surface waters by encouraging landowners to minimize nonpoint pollution sources on their properties, by providing information about the best management practices for both rural and urban areas, and by assisting counties with implementing their land and water resource management plans (WDNR et al., 2002).

The Drinking Water and Groundwater branch of the WDNR Water Division, following the standards set by the federal Safe Drinking Water Act and the Wisconsin Administrative Code protects Wisconsin waters by enforcing standards for wells and pumps, by conducting surveys and inspections of water systems, and by reviewing water quality monitoring reports. They also provide assistance to well owners and the public (WDNR et al., 2002).

The Wildlife Management branch of the WDNR Land Division, following the standards set by the Wisconsin Administrative Code, protects Wisconsin waters by establishing State Wildlife and State Natural Areas, by conducting population and habitat surveys, developing wildlife management plans, monitoring threatened and endangered species, evaluating hunting and trapping regulations, and by educating and encouraging responsible management techniques (WDNR et al., 2002).

The Endangered Resources branch of the WDNR Land Division, following the standards set by the Wisconsin Administrative Code, protects Wisconsin waters by managing the Natural Heritage Inventory Program (NHI), which is used to determine the existence and location of native plant and animal communities, and of Endangered or Threatened Species of Special Concern, and by providing permits for incidental take of these species (WDNR et al., 2002).
The Wisconsin Bureau of Forestry, following the standards set by the Wisconsin Administrative Code, protects Wisconsin waters by providing technical assistance to county, state and private

forest lands. The Bureau helps each county forest by developing a Ten Year Comprehensive Plan, and by assisting with timber sale, reforestation, development of wildlife habitat, and protection of endangered and threatened species. On the state level, the Bureau assists with establishing the best management practices of sustainable forestry, reforestation, and timber harvesting. With private landowners, they help with establishing best management practices of sustainable forestry, help protect endangered and threatened species, and provide assistance with forest disease and insect problems (WDNR et al., 2002).

These programs have been put in place the help preserve, protect and restore the water quality of all Headwater Basin lakes, including North Lake.

Resources

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Wisconsin Department of Natural Resources. 2013a. *Outstanding and Exceptional Resource Waters*. Retrieved 2014. < http://dnr.wi.gov/topic/SurfaceWater/orwerw.html>

Wisconsin Department of Natural Resources. 2013b. *Wisconsin's 2012 Impaired Waters List.* Retrieved 2014. <http://dnr.wi.gov/topic/impairedwaters/2012IR_IWLIST.html>

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March 1, 2013

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To whom it may concern:

As ecological consultants, White Water Associates works with lake associations to conduct studies, review data, and create management plans. We have helped organizations like *Keyes Lake Improvement Association* and *Spread Eagle Chain of Lakes Association* collect water quality data, fisheries data, and invasive species data, and prepare reports conveying these data. We currently have projects with these associations that are funded by the Wisconsin Department of Natural Resources. One of our tasks in these projects was to review the Florence County Land & Water Resource Management Plan.[1] The purposes of that review are to (1) determine where our lake management efforts integrate with the county plan and (2) provide input to the county for how future iterations of the plan might better address water resource issues. It is with those purposes in mind that we submit this summary of recommendations for your consideration to further improve an already comprehensive plan.

Organization

It was very logical to organize the majority of this plan by Land Resources and Water Resources. Here are a few suggestions to assist with continuing this organization:

It may be beneficial to break up the Resource Inventory and Assessment by Watershed section. The Geographic Description section would fit nicely in the beginning of the report so that readers have a mental image of Florence County. The Land Ownership and Land-Use sections would fit well under the Land Resources category.

I suggest that within the Land-Use section, sub-sections for each land-use subject are created: Agriculture, Forest, Water, and Developed land. This provides a more definitive separation of information where you can relay general information, statistics, regulations, and provide recommendations.

Similarly, the Soil Erosion and Sedimentation Information section could be broken down and the sub-sections dispersed elsewhere. For example, the soils paragraphs seem more relevant under the

[1] The Florence County Land & Water Resource Management Plan used for this review was from October, 2011 and was found at ftp://24-213-16-250.static.mrqt.mi.charter.com/LandConservation/IncludePages/Florence%20County%20LWRM%20printed%20version.pdf

Agriculture section (since it addresses cropland erosion); Non-point Source Pollution could be placed after (or within) the Watershed category (because of WDNR watershed ranking); Other Locally Important Resources could be better placed earlier in the report, after describing the General Physical Setting; and Resource Assessment can stand alone and be the last major category in Chapter 2.

Within the Water Resources section, it would be beneficial to create sub-sections for each: Impaired Waters, and Outstanding and Exceptional Resource Waters. Because these subjects can reflect a combination of lakes, rivers and wetlands, they would be best placed following these sections.

Lastly, I propose that Invasive Species becomes a new major category, placed after the Land and Water Resources sections. Since invasive species do not fall specifically under just one of these major categories, it merits a section of its own.

Content

If you decide to create sub-sections under the Land-Use category, it would be important to describe how much acreage each category covers (and percent coverage). A pie chart would show this well.

Under the Agriculture sub-section, after listing the acreage, I recommend listing the types of crops grown, acreage of those crops, and where and which crop is most predominant in the County. If there is cranberry farming in Florence County, I suggest describing the methods for harvesting and the potentially harmful impacts it can have on water resources. Mentioning the NRCS Nutrient Management Conservation Practice Standard (the "590 Standard") would be prudent.

Under the Forestry sub-section, after listing how many acres it spans, I recommend listing the forest types, listing the acreages of state and national forests, and talking about forest management (including timber harvesting). Since soil erosion was discussed earlier in the plan, addressing the specific soil erosion concerns stemming from silvicultural activities might be beneficial in this section.

I recommend addressing the susceptibility of groundwater to contamination in regards to the county's physical geography and/or to its land usage. Both of these can have an influence on how much pollution gets into the groundwater.

In the Watersheds category, it would be useful to provide a description of the WDNR watershed ranking of non-point source pollution. It would also be helpful to describe non-point sources and their effect on water quality, and the ability to manage these pollution sources. A figure or table displaying the watersheds and their rakings would a good visual tool.

Within the Rivers and Streams section, if there are any rivers associated with the Northern Rivers initiative (NRI), here would be a good place to inform the reader about NRI, and list the rivers involved.

If you decide to create new categories for Impaired Waters, and Outstanding and Exceptional Resource Waters, both sections should explain how a lake is qualified to be either; how many lakes, creeks or rivers Florence County has for each; and possibly create a map illustrating where they're located.

Within the Wetlands section, you might take advantage of a nice educational opportunity to explain why wetlands are so important to the quality of our water resources. For example, how they positively affect water quality and how wetland plants can take up and store pollutants, which results in cleaner waters.

In a similar educational mode, it might be nice to add more information to the Invasive Species section. In general, invasive species are detrimental to the native communities around them, but describing in detail how aquatic and terrestrial invasives species specifically affect the water quality of nearby waterbodies is also important. In each the Aquatic and Terrestrial Invasive Species sections, I recommend speaking generally about these species, listing which are found in Florence County with a short paragraph describing how they arrived, how they are spread, how they affect the native community, and where they are found in Florence County.

In the report, it is stated that "From 1990 to 2010, Florence County gained 1,005 housing units…" I assume this would also translate to an increase in residential areas. This may be a good place to describe the negative effects residential areas can have on water quality of waterbodies in those areas.

Since the Other Locally Important Resources section only describes rare, endangered and threatened species, this could instead be the title of the section.

<u>Minor formatting issues</u>

Instead of placing the General Soils map where it is, move it under the section discussing soils. Currently, there is no soils information preceding it.

Similarly, place the Watershed map under the Watershed section. Currently, it is within the Groundwater section.

I was very impressed with the detail you have incorporated in this plan. It is thorough and comprehensive. I am sure it serves the residents of Florence County well. If you have questions or comments regarding my recommendations, please contact me at the phone number given above.

Sincerely,

Caitlin Clarke
Biologist

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Appendix M
The History of the Spread Eagle Chain of Lakes and its Application to Lake Stewardship

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The History of the Spread Eagle Chain of Lakes and its Application to Lake Stewardship

Human presence in the Spread Eagle Chain of Lakes area has influenced the look of the land and the quality of the lakes. In fact, humans have altered these ecosystems in many ways. As we look toward the future of North Lake and the rest of the Spread Eagle Chain of Lakes, an understanding of the history of the area is important. This gives us perspective as we consider how human stewardship might protect what is best about the lakes and restore aspects that need improvement.

The Spread Eagle Chain of Lakes area was a wilderness in the middle of the 19th century as land surveyors were establishing township lines on the landscape. When the original land surveys were completed in the area surrounding the Spread Eagle Chain of Lakes, the U.S. Land Office opened the lands for sale creating a rush to obtain the valuable pine timber stands. This started about 1866 and brought timber cruisers into the area (Robbins, 1988). Just a few years later (in 1873), iron ore was discovered in the area and brought a second rush, this time to purchase mineral rights (Robbins, 1988). The Northwestern Railroad came shortly afterward and was responsible for opening the Spread Eagle Chain of Lakes to tourists and people who built cottages. From that point on to the present day, the Spread Eagle Chain's ecology has been closely linked to human recreational and residential use.

The Lake Planning Study for North Lake (MMA, 1996) summarized the history and it is not our intent to duplicate that effort (that summary is provided in Exhibit 1). In addition, the original source of much of this material is in a book called The Eagle Spreads its Wings written by Putnam W. Robbins in 1988. This book is available from the Dickinson County Library System. An anecdotal account published in The Daily Northwestern in 1927 gives an impression for the changes that occurred in the Spread Eagle Chain of Lakes area over the course of just 50 years (see Exhibit 2).

Exhibit 1. A brief history of the Spread Eagle Chain of Lakes.

From The Lake Planning Study for North Lake (MMA, 1996)

As with most of northern Wisconsin and the U.P. of Michigan, prior to the late 1800's the Florence area was a great virgin forest. The Iron Mountain and Florence areas developed in the late 1800's and earlier 1900's as a result of the logging and mining activities in the area.

Logging activities did not occur in the Florence area until the mid to late 1870's, shortly after the government land sales which started in 1886. Most of the logs cut in the late 1800's and early 1900's were floated down river to lumber mills. The Menominee River, located just north and east of the Spread Eagle Chain of Lakes, served as a main vehicle for transporting the logs to the lumber mills. By 1898, most of the large stands of virgin pine in Florence County had been cut by the major logging companies, including the virgin Red and White Pine stands in the Spread Eagle Chain of Lakes area. The last of the remaining stands of virgin pine were harvested from the Spread Eagle Chain of Lakes in winter of 1907-1908 (Ref. #1).

Iron ore was discovered by Hiram D. Fisher in the Florence area in 1873 and in Commonwealth in 1876. The Chicago and Northwestern Railway Company extended rail service to Commonwealth and Florence in 1880 to transport the iron ore mined from the Florence and Commonwealth area. Passenger rail service was provided to Spread Eagle, Commonwealth and Florence in 1881.

Rail service to Spread Eagle opened up the Spread Eagle Chain of Lakes area for recreation and tourism. In 1881, Fred John opened up a resort and an ice house on Bass Island on Bass Lake. It was expanded in 1889 when it was purchased by Emmanuel Chainey to include a popular dance pavilion. In 1894, a resort hotel opened with a saloon and ice house on Eagle Island between Bass Lake and Middle Lake. Each of these resorts had steam powered boats to transport people from the train depot near Railroad Lake to the resorts. Paradise Island on East Lake had a small resort in the 1880's until 1894 (Ref. #2).

In 1882, the first private cottage was built by Mark Dunn on Dunn's Point near the entrance to West Lake. The first major building of cottages on the Spread Eagle Chain of Lakes did not occur until 1904 when the lots on Mosquito Bay of Bass Lake were sold.

Waterfront lots on Spread Eagle Chain of Lakes accessible by roads from the railroad depot sold quickly, while lots which were only accessible by water usually did not sell until the roads were provided. The construction of cottages and homes on North Lake did not occur until Brown's Road was extended around North Lake in circa 1925.

Once roads were built around the Spread Eagle Chain of Lakes making the lots easily accessible, building around the Lakes flourished. Recently, building on vacant lots has given way to the conversion or replacement of summer cottages to year-round homes.

Ref. #1: Putnam Robbins. July 22, 1995 conversation and letter to MMA, Inc. dated January 8, 1996. Mr. Robbins, born in 1902, has spent part of every summer at the Spread Eagle Chain of Lakes. Author of The Eagle Spreads its Wings.

Ref. #2: Putnam Robbins. 1988. The Eagle Spreads its Wings.

Exhibit 2. Anecdotal account of changes in the Spread Eagle Chain of Lakes landscape from 1878 to 1927. (Original from The Daily Northwestern Oshkosh, Wisconsin, April 23, 1927 as posted on Wisconsin Genealogy Trails http://genealogytrails.com/wis/florence/spreadeagle.htm).

"The Man on the Corner"

1878, or forty-nine years ago. I went hunting in a part of Florence County in the extreme northeast part of the state, and only a few miles distant from the boundary line between Wisconsin and Michigan. There, that part of the state abounded in deer, black bear, wolves, wildcats, lynx and all varieties of small game. It was a wild country. It was uninhabited save by a few lumber camps, now and then a lone hunter and trapper, and occasionally, iron mine prospectors went through. The railroad ended at Quinnesec to where it had just been built in. There was a mine just opening there and one at Waucedah. Norway and Iron Mountain did not exist. At Florence a little prospecting had been done. The trip in from Powers to Quinnesec was made in boxcars. The rest of the distance with a team. It was a wild, rough country, with rather light soil and did not look as though it would ever amount to anything after the pine was cut and even that was rather scattering.

We camped on the shore of a little spring lake and not far from us was another body of water then known as Spread Eagle Lake, due to the fancied resemblance to an eagle with outstretched wings. The land around that lake was rather swampy or barren looking, but game abounded there and the waters were filled with fish and adjacent streams that found their way into the Menominee or Pine rivers were full of native brook trout. We hunted there several seasons with good success and much pleasure. In those days there were no game laws to speak of, no game wardens at all and no bag limits.

The other day I picked up The Florence Mining News and read that a company has just taken over part of the Spread Eagle lake and that "The company is investing many thousands of dollars in the new proposition and following are some of the various things they will have: a toboggan slide is now being created costing $1,500 along. A ride on this device carries you right into the lake. There will also be a merry-go-round, Ferris wheel, chair-o-plane, tilt-a-whirl, concessions and sensational free acts. This (__) will be located on the mainland across from the island. The large dance pavilion on the island has been beautifully decorated. Meals and lunches will be served at all houses, with big chicken dinners Sundays."

Iron Mountain, that did not exist in the early days I speak of, now 25,000. Some of the great iron mines of the world are there. Florence has a population of from 20,000 now the county seat of a promising county. So does time work its changes to the earth.

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Appendix N
Lake User Survey

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WHITE WATER ASSOCIATES, INC.

Lake User Survey
North Lake

The Lake Planning Study for North Lake (MMA, 1996) included a property owner survey distributed in June, 1995 to the Spread Eagle Chain of Lakes property owners. This survey queried survey takers with demographic questions as well as probed the reasons for owning property on the Spread Eagle Chain of Lakes. Other topics of inquiry included recreational use of the lakes, aquatic plants, and concerns for the lakes. A total of 257 surveys were sent out with 172 returned (67%). We briefly summarize the findings here and reference specific results on aquatic plants in the Aquatic Plant Management Plan (Appendix B). Since this 1995 survey is now nearly twenty years old, we would recommend that a new survey be devised and distributed to obtain information from a new generation of Spread Eagle Chain users. Certainly, there is value still in the 1995 results, but a lot has changed in the community of people (for example, awareness of environmental issues, different recreational habits and equipment, and new property owners).

Highlights from the 1995 survey results include:

- The distribution of ages of the heads of households: 1% were ages 20-29, 6% were ages 30-39, 21% were ages 40-49, 24% were ages 50-59, 26% were ages 60-69, 18% were ages 70-79 and 4% were 80 or older;
- With regard to residency and employment status, 31% of respondents were seasonal residents who worked elsewhere, 30% were seasonal residents and retired, 20% were year-round residents who worked locally, and 17% were year-round residents who were retired;
- Respondents to a question that probed the reasons for owning property on the Spread Eagle Chain of Lakes revealed the top two reasons - 50% purchased property because of natural beauty and solitude and 28% purchased property because of water-related recreation;
- The primary water recreation activities reported by respondents were motorized boating (42% of respondents), swimming (27%), fishing (23%) water skiing (6%), canoeing/rowing (3%), and jet skiing (1%);
- Respondents indicated owning several kinds of watercraft including outboard motorboat (62%), canoe (48%), row boat (39%), paddle boat (32%), pontoon boat (28%), inboard/outboard (25%), inboard (22%), other (8%), and jet ski (4%); and
- When asked about their top concerns for the Spread Eagle Chain of Lakes, the list includes water quality (29% of respondents), boat safety (13%), overcrowding (10%), fishing (10%), noise (7%), and lake water levels (6%).

Respondents were given opportunity to address how they might address their concerns about the Spread Eagle Chain of Lakes and here the responses were quite broad in their topics including:

- Jet skis and speed boats (when they should operated, should they be outlawed, safety, over use of the boat landing, noise pollution, and enforcement);
- Large boats (safety concern and erosion);
- No wake areas (stakeholders mentioned that better buoys or signage in the no-wake areas);
- Water level (stakeholders stated that the water level is an issue and cited beavers as a contributing agent);

- Septic tanks (concern for repair and maintenance);
- Fee at the boat landing (many property owners advocated for having a fee at the boat landing to help with education, boater safety, fish stocking, and reducing traffic);
- Light pollution (stakeholders complained about outdoor lighting at the lakes);
- Lawn fertilizer runoff (a few of the property owners cited this as a concern for water quality);
- Litter (a few respondents mentioned this as an issue);
- Dilapidated boat houses and docks (cited as an issue of unsightliness by a few respondents);
- Dock length (mentioned by a few respondents); and
- Boat landing attendant (one respondent recommended someone be stationed at the boat landing to monitor for invasives, educate on boater safety and rules, and to collect a fee for use of lakes).

Although aquatic plants were not identified as a top concern by many respondents, some responses to the more open question of land owner concern dealt with aquatic plants. Some of these responses were negative and probably indicate an educational opportunity. For example, various responses state “Weed growth needs to be controlled," “Use a harvester where needed to control growth of aquatic plants,” “Something must be done to stop the weed growth in North and West Lakes,” “Feel certain plants are over grown and choking the lakes,” and “Would like to see weeds eliminated in most areas.” Other responses hinted recognition of the role of aquatic plants. Examples of this sentiment include, “Don’t overcut weeds, check septic systems, stop using fertilizers and pesticides” and “recommend mandatory septic test for all cottage systems to avoid polluting lakes and encouraging weed growth.”

Literature Cited

MMA, Inc. May 1996. *Lake Planning Study for North Lake*. MMA, Inc. Civil and Environmental Engineers. Green Bay, WI.